B.Tech. (Biotechnology)

2022 Regulations, Curriculum & Syllabi

Stay Ahead

BANNARI AMMAN INSTITUTE OF TECHNOLOGY

An Autonomous Institution Affiliated to Anna University - Chennai • Approved by AICTE • Accredited by NAAC with "A+" Grade

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BANNARI AMMAN INSTITUTE OF TECHNOLOGY, SATHYAMANGALAM

REGULATIONS 2022

(CHOICE BASED CREDIT SYSTEM)

(Common to all B.E./B.Tech. Degree Programmes)

Regulations 2022 have been prepared in accordance with the guidelines given by the University Grants Commission, All India Council for Technical Education and affiliating Universities incorporating the features of the Choice Based Credit System (CBCS). The Regulations 2022 is applicable to the candidates admitted to the Bachelor of Engineering (B.E.) / Bachelor of Technology (B.Tech.) Degree Programmes of the Institution in the Academic Year 2022-2023 for Regular admission (Academic Year 2023-2024 for Lateral Entry) and subsequently.

The regulations hereunder are subjected to amendments as may be decided by the Academic Council of the Institution from time to time. Any or all such amendments will be effective from such date and to such batches of students (including those already in the middle of the programme) as may be decided by the Academic Council.

1. ADMISSION

Candidate, seeking admission to the B.E./B.Tech. Programme, shall satisfy the conditions of admission prescribed by the Directorate of Technical Education (DoTE) and Anna University, Chennai as given below.

1.1 Regular Admission

Candidates, for admission to the first semester of the eight semesters B.E./B.Tech. Degree Programmes, shall be required to have passed:

Higher Secondary Examination (10 +2) of curriculum (Regular Academic Stream) prescribed by the Government of Tamil Nadu with Mathematics, Physics, and Chemistry as three of the four subjects of the study prescribed under Part-III or any other examinations of any Board or University or authority accepted by the Syndicate of the University / DoTE, Chennai as equivalent thereto.

(or)

Should have passed Higher Secondary Examination of Vocational Stream (Engineering/Technology), prescribed by the Government of Tamil Nadu.

1.2 Lateral Entry Admission

1.2.1 The candidates who possess Diploma in Engineering / Technology awarded by the State Board of Technical Education and Training, Tamil Nadu or its equivalent are eligible to apply for lateral Entry admission to the third semester of B.E. / B.Tech. programmes in the branch of study as per the eligibility criteria prescribed by the DoTE from time to time.

(or)

The candidates who possess the Bachelor Degree in Science (B.Sc.) (10+2+3 stream) with Mathematics as a subject in B.Sc. is eligible to apply for lateral entry admission to the third semester of B.E./B.Tech. programmes, as per the eligibility criteria prescribed by the DoTE from time to time. Such candidates shall undergo two additional Engineering subject(s) one each in third and fourth semesters, as bridge courses.

2. PROGRAMMES OFFERED

A candidate may be offered admission to any one of the programmes offered by the Institution for the candidates specified in Clause 1.1 and as per the eligibility criteria of DoTE for the candidates under Clause 1.2 from the list given below:

B. E. Programmes

1. Biomedical Engineering
2. Civil Engineering
3. Computer Science and Design
4. Computer Science and Engineering
5. Electrical and Electronics Engineering
6. Electronics and Communication Engineering
7. Electronics and Instrumentation Engineering
8. Information Science and Engineering
9. Mechanical Engineering
10. Mechatronics

B. Tech. Programmes

1. Agricultural Engineering
2. Artificial Intelligence and Data Science
3. Artificial Intelligence and Machine Learning
4. Biotechnology

5. Computer Science and Business Systems
6. Computer Technology
7. Fashion Technology
8. Food Technology
9. Information Technology
10. Textile Technology

3. STRUCTURE OF THE PROGRAMME

3.1 Every programme shall have a distinct curriculum with syllabi consisting of theory, laboratory, project, soft-skills and personality development courses, as prescribed by the respective Boards of Studies, broadly categorized under:

Basic Science (BS) courses including Mathematics, Physics, Chemistry and further specialization in these subjects

Engineering Science (ES) courses including Engineering Graphics, Basics of Electrical / Electronics / Civil / Mechanical, Engineering Mechanics and Computer Programming.

Humanities and Social Sciences (HSS) courses including Language Courses, Management Courses, Soft Skills and Professional Ethics.

Professional Courses(PC) include Discipline Core Courses, Professional Electives, and Open Electives.

Employability Enhancement Courses (EEC) includes Project Work, Mini Project and /or Internship, Seminar, Industrial /Practical Training, Startup Management, Value Added, and Certificate Courses.

The medium of instruction is English for all the Courses (except Tamil), examinations, seminar presentation, projects, and any other courses that a student registers for.

3.2 Each course is normally assigned a certain number of credits based on the following.

Contact period per week	Credit(s)
1 Lecture / 1 Tutorial period	1
2 laboratory Periods (Laboratory / Seminar / Project Work / etc.)	1

3.3 All the B.E. / B.Tech. Students will study Communicative English I during the firstsemester. In the second semester, they will be provided an option to enroll and study Communicative English II / German / Japanese / French / Hindi. while the lower segment will study Communicative English II.

3.4 Every student shall be required to opt for 10electives from the list of electives. Students can opt for the electives (Core / Professional) from his / her own discipline courses, during IV to VII Semesters, if he/she satisfies the prerequisite for that particular course.

3.5 However, out of ten electives, every student shall be required to opt for, a minimum of one and subject to a maximum of three courses as open electives from the list of electives of the branch / branches other than his / her branch of specialization, if he/she satisfies the prerequisite for that particular course. The course / content should not be covered in their own curriculum and syllabi.

3.6 Students can also opt for **one-credit courses** of 15 to 20 hours duration, which will be offered by the experts from the industry on specialised topics. Students can opt for such **one-credit courses** during the semesters I to VI as and when these courses are offered. A student will also be permitted to register the **one-credit courses** offered by other departments, provided the student has fulfilled the necessary prerequisites or the courses that may not require any prerequisites. Under no circumstances, the same one credit course shall be repeated in subsequent semesters in any department / centre for the same batch of the students and a maximum batch size for a given course shall not exceed 40. In case of disciplines with multiple divisions (intake more than 60) multiple batches/ different course(s) shall be offered to other batch(es) of students.

On successful completion of one credit courses, credits will be indicated in the grade sheet, but will not be considered for computing the Cumulative Grade Point Average (CGPA). However, if a student wishes to avail the exemption from any one of the electives (other than open elective) of the semester VII, he / she can do so by exercising his / her option in writing to the respective Head of the Department during the beginning of the VII semester, following the equivalence norm, that one **regular elective** (in the **VII Semester**) is equivalent to **three one-credit courses** completed by the student during the previous semesters, III to VI. Details of the one credit courses offered by the department shall be forwarded to the Office of the Controller of Examinations. However, one credit courses completed during I to II semesters shall be maintained in the Grade sheet as “Additional credits earned” (not considered for the computation of SGPA/CGPA).

3.7 A student can register for Self-Study Elective(s) over and above the electives from any branch of Engineering / Technology at the rate of one per semester starting from V semester onwards provided he/she maintains a Cumulative Grade Point Average (CGPA) of 8.50 or above till the previous semesters with no current arrears. Credits will be indicated for such courses in the grade sheets (additional credits) but will not be considered for computing the CGPA.

3.8 A Student may be permitted to credit three online courses with the approval of the Departmental Consultative Committee constituted by the Head of the Department, subject to a maximum of 9 credits. The Head of the Institution shall form a 3-member committee with one of the members as HoD and two senior faculty members to ensure that the student has not studied such courses and would not repeat it again as Professional Core/Professional Elective/Open Elective courses. A student can get exemption for a maximum of 9 credits (refer amendments of R2022 approved in 29th ACM) during the entire programme (in lieu of core elective or open elective). These online courses shall be chosen from the SWAYAM NPTEL platform, provided the offering organisation conducts regular examination and provides marks. The credits earned shall be transferred and the marks earned shall be converted into grades and transferred, provided the student has passed in the examination as per the norms of the offering organisation.

For online courses the following grading pattern is applicable in case of credit transfer and CGPA calculations

Range of percentage of total marks	**Letter Grade**	**Grade Point**
91 - 100	O	10
81 - 90	A+	9
71 - 80	A	8
61 - 70	B+	7
51 - 60	B	6
40-50	C	5
< 40	U	0

3.9 Industrial Training / Internship

The students may undergo Industrial training / Internship optionally for a period as specified in the table during summer / winter vacation and the credits earned will be indicated in the grade sheet. If the student earns three credits in Industrial Training / Internship, the student may drop Professional Elective subjected to a maximum of one. In such cases, Industrial Training / Internship need to be undergone continuously from one organization only. However, if the number of credits earned is 1 or 2, these credits shall not be considered for classification of the degree. The students may also undergo Internship at Research organization / University (after due approval from the Department Consultative Committee) during summer / winter vacation.

Duration of Training / Internship	**Credit(s)**
2 Weeks	1
4 Weeks	2
6 Weeks	3

3.10 Socially Relevant Projects

A student may be permitted to carry out socially relevant projects during semester II to semester VI in consultation with the faculty guide and submit the project report, in the prescribed format, at the end of the Semester for valuation.

On successful completion of socially relevant project work, one credit will be indicated in the grade sheet (Additional credits), but these credits will not be considered for computing the CGPA.

3.11 Mandatory courses

The student shall study the mandatory courses prescribed by the institute which will be mentioned in the Grade Sheet. However, it will not be considered for computation of CGPA.

For the students who complete the Mandatory Course satisfying the attendance requirement, the title of the Mandatory Course will be mentioned in the Grade Sheet.

3.12 Choice of Professional Elective Courses

The professional Elective Courses are listed in the Curriculum in Table format as verticals (Specialisation groups). A student can choose all the Professional Elective

Courses either from one of the verticals or a combination of courses from all verticals in a semester. However, students irrespective of enrolling for additional Insertion of New Clause 6.3 are not permitted to choose more than one course from a row. Students are permitted to enroll in more than one elective course from the same vertical in a semester. In the subsequent semesters students are permitted to enroll one more course in a row, provided if he/she has cleared the earlier course of the same row. For a professional elective course and open elective course, the minimum number of students enrolment permitted shall be 10. However, the minimum number is not applicable for students enrolling B.E. / B. Tech. (Hons) and B.E. / B. Tech. Minor. For the offer of each professional elective at least two choices shall be offered.

4. VALUE ADDED COURSES

A student can opt for the Value Added Courses offered by the various departments from semester II to VII.A separate certificate will be issued on successful completion of the value added course by the competent authority.

5. DURATION OF THE PROGRAMME

5.1 A regular student (admitted after 10+2) or equivalent is normally expected to satisfactorily fulfil the requirements for award of the degree B.E. / B.Tech. within four academic years (8 semesters) from the date of admission but in any case not more than 7 years (14 Semesters); lateral entry students shall fulfil such requirements within three academic years (6 semesters) from the date of admission but in any case not more than six years (12 semesters) leading to the award of Degree of Bachelor of Engineering (B.E.) / Bachelor of Technology (B.Tech.) of Anna University, Chennai.

5.2 The total period for completion of the programme from the commencement of the semester, to which the student was admitted, shall not exceed the maximum period (Clause 5.1), regardless to the break-of-study (vide Clause 15) or period of prevention in order.

5.3 Each semester shall consist of minimum 75 working days. Head of the Department shall ensure that every faculty member teaches the course as prescribed in the approved curriculum and syllabi.

5.4 Special Theory / Practical Sessions may be conducted for students who require additional inputs (remedial classes) over and above the number of periods normally specified, as decided by the Head of the Department, within the specified duration of the semester / programme.

6. COURSE ENROLLMENT AND REGISTRATION

6.1 Each student, on admission shall be assigned to a faculty advisor (vide Clause 8) who shall advise / counsel the student about the details of the academic programme and the choice of course(s) considering the student's academic background and career objectives.

6.2 Each student shall register for all courses to be undergone in the curriculum of a particular semester (with the facility to drop courses to a maximum of 8 credits (vide clause 6.6)). The courses dropped in earlier semesters can be registered in the subsequent semesters when offered.

Every student shall enrol for the courses of the succeeding semester, in the current semester. However, the student shall confirm the enrolment by registering for the courses within the first five working days after the commencement of the semester concerned.

6.3 The courses that a student registers in a particular semester may include

i. Courses of the current semester.

ii. Courses dropped in the lower semesters

6.4 The maximum number of credits that can be registered in a semester is 30. However, this does not include the number of Re-appearance (RA) and Withdrawal (W) courses registered by the student for the appearance of the examination.

6.4.1 From the V to VIII semesters, the student has the option of registering for additional courses in a semester. With regard to enrolling for B.E. / B. Tech. (Hons) or B.E. / B. Tech. Minor. Maximum number of credits enrolled in a semester (Honours and Minor) shall not exceed 36. The online courses registered for B.E. / B. Tech. (Hons.) and B.E. / B. Tech. minor shall be over and above this 36 credits.

6.5 Flexibility to Drop Courses

6.5.1 A student has to earn the total number of credits specified in the curriculum of the respective programme of study in order to be eligible to obtain the degree. However, if a student wishes, the student is permitted to earn more than the total number of credits prescribed in the curriculum by opting for one credit courses, self-study electives, or additional courses.

6.5.2 From the III to VII semesters (from IV to VII semesters in case of lateral entry students), the student has the option for dropping existing courses. The number of courses a student can drop is limited to 2 in a given semester. The student is permitted to drop the course(s) within 30 days of the commencement of the academic schedule. In such cases, the attendance requirement as stated in Clause 7 is mandatory.

6.5.3 The student shall register Project work I in semester VII and Project work II in semester VIII only.

6.6 Reappearance Registration

6.6.1 If a student fails in a theory course, the student shall do reappearance registration (examination) for that course in the subsequent semesters or when it is offered next.

6.6.2 On registration, a student may attend the classes for the reappearance registration courses, if the student wishes, and the attendance requirement (vide Clause 7) is not compulsory for such courses.

6.6.3 If the theory course, in which the student has failed, is either a professional elective or an open elective, the student may register for Semester End Examinations of the same professional elective or open elective course, respectively in the subsequent semesters.

6.6.4 In this case (Clause 6.6.3), the student shall attend the classes, satisfy the attendance requirements (vide Clause 7), earn Continuous Assessment marks and appear for the Semester End Examination.

6.6.5 The student who fails in any continuous assessment courses shall register for the same in the subsequent semesters or when offered next, and **repeat** the course as per Clause 6.6.4.

6.6.6 If a student is prevented from writing the Semester End Examination of courses due to lack of attendance, the student has to repeat the semester when it is offered next time.

7. REQUIREMENTS FOR APPEARING FOR THE SEMESTER END EXAMINATIONS OF A COURSE

A student who has fulfilled the following conditions (vide Clause 7.1 and 7.2) shall be deemed to have satisfied the attendance requirements for appearing for Semester End Examination of a particular course.

7.1 Every student is expected to attend all the periods and earn 100% attendance. However, a student shall secure not less than 80% overall attendance.

7.2 If a student, secures overall attendance between 70% and less than 80%) in the current semester due to medical reasons (prolonged hospitalization / accident / specific illness) or participation in Institution/ University/ State/ National/ International level extra and co-curricular activities, with prior permission from the Head of the Department, shall be permitted to appear for the current semester examinations subject to the condition that the student shall submit the medical certificate / participation certificate attested by the Head of the Institution (along with condonation form). Such certificates along with the condonation forms shall be forwarded to the Office of the Controller of Examinations for verification and permission to attend the examinations. However, during the entire programme of study, a student can avail such condonation in any two semesters only.

7.3 A student shall normally be permitted to appear for Semester End Examination of the course(s) if the student has satisfied the attendance requirements (vide Clause 7.1 – 7.2) and has registered for examination in those courses of that semester by paying the prescribed fee.

7.4 Students who do not satisfy Clause 7.1 and 7.2 and who secure less than 70% overall attendance would not be permitted to move to the higher semester and has to repeat the current semester in the next academic year as per the norms prescribed.

7.5 In the case of reappearance (Arrear) registration for a course, the attendance requirement as mentioned in Clauses 7.1 - 7.3 is not applicable. However, the student has to register for examination in that course by paying the prescribed fee.

7.6 A student who has already appeared for a course in a semester and passed the examination is not entitled to reappear in the same course for improvement of grades.

8. FACULTY ADVISOR

To help the students in planning their courses of study and for general advice on the academic programme, the Head of the Department will attach a certain number of students to a faculty member of the department who shall function as faculty advisor for those students. The faculty advisor shall advise and guide the students in registering of courses, reappearance of courses, monitor their attendance and progress and counsel them periodically. The faculty advisor also discusses with or informs the parents about the progress / performance of the students concerned.

The responsibilities of the faculty advisor are:

- To inform the students about the various facilities and activities available to enhance the student's curricular and co-curricular activities.
- To guide student enrolment and registration of the courses.
- To authorize the final registration of the courses at the beginning of each semester.

- To monitor the academic and general performance of the students including attendance and to counsel them accordingly.

9. COMMITTEES

9.1 Common Course Committee

9.1.1 A theory course handled by more than one faculty member including the discipline with multiple divisions (greater than or equal to 2) shall have a "Common Course Committee" comprising of all members of faculty teaching that course with one of the members as the Course Coordinator, nominated by the Head of the Institution (Head of the Department in the case of multiple divisions of a discipline) and student representatives (one per specialization or division) registered for that course in the current semester. First meeting of the Common Course Committee shall be held within fifteen days from the date of commencement of the semester. Two subsequent meetings in a semester may be held at suitable intervals. During these meetings, the student members shall meaningfully interact and express their opinions and suggestions of all the students to improve the effectiveness of the teaching learning process. It is the responsibility of the student representatives to convey the proceedings of these meetings to all the students.

9.1.2 In addition to this, Common Course Committee (without the student representatives) shall meet to ensure uniform evaluation through the common question papers during continuous assessment and Semester End Examinations.

9.2 Class Committee Meeting

For all the courses taught, prescribed in the curriculum, Class Committee meeting shall be convened thrice in a semester (first meeting within 15 days from the commencement of the semester and other two meetings at equal interval after the first meeting) comprising members of the faculty handling all the courses and two student representatives from the class.

One of the members of the faculty (preferably not handling any courses to that class), nominated by the Head of the Department, shall coordinate the activities of the committee. During these meetings, the student members shall meaningfully interact and express their opinions and suggestions of all the students to improve the effectiveness of the teaching learning process. It is the responsibility of the student representatives to convey the proceedings of these meetings to all other students.

10. SYSTEM OF EXAMINATION

10.1 Performance in each course of study shall be evaluated based on (i) Continuous Assessment throughout the semester and (ii) Semester End Examination at the end of the semester for the regular courses or as given in the Clause 17.

10.2 Each course, both theory, theory with lab component and laboratory including project work, shall be evaluated as per the scheme of assessment given in Clause 17.

10.3 The Semester End Examinations shall normally be conducted after satisfying the Clause 5.2.

10.4 For the Semester End Examinations, both theory, theory with lab component the internal and external examiners (from Academia) shall be appointed by the Controller of Examinations as per the guidelines given by the Examination cum Evaluation committee of the Institute.

11. PASSING REQUIREMENTS AND PROVISIONS

11.1 The Passing requirement for a student in a course is determined based on the marks obtained both in continuous assessment and Semester End Examinations. A student who secures not less than 50% of total marks prescribed for the course [Continuous Assessment + Semester End Examinations] with a minimum of 45% of the marks prescribed for the Semester End Examinations, shall be declared to have passed the course and acquired the relevant number of credits.

11.1.1 If a student fails to secure a pass in a particular course, i.e., failing to obtain minimum marks, as stated above, it is mandatory that he/she shall reappear for the examination in that course in the subsequent semester(s) whenever the examinations are conducted for that course, till he / she secures a ‘Pass’.

Continuous Assessment (CA) marks obtained by the student in the first appearance shall be retained and considered valid for one subsequent attempt, except Clause 6.6.4, 6.6.5, 6.6.6 and 6.6.7. However, from the third attempt onwards, the student shall be declared to have passed the course if he/she secures a minimum of 50% in the course prescribed during the Semester End Examinations.

11.2 If a candidate fails in the seventh semester examinations of Project work I, he/she has to resubmit the Project Report within 30 days from the date of declaration of the results. If he / she fails in the Semester End examination of Project work II, he/she shall resubmit the Project Report within 60 days from the date of declaration of the results. The resubmission of the project report and the subsequent viva-voce examination will be considered as reappearance with payment of exam fee. In case a student fails in the resubmission of a project report and subsequent viva-voce examination, the student shall register for the course again, when offered next.

11.3 The passing requirement for the courses which are assessed only through continuous assessment (Laboratory and EEC courses except project work), shall be fixed as minimum 50% and the remaining grades are decided as per clause 12.4. If a candidate fails in EEC courses (Except Project work), he/she has to register and repeat the course within 30 days from the date of declaration of the results. In case a student fails to register within 30 days, he/she shall register for the course again, when offered next.

11.4 The minimum number of total credits to be earned by a student to qualify for the award of degree in the various branches of study as prescribed by the respective Boards of Studies is given below:

Branch of Study	**Minimum Credits**	
	Regular Admission	**Lateral Entry**
B.E. Programmes		
Biomedical Engineering	163	121
Civil Engineering	164	122
Computer Science and Design	163	119
Computer Science and Engineering	163	119
Electrical and Electronics Engineering	163	121
Electronics and Communication Engineering	163	121
Electronics and Instrumentation Engineering	163	121
Information Science and Engineering	162	118
Mechanical Engineering	164	122
*Mechatronics / #Mechatronics Engineering	165	123
B.Tech. Programmes		
Artificial Intelligence and Data Science	165	121
Artificial Intelligence and Machine Learning	163	119
Biotechnology	165	123

Computer Science and Business Systems	163	123
Computer Technology	163	119
Fashion Technology	163	121
Food Technology	163	121
Information Technology	163	119
Textile Technology	163	121

*-applicable to candidates admitted during the AY.:2022-2023

#-applicable to candidates admitted during the AY.:2023-2024 onwards

11.5 Total number of credits to be earned by the student shall be more than or equal to the total number of credits prescribed in the curriculum in force. If the credit assigned for L T P of the courses are not same in two Regulations under consideration, then equivalence shall be arrived as per the credit assignment followed in the Regulations in force.

11.6 Student Migration and Credit Transfer: Normalization of the credits will be carried out in consultation with the Board of Studies of the programme concerned and approved by the Head of the Institution, if a student migrates from other affiliated institutions to Bannari Amman Institution of Technology or rejoins from previous regulation to this regulation.

11.7 A student shall be declared to have qualified for award of B.E/B.Tech. degree if he/she successfully completes the course requirements (vide Clause 7, 10 and 11) and passed all the prescribed courses of study of the respective programme (listed in Clause 2), within the duration specified in Clause 5.1.

12. ASSESSMENT AND AWARD OF LETTER GRADES

12.1 The assessment shall be based on the performance in the Semester End Examinations and/or Continuous Assessments, carrying marks as specified in Clause 17. Letter Grades (based on Credits and Grades) are awarded to the students based on the performance in the evaluation process.

12.2 Credit Point is the product of Grade Point and the number of credits for a course and Grade Point is a numerical weight allotted to each letter grade on a 10-point scale (as specified in Clause 12.4), while the Letter Grade is an index of the performance of a student in a said course.

12.3 Condition for Relative Grading

The students' strength is greater than 30, the relative grading method shall be adopted. If the students' strength is less than or equal to 30 then the absolute grading system shall be followed with the grade range as specified below. The relative grading system shall not be applicable for laboratory, project works and continuous assessment courses.

O	A+	A	B+	B	C	U
91-100	81- 90	71- 80	61-70	56- 60	50–55	<50

12.4 The performance of a student will be reported using Letter Grades, each carrying certain points as detailed below: A student who earns a minimum of 5 grade points in a course is declared to have successfully passed the course.

Description	Letter Grade	Grade Points
Outstanding	O	10
Excellent	A +	9
Very Good	A	8
Good	B +	7
Average	B	6
Satisfactory	C	5
Reappearance	U	0
Withdrawal	W	0
Absent	AB	0
Shortage of Attendance	SA	0

'U' ---Reappearance is required for that particular course

'SA' --- shortage of attendance (Clause 7) and hence prevented from writing end semester examination.

12.5 After completion of the evaluation process, Semester Grade Point Average (SGPA), and the Cumulative Grade Point Average (CGPA) are calculated using the formula:

$$SGPA/CGPA = \frac{\sum_{1}^{n} C_i * g_i}{\sum_{1}^{n} C_i}$$

Where

C_i : Credit allotted to the course.

g_i : Grade Point secured corresponding to the course.

n : number of courses successfully cleared during the particular semester in the case of SGPA and all the semesters, under consideration, in the case CGPA.

RA grades will be excluded for calculating SGPA and CGPA.

12.6 A student who does not appear for the Semester End Examinations in a course, after registering for the same, shall be deemed to have appeared for that examination for the purpose of classification (Subject to Clause 14 and 15).

12.7 For the non-credit courses grades shall be indicated as given in Clause 17 and shall not be counted for the computation of SGPA/CGPA.

For the co-curricular activities such as NCC / NSS / NSO / YRC etc.., a completed status will appear in the grade sheet. Every student shall put in a minimum of 75% attendance in the training and attend the camp compulsorily. The training and camp shall be completed before registering for the fifth semester courses. A completed status in the co-curricular activities is compulsory for the award of a degree.

12.8 **Revaluation:** A student, who seeks the revaluation of the answer script, is directed to apply through proper application to the Office of the Controller of Examinations in the prescribed format through the Head of the Department. The Office of the Controller of Examinations shall arrange for the revaluation and declare the results. Revaluation is not permitted for the courses other than theory courses. In the case of theory courses with laboratory component, a student can seek revaluation for the theory component only, following the procedure stated above.

12.9 **Eligibility for the Award of Degree**

A student shall be declared to be eligible for the award of the B.E. / B.Tech. degree provided the student has

i. Successfully gained the required number of total credits as specified in the curriculum corresponding to the student's programme within the stipulated time.

ii. Successfully completed the course requirements, appeared for the Semester End Examinations and passed all the courses prescribed in all the 8 semesters within a maximum period of 7 years for regular / 6 years for lateral reckoned from the commencement of the first semester to which the candidate was admitted.

iii. Successfully completed the NCC / NSS / NSO / YRC / Extra-curricular/ Co-curricular requirements.

iv. No disciplinary action is pending against the student.

v. The award of degree must have been approved by the Syndicate of the University.

12.10 Conduct of Academic Audit

The purpose of the academic audit is to encourage departments to evaluate the quality of their education processes, thereby assure and regularly improve the quality of teaching learning process and the outputs. A regular academic audit is conducted in the Institute to evaluate the performance of various departments so that the issues that need attention can be identified to improve the overall quality of curriculum design, teaching learning process, and evaluation. The academic audits are conducted by internal and external academic experts.

12.11 Conduct of Special Examination

The special or makeup exams may be conducted for the students who missed the regular examination due to participation / representing the institute in various activities and the schedule may be included in the academic calendar. The special or makeup exams may be conducted after the completion of Semester End Examinations and prior to publishing the results of semester end examinations.

12.12 In the consolidated grade sheet the CGPA earned shall be convertedinto Percentage of marks as follows: Percentage of Marks = CGPA × 10

13. CLASSIFICATION OF THE DEGREE AWARDED

For the purpose of the 'Award of Degree', the duration of completion of the programme shall be the total duration taken by a student for completing first time registration of all the required courses and satisfying Clause 11, regardless of the period of Break of study as per Clause 15 and satisfy any one of the conditions required as given below.

13.1 First Class with Distinction: A student who satisfies the following conditions shall be declared to have passed the examination in **First class with Distinction**:

- Should have passed the examination in all the courses of all the eight semesters (six semesters for lateral entry students) in the student's First Appearance within five years / four years for lateral, which includes authorised break of study of one year. Withdrawal from examination (vide Clause 15) will not be considered as an appearance.

- Should have secured a CGPA of **not less than 8.50**
- Should **NOT** have been prevented from writing Semester End Examination due to lack of attendance.

13.2 **First Class:** A student who satisfies the following conditions shall be declared to have passed the examination in **First class**:

- Should have passed the examination in all the courses of all eight semesters (six semesters for lateral entry students) within five years / four years for lateral, which includes one year of authorized break of study (if availed) or prevention from writing the Semester End Examination due to lack of attendance (if applicable).
- Should have secured a CGPA of **not less than 6.50**

13.3 **Second Class:** All other students (not covered in clauses 13.1 and 13.2) who qualify for the award of the degree shall be declared to have passed the examination in **Second class.**

14. WITHDRAWAL FROM THE EXAMINATION

14.1 A student may, for valid reasons, be granted permission by the Head of the Department to withdraw from appearing in the examination in any course(s) only once during the entire duration of the degree programme. The application shall be sent to the office of the Controller of Examinations through the Head of the Institution with required documents.

14.2 Withdrawal application shall be valid only, if the student is eligible to write the examination as per Clause 7 and, if it is made within 10 working days before the commencement of the Semester End Examination in that course or courses and also recommended by the Head of the Department.

14.3 Notwithstanding the requirement of mandatory 10 working days notice, applications for withdrawal for special cases under extraordinary conditions will be considered on the merit of the case.

14.4 If a student withdraws a course or courses from writing Semester End Examinations, he/she shall register the same in the subsequent semester and write the Semester End Examination(s).

14.5 Withdrawal shall not be considered as an appearance in the examination for the eligibility of a student for First Class with Distinction or First Class.

14.6 Withdrawal is permitted for the Semester End Examinations in the final semester, only if the period of study of the student concerned does not exceed 5 years (for regular) / 4 years (for lateral) as per clause 13.1 & 13.2.

15. AUTHORIZED BREAK OF STUDY FROM A PROGRAMME

15.1 A student is permitted to go on break of study for a fixed period of one year as a single break in the entire course of study.

15.2 A student is normally not permitted to break the period of study temporarily. However, if a student happens to discontinue the programme temporarily during the middle of programme of study, for reasons such as personal accident or hospitalization due to ill health or in need of health care, he/she shall apply to the Head of the Institution in advance, in any case, not later than the last date for registering for the semester examination, through the Head of the Department stating the reasons for the break of study. However, a student detained for want of minimum attendance requirement as per Clause 7 shall not be considered as permitted 'Break of Study' and Clause 15.3 is not applicable for such case.

15.3 The student is permitted to re-join the programme after the break / prevention due to lack of attendance, shall be governed by the curriculum and regulations in force at the time of rejoining. The students re-joining in new regulations shall apply to the Academic In charge in the prescribed format through the Head of the Department at the beginning of the readmitted semester itself for prescribing additional/equivalent courses, if any, from any semester of the regulations in force, so as to bridge the curriculum in force and the old curriculum.

15.4 Authorized break of study will be counted towards the duration specified for passing all the courses (vide Clause 5.1 and 5.2) and for the purpose of classification of degree (vide Clause 13).

15.5 The total period for completion of the programme reckoned from the commencement of the first semester to which the student is admitted shall not exceed the maximum period specified in Clause 5.1, irrespective of the period of break of study in order that he / she may be eligible, for the award of the degree (vide Clause 13).

15.6 In case of valid reasons (as stated in Clause 15.2) extended break of study may be granted by the Head of the Institution for a period not more than one year in addition to the earlier authorized break of study.

15.7 If a student does not report back to the Institute, even after the extended break of study, the student's name shall be permanently deleted from the college enrollment. Such students are not entitled to seek readmission under any circumstances.

16. IMPLEMENTATION OF HONOURS / MINOR DEGREE

16.1 B.E. / B.Tech. (Hons.)

- The students should have earned additionally a minimum of 18 credits from more than one vertical of the same programme.
- Should have passed all the courses in the first attempt.
- Should have earned a minimum CGPA of 7.50.

16.2 B.E. / B.Tech. Minor in another discipline

The student should have earned additionally a minimum of 18 credits in any one of the verticals of other B.E/B.Tech. programmes.

- B.E / B.Tech. (Hons.) and B.E./B.Tech. Minor in another discipline will be optional for students and the students shall be permitted to select any of them only.
- B.E/B.Tech. (Hons.) or B.E./ B.Tech. Minor shall be offered by the Department irrespective of the number of students enrolled.

If the student has failed in the additional courses or faced a shortage of attendance, they will not be printed in the grade sheet and will not be considered for CGPA calculation and classification of degree.

16.3 Students can earn a maximum of 6 credits in online mode (SWAYAM NPTEL platform), out of these 18 credits with the approval of the Departmental Consultative Committee constituted by the Head of the Department.

16.4 B.E./ B. Tech. (Honours) in the same discipline, B.E. / B.Tech. Honours and B.E. / B.Tech. Minor in another discipline degrees will be optional for students.

16.5 For category 16.1, the students will be permitted to register for the courses from V Semester onwards provided the CGPA earned by the students until semester III should be of 7.50 and above and cleared all the courses in the first attempt.

16.6 For category 16.2, the students will be permitted to register the courses from semester V onwards provided the CGPA earned by the students until semester III is 7.50 and above.

16.7 If a student decides not to opt for Honours, after completing a certain number of additional courses, the additional courses studied shall be considered instead of the professional elective courses which are part of the curriculum. If the student has studied more number of such courses than the number of Professional Elective courses required as per the curriculum, the courses with higher grades shall be considered for the calculation of CGPA. Remaining courses shall be printed in the grade sheet, however, they will not be considered for the calculation of CGPA.

16.8 If a student decides not to opt for Minor degree, after completing a certain number of courses, the additional courses studied shall be considered instead of open elective courses which are part of the curriculum. If the student has studied more of such courses than the number of open electives required as per the curriculum, the courses with higher grades shall be considered for calculation of CGPA. Remaining courses shall be printed in the grade sheet, however, they will not be considered for the calculation of CGPA.

16.9. If a student successfully completes all the requirements of the programme and also meets the requirements of B.E. / B. Tech. (Hons) or B.E. / B. Tech. Minor but desires not to opt for the additional qualification, then he/she has to submit a declaration with regard to the same 30 days before the completion of VIII semester.

16.10 Classification of the Degree Awarded

The conditions for First Class with Distinction, First Class, and Second Class are the same as Clause 13.1, 13.2 and 13.3 except the following classification.

First Class: A student who satisfies the following conditions shall be declared to have passed the examination in First class for the purpose of the 'Award of Degree', of **B.E. / B.Tech.** Honors should have secured a CGPA of not less than 7.50.

17. SCHEME OF ASSESSMENT

Courses offered under B.E. / B.Tech. Programmes are assessed as given below:

I CO- CURRICULAR /EXTRACURRICULAR ACTIVITY

a. CO-CURRICULAR ACTIVITY

Component	Applicable from academic year 2024-2025 onwards
	Marks
Continuous Internal Assessment (CIA)	**100**
Distribution of marks for CIA	
Programme Organization / Participation	20
Member of Technical society (International / National repute like IEEE, IET etc.)	20
Brief Report of event	20
Sharing of Views / Presentation / Seminar	20
Attendance	10
Coordinator Assessment	10
Total Marks	**100**

b. EXTRACURRICULAR ACTIVITY (NCC/NSS/ NON-TECHNICAL CLUBS)

Component	Applicable from academic year 2024-2025 onwards
	Marks
Continuous Internal Assessment (CIA)	**100**
Distribution of marks for CIA	
Activity plan and Programme Organization	20
Participation (National / State / Regional /Institute)	20
Activity Report	20
Achievements	20
Attendance	10
Coordinator Assessment	10
Total Marks	**100**

c. EXTRA CURRICULAR ACTIVITY (SPORTS AND GAMES)

Component	**Applicable from academic year 2024-2025 onwards**
	Marks
Continuous Internal Assessment (CIA)	**100**
Distribution of marks for CIA	
Participation (National / State / Regional /Institute)	20
Regular practice	20
Skill Development	20
Sportsmanship (sports ethics) and Teamwork	20
Achievements	10
Coordinator Assessment	10
Total Marks	**100**

II COMPREHENSIVE WORK

Component	**Applicable till academic year 2022-2023**
	Marks
Concept Application	50
Comprehensive Interview	50
Total Marks	**100**

III ENGINEERING DRAWING

Component	**Applicable till academic year 2023-2024**	**Applicable from academic year 2024-2025 onwards**
	Marks	**Marks**
Continuous Internal Assessment (CIA)	**100**	**50**

Distribution of marks for CIA		
Exercise (Minimum 10 Exercises /Modelling)	60	-
Model Examinations	40	25
Class work	-	05
Assignments (Minimum 8)	-	20
Semester End Examinations (SEE)	**-**	**50**
Total Marks	**100**	**100**

IV ENVIRONMENTAL SCIENCE

Component	**Applicable till academic year 2023-2024**	**Applicable from academic year 2024-2025 onwards**
	Marks	**Marks**
Continuous Internal Assessment (CIA)	**100**	**100**
Distribution of marks for CIA		
Periodical Test I	25	25
Periodical Test II	25	25
Innovative Practices / Case studies (50)	50	-
Assignments / Case studies	-	50
Total Marks	**100**	**100**

V HOSPITAL TRAINING

Component	**Applicable till academic year 2023-2024**	**Applicable from academic year 2024-2025 onwards**
	Marks	**Marks**
Continuous Internal Assessment (CIA)	**100**	**60**
Distribution of marks for CIA		
Assessment by Industry	30	-

Viva-voce	20	-
Presentation	30	-
Case Study / Report	20	-
Daily Work log	-	30
Workplace learning report (1 page)	-	10
Trainer Assessment	-	20
Semester End Examinations (SEE) *a. Presentation* *b. Report* *c. Viva voce*	-	**40** *20* *10* *10*
Total Marks	**100**	**100**

VI HUMAN VALUES AND ETHICS

Component	Applicable till academic year 2023-2024	Applicable from academic year 2024-2025 onwards
	Marks	**Marks**
Continuous Internal Assessment (CIA)	**100**	**40**
Distribution of marks for CIA		
Periodical Test I	25	15
Periodical Test II	25	15
Innovative Practices / Case studies	50	-
Assignments / Case studies	-	10
Semester End Examinations (SEE)	-	**60**
Total Marks	**100**	**100**

VII INDUSTRIAL TRAINING/ INTERNSHIP

Component	Marks
Midterm Review	30
Final Presentation	30
Viva-voce	20

Case Study / Report	20
Total Marks	**100**

VIII LABORATORY COURSES

Component	**Applicable till academic year 2023-2024**	**Applicable from academic year 2024-2025 onwards**
	Marks	**Marks**
Continuous Internal Assessment (CIA)	**100**	**60**
Distribution of marks for CIA		
Preparation	20	10
Experiment and Analysis of Results	20	10
Record	10	10
Test – Cycle I	25	15
Test – Cycle II	25	15
Semester End Examinations (SEE)	-	**40**
Total Marks	**100**	**100**

IX LANGUAGE COURSES

a. LANGUAGE ELECTIVES - COMMUNICATIVE ENGLISH II / HINDI / GERMAN / JAPANESE / FRENCH)

Component	**Applicable till academic year 2023-2024**	**Applicable from academic year 2024-2025 onwards**
	Marks	**Marks**
Continuous Internal Assessment (CIA)	**100**	**50**
Distribution of marks for CIA		
Test1 *a. Listening* *b. Speaking* *c. Reading* *d. Writing*	**25** *5* *10* *5* *5*	**25** *5* *5* *5* *10*
Test 2	**25**	**25**

a. Listening *b. Speaking* *c. Reading* *d. Writing*	*5* *10* *5* *5*	*5* *5* *5* *10*
Oral Exam	**50**	-
Semester End Examinations (SEE)	**-**	**50**
Total Marks	**100**	**100**

b. TAMIL COURSES

Component	Applicable till academic year 2023-2024	Applicable from academic year 2024-2025 onwards
	Marks	**Marks**
Continuous Internal Assessment (CIA)	**100**	**40**
Distribution of marks for CIA		
Periodical Test	50	-
Quiz/ Assignment	50	20
Case study report	-	20
Semester End Examinations (SEE)	**-**	**60**
Total Marks	**100**	**100**

c. FOUNDATIONAL ENGLISH / SOFT SKILLS & EFFECTIVE COMMUNICATION / ADVANCED ENGLISH AND TECHNICAL EXPRESSION

Component	Applicable till academic year 2023-2024	Applicable from academic year 2024-2025 onwards
	Marks	**Marks**
Continuous Internal Assessment (CIA)	**100**	**60**
Distribution of marks for CIA		
Test	**50**	-
Quiz/ Assignment	**50**	-
Test 1 *a. Listening* *b. Speaking*	-	**30** *5* *10*

c. Reading *d. Writing*		*5* *10*
Test 2 *a. Listening* *b. Speaking* *c. Reading* *d. Writing*	-	**30** *5* *10* *5* *10*
Semester End Examinations (SEE)	-	**40**
Total Marks	**100**	**100**

d. BUSINESS COMMUNICATION AND VALUE SCIENCE COURSES

Component	**Applicable from academic year 2024-2025 onwards**
	Marks
Continuous Internal Assessment (CIA)	**50**
Distribution of marks for CIA	
Periodical Tests	25
Laboratory Assessment	25
Semester End Examinations (SEE) *Laboratory Assessment only*	**50**
Total Marks	**100**

X MINI PROJECT I & II

Component	**Applicable till academic year 2023-2024**	**Applicable from academic year 2024-2025 onwards**
	Marks	**Marks**
Continuous Internal Assessment (CIA)	**100**	**60**
Distribution of marks for CIA		
Review I	25	30
Review II	25	30
Final Presentation and Viva-voce	30	-
Report	20	

Semester End Examinations (SEE) *a. Report* *b. Presentation & Viva Voce*	**-**	**40** *20* *20*
Total Marks	**100**	**100**

XI PROJECT WORK I

Component	Applicable till academic year 2023-2024	Applicable from academic year 2024-2025 onwards
	Marks	**Marks**
Continuous Internal Assessment (CIA)	**50**	**60**
Distribution of marks for CIA		
Review I *a. Literature Survey* *b. Identification of topic and Justification* *c. Work plan* *d. Problem Statement and Literature Survey* *e. Contribution to the work* *f. Viva voce*	**20** *5* *5* *10* - - -	**30** - - *10* *5* *10* *5*
Review II *a. Approach & Results* *b. Conclusion* *c. Methodology & Results* *d. Conclusion with report* *e. Publication* *f. Viva voce*	**30** *15* *15* - - - -	**30** - - *10* *10* *5* *5*
Semester End Examinations (SEE) *a. Report* *b. Presentation* *c. Viva voce*	**50** *20* *20* *10*	**40** *15* *15* *10*
Total Marks	**100**	**100**

XII PROJECT WORK II

Component	Applicable till academic year 2023-2024	Applicable from academic year 2024-2025 onwards
	Marks	**Marks**
Continuous Internal Assessment (CIA)	**50**	**60**

Distribution of marks for CIA		
Review I *a. Progress* *b. Problem Statement and Literature Survey* *c. Methodology* *d. Work Contribution* *e. Viva voce*	**10** *10* - - - -	**20** - *5* *5* *5* *5*
Review II *a. Approach & Results* *b. Work Contribution* *c. Viva voce*	**10** *10* - -	**20** *10* *5* *5*
Review III *a. Conclusion & Final Presentation* *b. Report* *c. Publication of Paper in Conferences / Journals* *d. Results & Discussions* *e. Report and Contribution* *f. Publication* *g. Viva voce*	**30** *10* *15* *5* - - - -	**20** - - - *5* *5* *5* *5*
Semester End Examinations (SEE) *a. Presentation* *b. Viva voce* *c. Report*	**50** *30* *20* -	**40** *15* *10* *15*
Total Marks	**100**	**100**

XIII SOCIALLY RELEVANT PROJECT

Component	**Applicable from academic year 2024-2025 onwards**
	Marks
Continuous Internal Assessment (CIA)	**100**
Distribution of marks for CIA	
Field Survey	20
Problem Statement / Problem Identification and Social Relevance	20
Approach to the Problem / Methodology	20
Presentation / Seminar	10
Sustainable solutions and Future Plans	10
Report	10

Novelty	10
Total Marks	**100**

XIV STARTUP MANAGEMENT

Component	Applicable till academic year 2023-2024	Applicable from academic year 2024-2025 onwards
	Marks	Marks
Continuous Internal Assessment (CIA)	**100**	**50**
Distribution of marks for CIA		
Conduct of Fieldwork / Case Studies & Report	60	25
Model Examination	40	-
Assignments / Experiments & Report	-	25
Semester End Examinations (SEE)	**-**	**50**
Total Marks	**100**	**100**

XV THEORY COURSES

Component	Marks
Continuous Internal Assessment (CIA)	**40**
Distribution of marks for CIA	
Periodical Test I	12
Periodical Test II	12
Innovative Practices	16
Semester End Examinations (SEE)	**60**
Total Marks	**100**

XVI THEORY COURSES WITH LAB COMPONENT

<table>
<tr><th rowspan="2">Component</th><th>Applicable till academic year 2023-2024*</th><th>Applicable from academic year 2024-2025 onwards#</th></tr>
<tr><th>Marks</th><th>Marks</th></tr>
<tr><td>Continuous Internal Assessment (CIA)</td><td>50</td><td>50</td></tr>
<tr><td colspan="3">Distribution of marks for CIA</td></tr>
<tr><td>Periodical Test I</td><td>15</td><td rowspan="2">25</td></tr>
<tr><td>Periodical Test II</td><td>15</td></tr>
<tr><td>Innovative Practices
(Laboratory Assessment & Report)</td><td>20</td><td>25</td></tr>
<tr><td>Semester End Examinations (SEE) *
(QP pattern as per (I))</td><td>50</td><td>50</td></tr>
<tr><td>Semester End Examinations (SEE) #
Courses with L T P C: 2 0 2 3
a. Theory Examinations
b. Laboratory Assessment</td><td>-</td><td>25
25</td></tr>
<tr><td>Semester End Examinations (SEE) #
Courses with L T P C: 3 0 2 4, 2 1 2 4, 3 1 2 5
a. Theory Examinations
b. Laboratory Assessment</td><td>-</td><td>35
15</td></tr>
<tr><td>Total Marks</td><td>100</td><td>100</td></tr>
</table>

XVII VALUE-ADDED / CERTIFICATE COURSES

Component	Marks
Daily Assessment	50
Final Evaluation / Test	50
Total Marks	**100**

Optional Test: A student becomes eligible to appear for an optional test conducted after the Periodical Test II, only under the following circumstances: (i) absent for Test I or Test II or both on account of medical reasons (hospitalization / accident / specific illness), or (ii) participation in the College / University / State / National / International level Sports events with prior permission from the Head of the Institution and (iii) on satisfying the conditions (i) or (ii), the student should have registered for the Optional Test, through the concerned member of faculty who handles the course or through the respective Head of the Department, submitted to the Controller of Examinations. Such Optional Tests are conducted for the courses under the categories I and II courses listed above.

18. FIELD / INDUSTRIAL VISIT / INTERNSHIP

In order to provide the experiential learning to the students, Head of the Department shall take efforts to arrange at least two industrial visits / field visits. The students may also undergo in-plant training / internship during summer / winter vacation between III and VII semesters.

19. PERSONALITY AND CHARACTER DEVELOPMENT

Every student shall be required to undergo a minimum of 40 hours of Personality Development Programmes viz, NSS / NCC / YRC / YOGA / Sports and Games / Technical and Non-technical Club activities. The attendance of the personality and character development courses / events shall be maintained on the regular basis by the club coordinator and made available in the Office of the Controller of Examinations before the commencement of Semester examinations of Semester I to Semester IV.

20. DISCIPLINE

A student is expected to follow the rules and regulations laid down by the Institute and the affiliating University, as published from time to time. Any violations, if any, shall be treated as per the procedures stated thereof.

If a student indulges in malpractice in any of the Semester End Examination / Continuous Assessments, he / she shall be liable for punitive action as prescribed by the Institution / University from time to time.

21. REVISION OF REGULATIONS, CURRICULUM AND SYLLABI

The Institution reserves the right to revise/amend/change the Regulations, Curriculum, Syllabi, Scheme of Examinations through the Academic Council.

CONTENTS

	Page No.
Vision and Mission	1
PEOs	1
POs	2
PSOs	3
Mapping of PEOs and POs	4
Connectivity Chart	5
Curriculum	6
Syllabi	19
Electives	114
One Credit courses	218
Open Electives	238

VISION OF THE DEPARTMENT

To empower students with world-class education by providing academic and professional competence in tune with technological and societal aspirations.

MISSION OF THE DEPARTMENT

- To provide a state-of-art infrastructure for a professional environment through standard academic practices, co-curricular and extra-curricular activities in-line with National and International paradigms.
- To facilitate a platform for student and faculty members towards qualitative interdisciplinary research for developing sustainable circular bioeconomy.
- To establish collaborations with biotech ventures and research institutes to inculcate professional and leadership qualities for students career advancements and faculty competency enhancement.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

I. To maintain high standards of teaching through innovative pedagogy for enabling students to be lifelong learners and globally competent professionals.

II. To foster creativity through innovation based research activities for upliftment of self and society promoting socio-economic growth.

III. To inculcate professional ethics and skills amongst the graduates and empowering them to have career advancement through placements, higher studies, and entrepreneurship.

PROGRAMME OUTCOMES (POs)

Engineering Graduates will be able to:

1. **Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/ Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
6. **The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOME (PSOs)

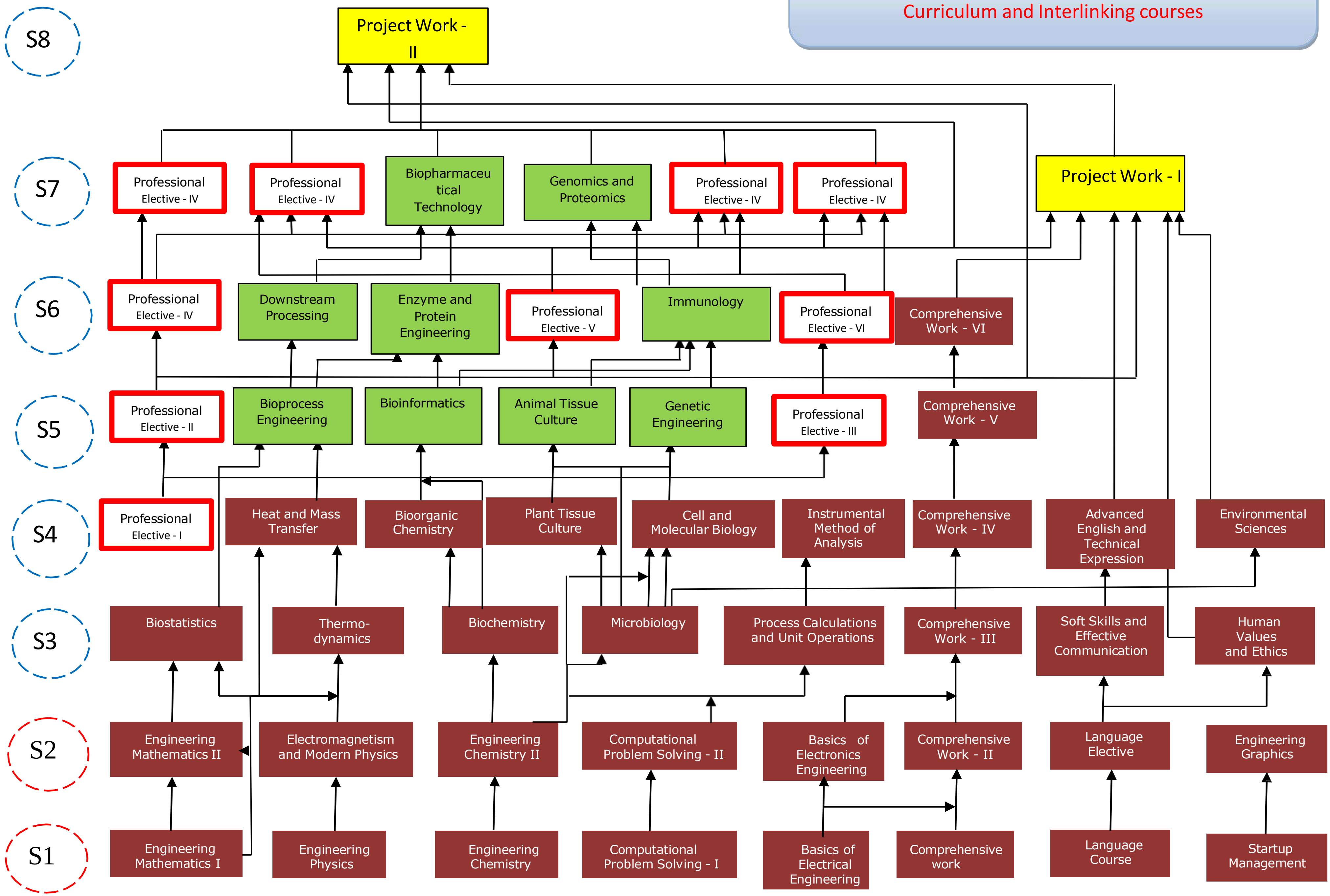
1. Use the analytical instruments and techniques to separate, purify and characterize biological compounds
2. Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors
3. Conceive, Plan and Deploy societal projects for environmental protection using bioresources.

MAPPING OF PEOs & POs

POs	1	2	3	4	5	6	7	8	9	10	11	12
PEO I	X	X	X		X		X			X	X	
PEO II		X	X	X	X			X		X	X	X
PEO III			X			X			X		X	X

Department of Biotechnology – R (2022)

Curriculum and Interlinking courses



DEPARTMENT OF BIOTECHNOLOGY
Minimum Credits to be Earned : 165

I SEMESTER

Code No.	Course	L	T	P	C	Hours/ Week	Maximum Marks			Category
							CA	ES	Total	
22MA101	ENGINEERING MATHEMATICS I	3	1	0	4	4	40	60	100	BS
22PH102	ENGINEERING PHYSICS	2	0	2	3	4	50	50	100	BS
22CH103	ENGINEERING CHEMISTRY I	2	0	2	3	4	50	50	100	BS
22GE001	FUNDAMENTALS OF COMPUTING	3	0	0	3	3	40	60	100	ES
22HS001	FOUNDATIONAL ENGLISH	1	0	2	2	3	50	50	100	HSS
22GE003	BASICS OF ELECTRICAL ENGINEERING	2	0	2	3	4	50	50	100	ES
22HS002	STARTUP MANAGEMENT	1	0	2	2	3	50	50	100	EEC
22HS003	தமிழர் மரபு HERITAGE OF TAMILS#*	1	0	0	1	1	40	60	100	HSS
22BT108	COMPREHENSIVE WORK$	0	0	2	1$	2	100	0	100	EEC
Total		**15**	**1**	**10**	**21**	**26**				-

II SEMESTER

Code No.	Course	L	T	P	C	Hours/ Week	Maximum Marks			Category
							CA	ES	Total	
22MA201	ENGINEERING MATHEMATICS II	3	1	0	4	4	40	60	100	BS
22PH202	ELECTROMAGNETISM AND MODERN PHYSICS	2	0	2	3	4	50	50	100	BS
22CH203	ENGINEERING CHEMISTRY II	2	0	2	3	4	50	50	100	BS
22GE002	COMPUTATIONAL PROBLEM SOLVING	3	0	0	3	3	40	60	100	ES
22GE004	BASICS OF ELECTRONICS ENGINEERING	2	0	2	3	4	50	50	100	ES
22GE005	ENGINEERING DRAWING	1	0	2	2	3	50	50	100	ES
	LANGUAGE ELECTIVE	1	0	2	2	3	50	50	100	HSS
22HS006	தமிழரும் தொழில்நுட்பமும் TAMILS AND TECHNOLOGY^*	1	0	0	1	1	40	60	100	HSS
22HS009	COCURRICULAR OR EXTRACURRICULAR ACTIVITY*	-	-	-	NC	-	100	-	100	HSS
Total		**15**	**1**	**12**	**21**	**28**				-

* Applicable for the students admitted during academic year 2024-2025. The lateral entry students have to complete these courses during III and IV semesters.
# Students admitted during academic year 2022-2023 studied this course in semester II.
^ Students admitted during academic year 2022-2023 studied this course in semester III.
$ Applicable only for the students admitted during academic year 2022-2023.

III SEMESTER

Code No.	Course	L	T	P	C	Hours/ Week	Maximum Marks			Category
							CA	ES	Total	
22BT301	FOURIER SERIES, TRANSFORMS AND BIOSTATISTICS	3	1	0	4	4	40	60	100	BS
22BT302	BIOCHEMISTRY	3	0	2	4	5	50	50	100	ES
22BT303	ENGINEERING THERMODYNAMICS	3	1	0	4	4	40	60	100	PC
22BT304	MICROBIOLOGY	3	0	2	4	5	50	50	100	PC
22BT305	PROCESS CALCULATIONS AND UNIT OPERATIONS	3	1	0	4	4	40	60	100	BS
22HS004	HUMAN VALUES AND ETHICS	2	0	0	2	2	40	60	100	HSS
22HS005	SOFT SKILLS AND EFFECTIVE COMMUNICATION	0	0	2	1	2	60	40	100	EEC
Total		**17**	**3**	**6**	**23**	**26**				-

IV SEMESTER

Code No.	Course	L	T	P	C	Hours/ Week	Maximum Marks			Category
							CA	ES	Total	
22BT401	BIOORGANIC CHEMISTRY	3	0	2	4	5	50	50	100	ES
22BT402	HEAT AND MASS TRANSFER	3	0	2	4	5	50	50	100	ES
22BT403	CELL AND MOLECULAR BIOLOGY	3	0	2	4	5	50	50	100	PC
22BT404	INSTRUMENTAL METHODS OF ANALYSIS	3	0	2	4	5	50	50	100	PC
22BT405	PLANT TISSUE CULTURE	2	0	2	3	4	50	50	100	PC
	PROFESSIONAL ELECTIVE I	3	0	0	3	3	40	60	100	PE
22HS007	ENVIRONMENTAL SCIENCE	2	0	0	-	2	100	0	100	HSS
22HS008	ADVANCED ENGLISH AND TECHNICAL EXPRESSION	0	0	2	1	2	60	40	100	EEC
22HS010	SOCIALLY RELEVANT PROJECT*	0	0	2	-	2	100	-	100	HSS
Total		**19**	**0**	**14**	**23**	**33**				-

* Applicable for the students admitted during academic year 2024-2025.

V SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
22BT501	GENETIC ENGINEERING	3	0	2	4	5	50	50	100	PC
22BT502	BIOPROCESS ENGINEERING	3	0	2	4	5	50	50	100	PC
22BT503	ANIMAL TISSUE CULTURE	3	0	2	4	5	50	50	100	PC
22BT504	BIOINFORMATICS	3	0	2	4	5	50	50	100	PC
	PROFESSIONAL ELECTIVE II	3	0	0	3	3	40	60	100	PE
	OPEN ELECTIVE	3	0	0	3	3	40	60	100	PE
22BT507	MINI PROJECT I	0	0	2	1	2	60	40	100	EEC
Total		**18**	**0**	**10**	**23**	**28**				-

VI SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
22BT601	DOWNSTREAM PROCESSING	3	0	2	4	5	50	50	100	PC
22BT602	IMMUNOLOGY	3	0	2	4	5	50	50	100	PC
22BT603	ENZYME AND PROTEIN ENGINEERING	3	0	2	4	5	50	50	100	PC
	PROFESSIONAL ELECTIVE III	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE IV	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE V	3	0	0	3	3	40	60	100	PE
22BT607	MINI PROJECT II	0	0	2	1	2	60	40	100	EEC
Total		**18**	**0**	**8**	**22**	**26**				-

VII SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
22BT701	GENOMICS AND PROTEOMICS*	3	0	2	4	5	50	50	100	PC
22BT702	BIOPHARMACEUTICAL TECHNOLOGY	3	0	2	4	5	50	50	100	PC
	PROFESSIONAL ELECTIVE VI	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE VII	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE VIII	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE IX	3	0	0	3	3	40	60	100	PE
22BT707	PROJECT WORK I	0	0	4	2	4	50	50	100	EEC
Total		**18**	**0**	**8**	**22**	**26**				**-**

VIII SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
22BT801	PROJECT WORK II	0	0	20	10	20	50	50	100	EEC
Total					**10**	**20**				**-**

* LTPC for this course is 2 0 2 3 for the students admitted during academic year 2022-2023.

ELECTIVES										
LANGUAGE ELECTIVES										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
22HS201	COMMUNICATIVE ENGLISH II	1	0	2	2	3	100	0	100	HSS
22HSH01	HINDI	1	0	2	2	3	100	0	100	HSS
22HSG01	GERMAN	1	0	2	2	3	100	0	100	HSS
22HSJ01	JAPANESE	1	0	2	2	3	100	0	100	HSS
22HSC01	CHINESE	1	0	2	2	3	100	0	100	HSS
22HSF01	FRENCH	1	0	2	2	3	100	0	100	HSS
PROFESSIONAL ELECTIVES										
VERTICAL 1 - BIOPROCESS ENGINEERING										
22BT001	FERMENTATION TECHNOLOGY	3	0	0	3	3	40	60	100	PE
22BT002	INDUSTRIAL MICROBIOLOGY	3	0	0	3	3	40	60	100	PE
22BT003	ENVIRONMENTAL BIOTECHNOLOGY	3	0	0	3	3	40	60	100	PE
22BT004	BIOENERGY AND BIOFUELS	3	0	0	3	3	40	60	100	PE
22BT005	BIOREACTOR DESIGN, MODELING AND SIMULATION	3	0	0	3	3	40	60	100	PE
22BT006	BIOPROCESS CONTROL AND INSTRUMENTATION	3	0	0	3	3	40	60	100	PE
22BT007	TRANSPORT PHENOMENON IN BIOLOGICAL SYSTEMS	3	0	0	3	3	40	60	100	PE
VERTICAL 2 – APPLIED BIOTECHNOLOGY										
22BT008	ASTROBIOLOGY AND ASTROCHEMISTRY	3	0	0	3	3	40	60	100	PE
22BT009	BIOPROSPECTING AND QUALITY ANALYSIS	3	0	0	3	3	40	60	100	PE
22BT010	FOOD PROCESS AND TECHNOLOGY	3	0	0	3	3	40	60	100	PE
22BT011	MARINE BIOTECHNOLOGY	3	0	0	3	3	40	60	100	PE
22BT012	BIODIVERSITY AND AGROFORESTRY	3	0	0	3	3	40	60	100	PE
22BT013	BIOSENSORS	3	0	0	3	3	40	60	100	PE
22BT014	BIOMATERIALS	3	0	0	3	3	40	60	100	PE

VERTICAL 3 - COMPUTATIONAL BIOTECHNOLOGY										
22BT015	PROGRAMS FOR BIOINFORMATICS	3	0	0	3	3	40	60	100	PE
22BT016	FUNDAMENTALS OF ALGORITHMS FOR BIOINFORMATICS	3	0	0	3	3	40	60	100	PE
22BT017	MOLECULAR MODELING	3	0	0	3	3	40	60	100	PE
22BT018	COMPUTER AIDED DRUG DESIGN	3	0	0	3	3	40	60	100	PE
22BT019	METABOLOMICS AND GENOMICS-BIG DATA ANALYTICS	3	0	0	3	3	40	60	100	PE
22BT020	DATA MINING AND MACHINE LEARNING TECHNIQUES FOR INFORMATICS	3	0	0	3	3	40	60	100	PE
22BT021	SYSTEMS AND SYNTHETIC BIOLOGY	3	0	0	3	3	40	60	100	PE
VERTICAL 4 - AGRO BIOTECHNOLOGY										
22BT022	PLANT TISSUE CULTURE AND TRANSFORMATION TECHNIQUE	3	0	0	3	3	40	60	100	PE
22BT023	TRANSGENIC TECHNOLOGY IN AGRICULTURE	3	0	0	3	3	40	60	100	PE
22BT024	BIOFERTILIZERS AND BIOPESTICIDES PRODUCTION	3	0	0	3	3	40	60	100	PE
22BT025	MUSHROOM CULTIVATION AND VERMICOMPOSTING	3	0	0	3	3	40	60	100	PE
22BT026	FUNGAL AND ALGAL TECHNOLOGY	3	0	0	3	3	40	60	100	PE
22BT027	PHYTOTHERAPEUTICS	3	0	0	3	3	40	60	100	PE
VERTICAL 5 - ANIMAL BIOTECHNOLOGY										
22BT028	ANIMAL PHYSIOLOGY AND METABOLISM	3	0	0	3	3	40	60	100	PE
22BT029	ANIMAL HEALTH AND NUTRITION	3	0	0	3	3	40	60	100	PE
22BT030	ANIMAL CELL CULTURE TECHNIQUES	3	0	0	3	3	40	60	100	PE
22BT031	BIOTECHNIQUES IN ANIMAL BREEDING	3	0	0	3	3	40	60	100	PE
22BT032	FUNDAMENTALS OF ANIMAL TRANSGENICS	3	0	0	3	3	40	60	100	PE
22BT033	STEM CELL TECHNOLOGY	3	0	0	3	3	40	60	100	PE
22BT034	TISSUE ENGINEERING	3	0	0	3	3	40	60	100	PE
VERTICAL 6 - MEDICAL BIOTECHNOLOGY										
22BT035	BASIC PRODUCTION ON MEDICAL BIOTECHNOLOGY	3	0	0	3	3	40	60	100	PE
22BT036	MOLECULAR THERAPEUTICS AND DIAGNOSTICS	3	0	0	3	3	40	60	100	PE

22BT037	BIONANOTECHNIQUES	3	0	0	3	3	40	60	100	PE
22BT038	CANCER AND NEURO BIOLOGY	3	0	0	3	3	40	60	100	PE
22BT039	HUMAN GENETICS	3	0	0	3	3	40	60	100	PE
22BT040	VACCINE TECHNOLOGY	3	0	0	3	3	40	60	100	PE
22BT041	BIOPHARMACEUTICS AND ITS BIOSIMILARS	3	0	0	3	3	40	60	100	PE
VERTICAL 7 - QUALITY AND REGULATORY AFFAIRS										
22BT042	CLINICAL TRIALS AND HEALTHCARE POLICIES IN BIOTECHNOLOGY	3	0	0	3	3	40	60	100	PE
22BT043	BIOTECH PRODUCTS AND ITS VALIDATION	3	0	0	3	3	40	60	100	PE
22BT044	QA AND QC IN BIOTECHNOLOGY	3	0	0	3	3	40	60	100	PE
22BT045	PATENT DESIGN, IPR IN BIOTECHNOLOGY AND BIOENTREPRENEURSHIP	3	0	0	3	3	40	60	100	PE
22BT046	BIOSAFETY AND HAZARD MANAGEMENT	3	0	0	3	3	40	60	100	PE
22BT047	GOOD MANUFACTURING PRACTICES	3	0	0	3	3	40	60	100	PE

HONOURS VERTICAL COURSES - ANIMAL BIOTECHNOLOGY*										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours /Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
22BTH28	ANIMAL PHYSIOLOGY AND METABOLISM	3	0	0	3	3	40	60	100	PE
22BTH29	ANIMAL HEALTH AND NUTRITION	3	0	0	3	3	40	60	100	PE
22BTH30	ANIMAL CELL CULTURE TECHNIQUES	3	0	0	3	3	40	60	100	PE
22BTH31	BIOTECHNIQUES IN ANIMAL BREEDING	3	0	0	3	3	40	60	100	PE
22BTH32	FUNDAMENTALS OF ANIMAL TRANSGENICS	3	0	0	3	3	40	60	100	PE
22BTH33	STEM CELL TECHNOLOGY	3	0	0	3	3	40	60	100	PE
22BTH34	TISSUE ENGINEERING	3	0	0	3	3	40	60	100	PE

MINOR VERTICAL COURSES - AGRO BIOTECHNOLOGY*										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours /Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
22BTM22	PLANT TISSUE CULTURE AND TRANSFORMATION TECHNIQUE	3	0	0	3	3	40	60	100	PE
22BTM23	TRANSGENIC TECHNOLOGY IN AGRICULTURE	3	0	0	3	3	40	60	100	PE
22BTM24	BIOFERTILIZERS AND BIOPESTICIDES PRODUCTION	3	0	0	3	3	40	60	100	PE
22BTM25	MUSHROOM CULTIVATION AND VERMICOMPOSTING	3	0	0	3	3	40	60	100	PE
22BTM26	FUNGAL AND ALGAL TECHNOLOGY	3	0	0	3	3	40	60	100	PE
22BTM27	PHYTOTHERAPEUTICS	3	0	0	3	3	40	60	100	PE

* Honor and Minor vertical courses offered for the students admitted during academic year 2022-2023 and 2023-2024.

ONE CREDIT COURSES										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours /Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
22BT0XA	DRUG DESIGN AND COMPUTATIONAL METHODS	1	0	0	1	1	50	50	100	EEC
22BT0XB	BIOANALYTICAL TECHNIQUES FOR PHARMACEUTICAL PRODUCTS	1	0	0	1	1	50	50	100	EEC
22BT0XC	MACHINE LEARNING FOR BIOLOGICAL DATA ANALYSIS	1	0	0	1	1	50	50	100	EEC
22BT0XD	BIOSTIMULANTS FOR ENHANCED CROP PRODUCTION	1	0	0	1	1	50	50	100	EEC
22BT0XE	MICROPROPOGATION FOR VIRAL FREE PLANT PRODUCTION	1	0	0	1	1	50	50	100	EEC
22BT0XF	CLINICAL RESEARCH AND DATA MANAGEMENT	1	0	0	1	1	50	50	100	EEC
22BT0XG	ADVANCED PHARMACEUTICAL FORMULATION: NANOTECHNOLOGY AND PERSONALIZED MEDICINE	1	0	0	1	1	50	50	100	EEC
22BT0XH	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN DRUG DISCOVERY	1	0	0	1	1	50	50	100	EEC
22BT0XI	CULTURED MEAT AND ALTERNATIVE PROTEIN PRODUCTION	1	0	0	1	1	50	50	100	EEC
22BT0XJ	PHYTOTHERAPEUTICS IN MODERN MEDICINE	1	0	0	1	1	50	50	100	EEC
22BT0XK	GENOME EDITING TECHNOLOGIES	1	0	0	1	1	50	50	100	EEC
22BT0XL	3D BIOPRINTING	1	0	0	1	1	50	50	100	EEC
22BT0XM	ANALYSIS OF GENOMIC AND PROTEIN CLONES	1	0	0	1	1	50	50	100	EEC

OPEN ELECTIVES (Offered for Biotechnology Students)										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours /Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
22OCE01	ENERGY CONSERVATION AND MANAGEMENT	3	0	0	3	3	40	60	100	PE
22OCS01	OBJECT ORIENTED PROGRAMMING	3	0	0	3	3	40	60	100	PE
22OCS02	JAVA FUNDAMENTALS	3	0	0	3	3	40	60	100	PE
22OCS03	KNOWLEDGE DISCOVERY IN DATABASES	3	0	0	3	3	40	60	100	PE
22OCS04	E-LEARNING TECHNIQUES	3	0	0	3	3	40	60	100	PE
22OCS05	SOCIAL TEXT AND MEDIA ANALYTICS	3	0	0	3	3	40	60	100	PE
22OEC01	BASICS OF ANALOG AND DIGITAL ELECTRONICS	3	0	0	3	3	40	60	100	PE
22OEC02	MICROCONTROLLER PROGRAMMING	3	0	0	3	3	40	60	100	PE
22OEC03	PRINCIPLES OF COMMUNICATION SYSTEMS	3	0	0	3	3	40	60	100	PE
22OEC04	PRINCIPLES OF COMPUTER COMMUNICATION AND NETWORKS	3	0	0	3	3	40	60	100	PE
22OEI01	PROGRAMMABLE LOGIC CONTROLLER	3	0	0	3	3	40	60	100	PE
22OEI02	SENSOR TECHNOLOGY	3	0	0	3	3	40	60	100	PE
22OEI03	FUNDAMENTALS OF VIRTUAL INSTRUMENTATION	3	0	0	3	3	40	60	100	PE
22OEI04	OPTOELECTRONICS AND LASER INSTRUMENTATION	3	0	0	3	3	40	60	100	PE
22OME01	DIGITAL MANUFACTURING	3	0	0	3	3	40	60	100	PE
22OME02	INDUSTRIAL PROCESS ENGINEERING	3	0	0	3	3	40	60	100	PE
22OME03	MAINTENANCE ENGINEERING	3	0	0	3	3	40	60	100	PE
22OME04	SAFETY ENGINEERING	3	0	0	3	3	40	60	100	PE
22OFD01	TRADITIONAL FOODS	3	0	0	3	3	40	60	100	PE
22OFD02	FOOD LAWS AND REGULATIONS	3	0	0	3	3	40	60	100	PE
22OFD03	POST HARVEST TECHNOLOGY OF FRUITS AND VEGETABLES	3	0	0	3	3	40	60	100	PE

22OFD04	CEREAL, PULSES AND OIL SEED TECHNOLOGY	3	0	0	3	3	40	60	100	PE
22OFT01	FASHION CRAFTSMANSHIP	3	0	0	3	3	40	60	100	PE
22OFT02	INTERIOR DESIGN IN FASHION	3	0	0	3	3	40	60	100	PE
22OFT03	SURFACE ORNAMENTATION	3	0	0	3	3	40	60	100	PE
22OPH01	NANOMATERIALS SCIENCE	3	0	0	3	3	40	60	100	PE
22OPH02	SEMICONDUCTOR PHYSICS AND DEVICES	3	0	0	3	3	40	60	100	PE
22OPH03	APPLIED LASER SCIENCE	3	0	0	3	3	40	60	100	PE
22OPH04	BIO-PHOTONICS	3	0	0	3	3	40	60	100	PE
22OPH05	PHYSICS OF SOFT MATTER	3	0	0	3	3	40	60	100	PE
22OCH01	CORROSION SCIENCE AND ENGINEERING	3	0	0	3	3	40	60	100	PE
22OCH02	POLYMER SCIENCE	3	0	0	3	3	40	60	100	PE
22OCH03	ENERGY STORING DEVICES	3	0	0	3	3	40	60	100	PE
22OMA01	GRAPH THEORY AND COMBINATORICS	3	0	0	3	3	40	60	100	PE
22OGE01	PRINCIPLES OF MANAGEMENT	3	0	0	3	3	40	60	100	PE
22OGE02	ENTREPRENEURSHIP DEVELOPMENT I	3	0	0	3	3	40	60	100	PE
22OGE03	ENTREPRENEURSHIP DEVELOPMENT II	3	0	0	3	3	40	60	100	PE
22OGE04	NATION BUILDING, LEADERSHIP AND SOCIAL RESPONSIBILITY	3	0	0	3	3	40	60	100	PE
22OAI01	FUNDAMENTALS OF DATA SCIENCE	3	0	0	3	3	40	60	100	PE
22OAM01	COMPUTER VISION IN HEALTHCARE APPLICATION	3	0	0	3	3	40	60	100	PE
22OAM02	NEURAL NETWORKS	3	0	0	3	3	40	60	100	PE
22OBM01	OCCUPATIONAL SAFETY AND HEALTH IN PUBLIC HEALTH EMERGENCIES	3	0	0	3	3	40	60	100	PE
22OBM02	AMBULANCE AND EMERGENCY MEDICAL SERVICE MANAGEMENT	3	0	0	3	3	40	60	100	PE
22OBM03	HOSPITAL AUTOMATION	3	0	0	3	3	40	60	100	PE
22OIT01	DATA STRUCTURES	3	0	0	3	3	40	60	100	PE
22OIT02	C++ PROGRAMMING	3	0	0	3	3	40	60	100	PE
22OIT03	PROGRAMMING IN JAVA	3	0	0	3	3	40	60	100	PE

22OAG01	RAIN WATER HARVESTING TECHNIQUES	3	0	0	3	3	40	60	100	PE
22OEE01	VALUE ENGINEERING	3	0	0	3	3	40	60	100	PE
22OEE02	ELECTRICAL SAFETY	3	0	0	3	3	40	60	100	PE
22OIT04	FUNDAMENTALS OF DATABASE MANAGEMENT SYSTEMS	3	0	0	3	3	40	60	100	PE
22OCB01	INTERNATIONAL BUSINESS MANAGEMENT	3	0	0	3	3	40	60	100	PE

OPEN ELECTIVES (Offered for other department students)

Code No.	Course	L	T	P	C	Hours /Week	Maximum Marks			Category
							CA	ES	Total	
22OBT01	BIOFUELS	3	0	0	3	3	40	60	100	PE

SUMMARY OF CREDIT DISTRIBUTION

S. No	CATEGORY	CREDITS PER SEMESTER								TOTAL CREDIT	CREDITS in %	Range of Total Credits	
		I	II	III	IV	V	VI	VII	VIII			Min	Max
1	**BS**	10	10	8	-	-	-	-	-	28	17%	15%	20%
2	**ES**	6	8	4	8	-	-	-	-	26	16%	15%	20%
3	**HSS**	3	3	2	-	-	-	-	-	8	5%	5%	10%
4	**PC**	-	-	8	11	16	12	8	-	55	33%	30%	40%
5	**PE**	-	-	-	3	6	9	12	-	30	18%	10%	15%
6	**EEC**	2	-	1	1	1	1	2	10	19	11%	7%	10%
Total		21	21	23	23	23	22	22	10	**165**	100%	-	-

BS	-	Basic Sciences
ES	-	Engineering Sciences
HSS	-	Humanities and Social Sciences
PC	-	Professional Core
PE	-	Professional Elective
EEC	-	Employability Enhancement Course
CA	-	Continuous Assessment
ES	-	End Semester Examination

22MA101 **ENGINEERING MATHEMATICS I** **3 1 0 4**

Course Objectives

- To impart mathematical modeling to describe and explore real-world phenomena and data.
- To provide basic understanding on Linear, quadratic, power and polynomial, exponential, and multi variable models.
- Summarize and apply the methodologies involved in framing the real world problems related to fundamental principles of polynomial equations.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Course Outcomes (COs)

1. Implement the concepts of mathematical modeling based on linear functions in Engineering.
2. Formulate the real world problems as a quadratic function model.
3. Demonstrate the real-world phenomena and data into Power and Polynomial functions.
4. Apply the concept of mathematical modeling of exponential functions in Engineering.
5. Develop the identification of multivariable functions in the physical dynamical problems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
3	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
5	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I **9 Hours**

MATHEMATICAL MODELING OF LINEAR FUNCTIONS

The geometry of linear equations - Formation of linear equations: Method of least squares and method of regression - Vector spaces: Basic concepts with examples - Linear combination - Eigen values and vectors.

UNIT II **9 Hours**

MATHEMATICAL MODELING OF QUADRATIC FUNCTIONS

General form of a quadratic function - Basic relationships between the equation and graph of quadratic function - Sum of squares error- - and the quadratic function of best-fit Quadratic forms: Matrix form - Orthogonality - Canonical form and its nature.

UNIT III **9 Hours**

MATHEMATICAL MODELING OF POWER AND POLYNOMIAL FUNCTIONS

Characteristics of the graphs of power and polynomial functions - Fitting of power and polynomial functions using the method of least squares - Local maxima and local minima of power and polynomial functions - Power series of functions with real variables, Taylors series, radius and interval of convergence - Tests of convergence for series of positive terms - comparison test, ratio test.

UNIT IV **9 Hours**

MATHEMATICAL MODELING OF EXPONENTIAL FUNCTIONS

Concept of exponential growth - Graphs of exponential functions - Relationship between the growth factor and exponential growth or decline - Exponential equations have a variable as an exponent and take the form $y = ab^x$ through least square approximation - Calculus of exponential functions - Exponential series – Characteristics.

UNIT V **9 Hours**

MATHEMATICAL MODELING OF MULTIVARIABLE FUNCTIONS

Graphing of functions of two variables –Partial derivatives - Total derivatives – Jacobians - Optimization of multivariable functions with constraints - Optimization of multivariable functions without constraints.

Tutorial: 15 Hours
Lecture: 45 Hours
Total: 60 Hours

References(s)

1. Erwin Kreyszig8, Advanced Engineering Mathematics, Tenth Edition, Wiley India Private Limited, New Delhi 2016.
2. B. S. Grewal, Numerical Methods in Engineering & Science: With Programs in C, C++&MATLAB, Khanna, 2014
3. S.C. Gupta, V.K. Kapoor, Fundamentals of Mathematical Statistics ,Sultan Chand & Sons2020
4. Thomas and Finney, Calculus and analytic Geometry, Fourteenth Edition, By Pearson Paperback, 2018

22PH102 **ENGINEERING PHYSICS** **2 0 2 3**

Course Objectives

- Understand the concept and principle of energy possessed by mechanical system
- Exemplify the propagation and exchange of energy
- Identify the properties of materials based on the energy possession

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research–based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life–long learning in the broadest context of technological change.

Course Outcomes (COs)

1. Apply the work-energy theorem to analyze and optimize mechanical system performance
2. Analyze free and forced mechanical oscillations in vibrational energy systems
3. Analyze the propagation of energy in mechanical systems through transverse and longitudinal waves
4. Analyze the exchange of energy and work between the systems using thermodynamic principles
5. Apply the concept of energy and entropy to understand the mechanical properties of materials

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	1	1	-	-	-	-	2	-	-	1	-	-
2	3	2	1	2	-	-	-	-	2	-	-	1	-	-
3	3	2	2	1	-	-	-	-	2	-	-	1	-	-
4	3	2	2	1	-	-	-	-	2	-	-	1	-	-
5	3	2	2	1	-	-	-	-	2	-	-	1	-	-

UNIT I **6 Hours**

CONSERVATION OF ENERGY

Concept of energy - types of energy - conservation of energy Mechanical energy: - translation - rotation - vibration - Kinetic and potential energies - conservation - work and energy - laws of motion - minimization of potential energy - equilibrium - dissipative systems - friction

UNIT II **5 Hours**

VIBRATIONAL ENERGY

Periodic Motion - Simple Harmonic Motion - Energy of the SHM - Pendulum types - Damped oscillations - forced oscillations - natural frequency - resonance

UNIT III **6 Hours**

PROPAGATION OF ENERGY

Transfer of energy - material medium - Transverse wave - Longitudinal wave - standing wave - interference - Doppler effect. Sound waves and its types - characteristics - human voice - reflection - refraction - beats

UNIT IV **7 Hours**

EXCHANGE OF ENERGY

Energy in transit - heat - Temperature - measurement - specific heat capacity and water - thermal expansion - Heat transfer processes. Thermodynamics: Thermodynamic systems and processes - Laws of thermodynamics - Entropy - entropy on a microscopic scale - maximization of entropy

UNIT V **6 Hours**

ENERGY IN MATERIALS

Elastic energy - Structure and bonding - Stress - strain - Tension and compression - elastic limit - Elastic Modulus - Stress - strain diagram - ductility - brittleness - rubber elasticity and entropy

EXPERIMENT 1 **5 Hours**

Assess the physical parameters of different materials for engineering applications like radius, thickness and diameter to design the electrical wires, bridges and clothes

EXPERIMENT 2 **5 Hours**

Evaluate the elastic nature of different solid materials for modern industrial applications like shock absorbers of vehicles

EXPERIMENT 3 **5 Hours**

Analyze the photonic behavior of thin materials for advanced optoelectronic applications like adjusting a patients head, chest and neck positions as a medical tool

EXPERIMENT 4 **5 Hours**

Investigate the phonon behavior of poor conductors for thermionic applications like polymer materials and textile materials

EXPERIMENT 5 **5 Hours**

Assess the elongation of different solid materials for industrial applications like buildings, bridges and vehicles

EXPERIMENT 6 **5 Hours**

Measure the compressibility of different liquids for modern industrial applications like navigation, medicine and imaging

Lecture: 30 Hours
Practical: 30 Hours
Total: 60 Hours

Reference(s)

1. C J Fischer, The energy of Physics Part I: Classical Mechanics and Thermodynamics, Cognella Academic Publishing, 2019
2. P G Hewitt, Conceptual Physics, Pearson education, 2017
3. R A Serway and J W Jewitt, Physics for Scientists and Engineers, Thomson Brooks/Cole, 2019
4. J Walker, D Halliday and R Resnick, Principles of Physics, John Wiley and Sons, Inc, 2018
5. H C Verma, Concepts of Physics (Vol I & II), Bharathi Bhawan Publishers & Distributors, New Delhi, 2017

22CH103 **ENGINEERING CHEMISTRY I** **2 0 2 3**

Course Objectives

- Understand the origin of elements from the universe
- Outline the properties of elements in the periodic table
- Analyse the different types of bond formed during chemical reactions and its reaction thermodynamics
- Summarize different states of matter based on atomic arrangement

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

Course Outcomes (COs)

1. Understand nuclear transmutation reactions that lead to the formation of elements in the universe
2. Illustrate atomic structure of elements in the periodic table and interpret the periodic trends in properties of elements with its anomaly
3. Apply the conditions for the formation of different types of chemical bonds and predict the minimum energy required for a reaction to occur
4. Analyse endothermic and exothermic processes and exchange of energy during chemical reactions
5. Analyse whether the given matter is a solid, liquid, gas, or plasma and interpret the arrangement of atoms

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
3	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
4	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
5	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I **6 Hours**

ORIGIN OF ELEMENTS

Hydrogen - Elements and Sun - fusion - hypernova - supernova - dying stars - man-made elements.

UNIT II **6 Hours**

ATOMIC STRUCTURE AND PERIODICITY

Atomic Structure - Electronic configuration - Periodic Table - Periodic trends in properties of elements - Anomalous behavior in periodicity.

UNIT III **6 Hours**

CHEMICAL BONDING

Octet rule & its limitations - types of chemical bonds - bond energy - bond cleavage - activation energy of reactions.

UNIT IV **6 Hours**

REACTION THERMODYNAMICS

Conservation of energy - Endothermic reactions & exothermic reactions - Exchange of energy involved in chemical reactions

UNIT V **6 Hours**

STATES OF MATTER

Solid - liquid - gas - plasma - quantum dots - arrangement of atoms/ions/molecules in different phases

EXPERIMENT 1 **5 Hours**

Evaluate the dissolved oxygen (DO) levels in effluent samples collected from sewage treatment plant in BIT. Ensure the suitability of outlet water for the growth of aquatic animals (fishes).

EXPERIMENT 2 **5 Hours**

Investigate the amount of Iron (Fe^{2+}) in a mild steel alloy sample using a spectrophotometer.

EXPERIMENT 3 **4 Hours**

Estimate the amount of chromium present in industry effluent samples and bottled beverages.

EXPERIMENT 4 **5 Hours**

Ensure the suitability of drinking water in the RO water supply in BIT based on the presence of chloride ions.

EXPERIMENT 5 **3 Hours**

Assess the acidic nature of effluent water from industries using the conductometric titration method.

EXPERIMENT 6 **4 Hours**

Measure the stain removal efficiency of the prepared soaps from stained clothes.

EXPERIMENT 7 **4 Hours**

Assess the purity of commercially available active pharmaceutical ingredients (aspirin) as per the government-prescribed standards.

Practical: 30 Hours
Lecture: 30 Hours
Total: 60 Hours

Reference(s)

1. Rose Marie Gallagher and Author Paul Ingram, Complete Chemistry Cambridge IGCSE, 2nd Edition, Oxford university press, 2020.
2. Peter Atkins, Julio D Paula and James Keeler, Atkins’ Physical Chemistry, 12th Edition, Oxford university press, 2019.
3. Gareth Price, Thermodynamics of chemical processes, 2nd Edition, Oxford university press, 2019.
4. D Tabor, Gases, liquids and solids and other states of matter, 3rd Edition, Oxford University press, 2018.
5. P L Soni, Text book of inorganic chemistry, Chand publishers, New Delhi, 2017.
6. J.D. Lee, Concise inorganic chemistry, 5th edition (Reprint), Blackman Science Ltd, France, Wiley-India, 2016.

22GE001 FUNDAMENTALS OF COMPUTING 3 0 0 3

Course Objectives

- To understand the fundamental digital logics behind computations of computer systems.
- To develop simple assembly language programs with respect to arithmetic operations.
- To understand the program execution process and basics of software development methodologies.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

Course Outcomes (COs)

1. Apply the hidden languages and inner structures of computer hardware and software through codes and combinations.
2. Apply the organizational and architectural issues of a digital computer with concepts of various data transfer techniques in digital computers and the I/O interfaces.
3. Analyze programming problems and apply assembly instructions to solve simple problems.
4. Evaluate the fundamentals of operating system and System programs basics.
5. Create the software development methodologies to various real life scenarios.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	1	1	1	-	-	-	-	-	-	-	-	-	-	-
2	3	3	3	1	-	-	-	-	-	-	-	-	-	-	-
3	2	2	2	1	-	-	-	-	-	-	-	-	-	-	-
4	2	2	2	1	-	-	-	-	-	-	-	-	-	-	-
5	2	2	2	1	-	-	-	-	-	-	-	-	-	-	-

UNIT I 8 Hours

CODES AND COMBINATIONS

Communication using Mores and Braille binary codes - Digitizing letters, numbers and objects using binary codes - Performing simple operations: addition through binary codes.

UNIT II 9 Hours

COMPUTATION USING COMPUTER

Communication to computing devices through various input sources - Computational operation - itsflow, functions and control - communication to output devices - Basic communication protocol

UNIT III **11 Hours**

ASSEMBLY LANGUAGE PROGRAMMING

Little Man Computing (LMC) Model - Instruction Set - Labels - Calculation -Branching - Input- Output- Loops - Simple programs.

UNIT IV **9 Hours**

OPERATING SYSTEM AND APPLICATION GENERATION

BIOS - Device Drivers - Resources - Scheduler - Applications Generation and Creation - Stages of Compilation - Linkers, Loaders and Libraries.

UNIT V **8 Hours**

SOFTWARE DEVELOPMENT

Phases of application life cycle management -Software Development Methodologies -Web Page development.

Total: 45 Hours

Reference(s)

1. Charles Petzold, "Code: The Hidden Language of Computer Hardware and Software", Microsoft Pressbooks, 2009.
2. David D. Riley, Kennya. Hunt, "Computational thinking for the modern problem Solver", CRC Press Taylor & Francis Group, 20PSO 2
3. Andrew Eliaz, "Little Man Computer Programming: For the Perplexed from the Ground Up", The Internet Technical Bookshop; 1st edition, 2016.
4. Abraham Silberschatz, "Peter Baer Galvin and Greg Gagne, Operating System Concepts", 9th Edition,John Wiley & Sons Pvt. Ltd, 20PSO 3
5. Roger S.Pressman, "Software Engineering: A Practitioner"s Approach", McGraw Hill International edition, Seventh edition, 2010

22HS001 **FOUNDATIONAL ENGLISH** **1 0 2 2**

Course Objectives

- Heighten awareness of grammar in oral and written expression
- Improve speaking potential in formal and informal contexts
- Improve reading fluency and increased vocabulary
- Prowess in interpreting complex texts
- Fluency and comprehensibility in self-expression
- Develop abilities as critical readers and writers
- Improve ability to summarize information from longer text, and distinguish between primaryand supporting ideas.

Programme Outcomes (POs)

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outcomes (COs)

1. Express themselves in a professional manner using error-free language.
2. Express in both descriptive and narrative formats.
3. Interpret and make effective use of the English Language in Business contexts.
4. Actively read and comprehend authentic text.
5. Express opinions and communicate experiences.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	-	-	-	2	3	-	2	-	-	-
2	-	-	-	-	-	-	-	-	2	3	-	2	-	-	-
3	-	-	-	-	-	-	-	-	2	3	-	2	-	-	-
4	-	-	-	-	-	-	-	-	2	3	-	2	-	-	-
5	-	-	-	-	-	-	-	-	2	3	-	2	-	-	-

UNIT I **15 Hours**

SELF-EXPRESSION

Self-Introduction-Recreating Interview Scenarios (with a focus on verbal communication)-Subject Verb Concord - Tenses - Common Errors in verbal communication Be-verbs Self-Introduction- Recreating interview scenarios-Haptics-Gestures-Proxemics-Facial expressions- Paralinguistic / Vocalic- Body Language- Appearance-Eye Contact-Artefacts Self-Introduction-Powerful openings and closings at the interview-Effective stock phrases - Modified for spontaneity and individuality-Question tags, framing questions including WH- questions-Prepositions-Listening to Ted talks-Listening for specific information.

UNIT II **15 Hours**

CREATIVE EXPRESSION

Descriptive Expression-Picture Description and Blog Writing -Vocabulary-One-word substitution- Adjectives-Similes, Metaphors, Imagery & Idioms -Link words - Inclusive language Narrative Expression- Travelogue and Minutes of Meeting -Verbal Analogy-Sequence & Time order words - Jumbled paragraph, sentences, Sequencing-Text & Paragraph Completion-Past tense -Using quotation marks.

UNIT III **15 Hours**

FORMAL EXPRESSION

Formal Letters and Emails-Writing: E-mails and Letters of apology, Requisition and Explanation, and Letters to newspapers-Speaking: Tendering verbal apologies, and explanations, persuading a listener/ audience-Hierarchy in Business correspondence- Subject of a mail, Header, Body (Salutation) and Footer of a mail- Conjunctional clause Punctuation-Formal Idioms-Phrases-Articles - Definite & Indefinite-Types of sentences-Modal verbs Precision in comprehension, Summary writing, Selective summary-Reading: Active reading- short paragraphs, excerpts, articles and editorials-Skimming and Scanning Reading comprehension & analysis- Tenses, QP/ PQ approach. Identifying the central themes/ crux-Interpreting tone - formal/informal/semi-formal-Note-taking-Listening: Listening for data, for specific information, for opinion-Active and passive Listening-Transcription-Paraphrasing and summarizing information-Agreeing & disagreeing-Note-taking-Writing: Summary writing, selective summary, paraphrasing, note-making, opinion pieces-Finding synonyms in the context Paraphrasing-Sentence Transformation - simple, compound, complex. Sentence Substitution-Sentence completion- Interpreting paragraphs.

Total: 45 Hours

Reference(s)

1. Sasikumar, V, et.al. A Course in Listening & Speaking Foundation Books, 2005.
2. Murphy, Raymond. English Grammar in Use: A Self-Study Reference and Practice Book for Intermediate Students: with Answers. Cambridge: Cambridge University Press, 1985.
3. Prasad, Hari Mohan. A Handbook of Spotting Errors. Mcgraw Hill Education, 2010
4. Reynolds, John. Cambridge IGCSEÃ,Â® First Language English. 2018th ed., Hodder Education, 2018.
5. Wiggins, Grant P., and Jay McTighe. Understanding by Design. Association for Supervision and Curriculum Development, 2008.

22GE003 BASICS OF ELECTRICAL ENGINEERING 2 0 2 3

Course Objectives

- To understand the basic concepts of electrical charge and its properties
- To interpret the formation of electric field due to electric charges.
- To illustrate the concept of magnetic fields due to revolving electron.
- To illustrate the force on moving charges in electric and magnetic field.
- To understand the energy transfer in electro mechanical conversion.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

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Course Outcomes (COs)

1. Apply the basic concepts and properties of electric charge.
2. Apply the significance of electric field and electric dipole formation.
3. Analyze the formation of magnetic field and magnetic dipole.
4. Analyze the force on the moving charges.
5. Evaluate the concept of energy conversion principle in electromagnetics.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	-	1	-	-	-	-	-	-	-	-	-	-	-
2	3	2	-	1	-	-	-	-	-	-	-	-	-	-	-
3	1	1	3	-	-	-	-	-	-	-	-	-	-	-	-
4	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I 5 Hours

ELECTRIC CHARGE

Properties of charge – additivity of charges, quantization of charge, conservation of charge - Forces between multiples of charges – Electric charge in conductors- Drift of Electrons– Charges in Clouds.

UNIT II 7 Hours

ELECTRIC FIELD

Electric field due to system of charges – Significance- Electric field line – Electric Dipole and its significance – Continuous charge distribution. Field in infinite long uniform straight conductors – field in uniform charged uniform infinite plane sheet – field due to uniform thin spherical sheet.

UNIT III **7 Hours**

MAGNETIC FIELD

Concept of magnetic field –magnetic fields in infinitely long straight wire, straight and toroidal solenoids. Magnetic dipole moment of a revolving electron - Magnetic field intensity due to a magnetic dipole (bar magnet) along its axis and perpendicular to axis - Induced Electric field due to changing Magnetic Field.

UNIT IV **6 Hours**

FORCE ON CHARGES

Force on a moving charge in uniform magnetic and electric fields- Force on a current-carrying conductor in a uniform magnetic field. Force between two parallel current-carrying conductors.

UNIT V **5 Hours**

ELECTRO – MECHANICAL ENERGY CONVERSION

Energy transfer in electromagnetic fields – Energy storage in magnetic field - Electromagnetic induction - induced emf - Eddy currents. Self and mutual inductance Linear Momentum and Angular Momentum carried by Electromagnetic Fields.

EXPERIMENT 1 **15 Hours**

Analyze and design of Electromechanical energy conversion system.

EXPERIMENT 2 **15 Hours**

Develop an electrical machine and analyze its performance with supplied input of AC from 0 V to 230 V.

Practical: 30 Hours
Lecture: 30 Hours
Total: 60 Hours

Reference(s)

1. Mathew N. O. Sadiku, ‘Principles of Electromagnetics’, 6th Edition, Oxford University,2015
2. William H. Hayt and John A. Buck, ‘Engineering Electromagnetics’, McGraw Hill Special,2020
3. Kraus and Fleish, ‘Electromagnetics with Applications’, McGraw Hill International Editions, Fifth Edition, 2017.
4. S.P.Ghosh, Lipika Datta, ‘Electromagnetic Field Theory’,First Edition,McGraw Hill Education (India) Private Limited, 2012.

22HS002 **STARTUP MANAGEMENT** **1 0 2 2**

Course Objectives

- Promote entrepreneurial spirit and motivate to build startups
- Provide insights on markets and the dynamics of buyer behavior
- Train to develop prototypes and refine them to a viable market offering
- Support in developing marketing strategies and financial outlay
- Enable to scale up the prototypes to commercial market offering

Programme Outcomes (POs)

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

Course Outcomes (COs)

1. Apply the valid and feasible business ideas
2. Analyze Business Model Canvas and formulate positioning statement
3. Analyze prototypes that fulfills an unmet market need
4. Evaluate the business strategies and create pitch decks
5. Create appropriate strategies for commercialization

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	-	1	2	1	-	1	-	-	-	-
2	-	-	-	-	-	-	2	2	1	1	2	-	-	-	-
3	-	-	-	-	-	-	3	3	1	2	2	-	-	-	-
4	-	-	-	-	-	-	1	3	1	2	2	-	-	-	-
5	-	-	-	-	-	-	2	3	2	2	2	-	-	-	-

UNIT I **3 Hours**

BUSINESS MODELS AND IDEATION

Startups: Introduction, Types of Business Modes for Startups. Ideation: Sources of Ideas, Assessing Ideas, Validating Ideas, Tools for validating ideas, Role of Innovation and Design Thinking

UNIT II **3 Hours**

UNDERSTANDING CUSTOMERS

Buyer Decision Process, Buyer Behaviour, Building Buyer Personas, Segmenting, Targeting and Positioning, Value Proposition (Business Model Canvas), Information Sourcing on Markets, Customer Validation.

UNIT III **3 Hours**

DEVELOPING PROTOTYPES

Prototyping: Methods-Paper and Digital, Customer Involvement in Prototyping, Product Design Sprints, Refining Prototypes

UNIT IV **3 Hours**

BUSINESS STRATEGIES AND PITCHING

Design of Marketing Strategies and Campaigns, Go-To-Market Strategy, Financial KPIs Financial Planning and Budgeting, Assessing Funding Alternatives, Pitching, Preparing Pitch Decks

UNIT V **3 Hours**

COMMERCIALIZATION

Implementation: Prototype to Commercialization, Test Markets, Institutional Support, Registration Process, IP Laws and Protection, Legal Requirements, Type of Ownership, Building and Managing Teams, Defining role of investors

EXPERIMENT 1 **1 Hour**

Analysis of various business sectors

EXPERIMENT 2 **2 Hours**

Developing a Design Thinking Output Chart

EXPERIMENT 3 **1 Hour**

Creating Buyer Personas

EXPERIMENT 4 **3 Hours**

Undertake Market Study to understand market needs and assess market potential.

EXPERIMENT 5 **2 Hours**

Preparation of Business Model Canvas

EXPERIMENT 6 **15 Hours**

Developing Prototypes

EXPERIMENT 7 **2 Hours**

Organizing Product Design Sprints

EXPERIMENT 8 **2 Hours**

Preparation of Business Plans

EXPERIMENT 9 **2 Hours**

Preparation of Pitch Decks

Practical: 30 Hours
Lecture: 15 Hours
Total: 45 Hours

References(s)

1. Rashmi Bansal, Connect the Dots, Westland and Tranquebar Press, 2012
2. Pavan Soni, Design Your Thinking: The Mindsets, Toolsets and Skill Sets for Creative Problem-solving, Penguin Random House India, 2020
3. Ronnie Screwvala, Dream with Your Eyes Open: An Entrepreneurial Journey, Rupa Publications,2015
4. Stephen Carter, The Seed Tree: Money Management and Wealth Building Lessons for Teens,Seed Tree Group, 2021
5. Kotler Philip, Marketing Management, Pearson Education India, 15th Edition
6. Elizabeth Verkey and Jithin Saji Isaac, Intellectual Property, Eastern Book Company, 2ndEdition,2021

22HS003 **HERITAGE OF TAMILS** **1 0 0 1**

Course Objectives

- Describe the linguistic diversity in India, highlighting Dravidian languages and their features.
- Summarize the evolution of art, highlighting key transitions from rock art to modern sculptures.
- Examine the role of sports and games in promoting cultural values and community bonding.
- Discuss the education and literacy systems during the Sangam Age and their impact.
- Outline the importance of inscriptions, manuscripts, and the print history of Tamil books in preserving knowledge and culture.

Programme Outcomes (POs)

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Course Outcomes (COs)

1. Understand the concept of language families in India, with a focus on Dravidian languages.
2. Trace the evolution of art from ancient rock art to modern sculptures in Tamil heritage.
3. Identify and differentiate various forms of folk and martial arts in Tamil heritage.
4. Understand the concepts of Flora and Fauna in Tamil culture and literature.
5. Evaluate the contributions of Tamils to the Indian Freedom Struggle.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
2	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
3	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
4	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
5	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-

UNIT I **3 Hours**

LANGUAGE AND LITERATURE

Language Families in India - Dravidian Languages – Tamil as a Classical Language – Classical Literature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam Literature - Management Principles in Thirukural - Tamil Epics and Impact of Buddhism & Jainism in Tamil Land - Bakthi Literature Azhwars and Nayanmars - Forms of minor Poetry - Development of Modern literature in Tamil - Contribution of Bharathiyar and Bharathidhasan.

UNIT II **3 Hours**

HERITAGE - ROCK ART PAINTINGS TO MODERN ART – SCULPTURE

Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts - Art of temple car making - Massive Terracotta sculptures, Village deities, Thiruvalluvar Statue at Kanyakumari, Making of musical instruments - Mridhangam, Parai, Veenai, Yazh and Nadhaswaram - Role of Temples in Social and Economic Life of Tamils.

UNIT III **3 Hours**

FOLK AND MARTIAL ARTS

Therukoothu, Karagattam, Villu Pattu, Kaniyan Koothu, Oyillattam, Leather puppetry, Silambattam, Valari, Tiger dance - Sports and Games of Tamils.

UNIT IV **3 Hours**

THINAI CONCEPT OF TAMILS

Flora and Fauna of Tamils & Aham and Puram Concept from Tholkappiyam and Sangam Literature - Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports of Sangam Age - Export and Import during Sangam Age - Overseas Conquest of Cholas.

UNIT V **3 Hours**

CONTRIBUTION OF TAMILS TO INDIAN NATIONAL MOVEMENT AND INDIAN CULTURE

Contribution of Tamils to Indian Freedom Struggle - The Cultural Influence of Tamils over the other parts of India – Self- Respect Movement - Role of Siddha Medicine in Indigenous Systems of Medicine – Inscriptions & Manuscripts – Print History of Tamil Books.

Total: 15 Hours

Reference(s)

1. Dr.K.K.Pillay , Social Life of Tamils, A joint publication of TNTB & ESC and RMRL.
2. Dr.S.Singaravelu, Social Life of the Tamils - The Classical Period, International Institute of Tamil Studies.
3. Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu, Historical Heritage of the Tamils, International Institute of Tamil Studies.
4. Dr.M.Valarmathi, The Contributions of the Tamils to Indian Culture, International Institute of Tamil Studies.
5. Keeladi, Sangam City Civilization on the banks of river Vaigai, Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu
6. Dr.K.K.Pillay, Studies in the History of India with Special Reference to Tamil Nadu
7. Porunai Civilization, Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu
8. R.Balakrishnan, Journey of Civilization Indus to Vaigai, RMRL

22MA201 ENGINEERING MATHEMATICS II 3 1 0 4

Course Objectives

- To impart and analyze the concepts of differential equations to describe in real-world phenomena.
- To provide basic understanding on differential equation models and vector field models.
- Summarize and apply the methodologies involved in framing the real world problems related to fundamental principles of complex functions.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Course Outcomes (COs)

1. Interpret the concept of differential equations through mathematical modeling and analyze its applications in engineering
2. Formulate the real world problems as second order linear differential equations and give solutions for the same
3. Demonstrate the real-world phenomena with magnitude and direction in the form of vector functions
4. Apply the concept of vector fields and line integrals through mathematical modeling in engineering
5. Determine complex functions and apply them to formulate problems arising in engineering

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
3	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
4	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
5	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I 9 Hours

FIRST ORDER LINEAR DIFFERENTIAL EQUATIONS

Formation of differential equations- Solutions of first order linear ODE: Leibnitzs and method of separation of variables - Cooling/Heating of an object - A falling object - Modeling of electric circuits: RL and RC circuits - Modeling of population dynamics: Exponential growth and decay - Logistic growth model

UNIT II 9 Hours

SECOND ORDER LINEAR DIFFERENTIAL EQUATIONS

Methods of solving second order linear ordinary differential equations - Models for linear oscillators: Simple harmonic motion - Mechanical vibrations with and without damping - Electric circuit system: RLC circuits.

UNIT III 9 Hours

VECTOR DIFFERENTIAL CALCULUS

Vector and scalar functions - Fields - Derivative of a vector function and geometrical interpretation - Velocity and acceleration - Gradient and its properties - Tangent and normal vectors - Directional derivative - Divergence of a vector field - Curl of a vector field - Projectile motion

UNIT IV **9 Hours**

VECTOR INTEGRAL CALCULUS

Line integrals of vector point functions - Surface integral of vector point functions - Applications of line and surface integrals. Greens theorem in a plane - Stokes theorem - Gauss divergence theorem

UNIT V **9 Hours**

COMPLEX FUNCTIONS

Basic concepts of Complex numbers Geometrical representation of complex number - Analytic functions and its properties - Construction of Analytic functions: Fluid flow Electric flow - Mapping of complex functions

Tutorial: 15 Hours
Lecture: 45 Hours
Total: 60 Hours

Reference(s)

1. Richard E. Williamson, Introduction to Differential Equations and Dynamical Systems, McGraw Hill Companies. Inc, 1997
2. Michael Greenberg, Advanced Engineering Mathematics, 2/e, Pearson, 2018
3. George B. Thomas, Maurice D. Weir and Joel Hass Thomas Calculus, 13/e, Pearson Publishers, 2013
4. Erwin Kreyszig, Advanced Engineering Mathematics Wiley, 10th editi5. J. Stewart, Essential Calculus, Cengage, 2nd edition, 2017on ,2015
5. J. Stewart, Essential Calculus, Cengage, 2nd edition, 2017

22PH202 ELECTROMAGNETISM AND MODERN PHYSICS 2 0 2 3

Course Objectives

- Understand the principles and mechanisms of electricity and magnetism
- Infer the classification of electromagnetic waves
- Analyze the theory of relativity and energy bands

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research–based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life–long learning in the broadest context of technological change.

Course Outcomes (COs)

1. Understand the principles and mechanism of electrostatics and current
2. Illustrate the principles and mechanism of magnetostatics
3. Classify electromagnetic waves and infer the characteristics of visible light
4. Outline the importance of theory of relativity and analyze the wave nature of particles
5. Exemplify the electrical properties of semiconductor based on the band theory

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	1	1	-	-	-	-	2	-	-	1	-	-	-
2	3	2	1	2	-	-	-	-	2	-	-	1	-	-	-
3	3	2	2	1	-	-	-	-	2	-	-	1	-	-	-
4	3	2	2	1	-	-	-	-	2	-	-	1	-	-	-
5	3	2	2	1	-	-	-	-	2	-	-	1	-	-	-

UNIT I 6 Hours

ELECTRICITY

Electric monopoles - Electric field- Electric flux - Electric potential - Electrical energy- Capacitor-Conductors and Insulators-Electric dipole and polarization - Electric current -Voltage sources- Resistance.

UNIT II 6 Hours

MAGNETISM

Sources of magnetism- Monopoles-Magnetic field and force-magnetic field and current distribution-Magnetic dipole-Magnetic potential energy-Inductor- Electric and magnetic field comparison.

UNIT III **6 Hours**

ELECTROMAGNETIC WAVES AND LIGHT

Electromagnetism: Basic laws-Electromagnetic energy-radiation. Electromagnetic waves: origin, nature and spectrum-visible light, Principle of least time- geometrical optics-Human eye - Diffraction - Interference – polarization-LASER.

UNIT IV **6 Hours**

MODERN PHYSICS

Special theory of relativity - simultaneity and time dilation - length contraction - relativistic mass variation. Matter waves - de-Broglie hypothesis - Wave nature of particles.

UNIT V **6 Hours**

ENERGY BANDS IN SOLIDS

Band theory of solids - Classification of materials - Semiconductors - Direct and indirect semiconductor – Fermi energy - Intrinsic and extrinsic semiconductor - Carrier concentration - Electrical conductivity

EXPERIMENT 1 **5 Hours**

Analysis of I-V characteristics of a solar cell for domestic applications.

EXPERIMENT 2 **5 Hours**

Determine the carrier concentration of charge carriers in semiconductors for automotive applications

EXPERIMENT 3 **5 Hours**

Investigate the photonic behavior of laser source for photo copier device

EXPERIMENT 4 **5 Hours**

Implement the principle of stimulated emission of laser for grain size distribution in sediment samples

EXPERIMENT 5 **5 Hours**

Assess the variation of refractive index of glass and water for optical communication

EXPERIMENT 6 **5 Hours**

Evaluate the band gap energy of semiconducting materials for display device applications

Practical: 30 Hours
Lecture: 30 Hours
Total: 60 Hours

Reference(s)

1. C J Fischer, The energy of Physics Part II: Electricity and Magnetism, Cognella Academic Publishing, 2019
2. P G Hewitt, Conceptual Physics, Pearson education, 2017
3. R A Serway and J W Jewitt, Physics for Scientists and Engineers, Thomson Brooks/Cole, 2019
4. J Walker, D Halliday and R Resnick, Principles of Physics, John Wiley and Sons, Inc, 2018
5. H C Verma, Concepts of Physics (Vol I & II), Bharathi Bhawan Publishers & Distributors, New Delhi, 2017

22CH203 **ENGINEERING CHEMISTRY II** **2 0 2 3**

Course Objectives

- Understand the concept of electrochemistry for determination of electrode potential, pH and applications as energy storage devices
- Outline the chemistry of metal corrosion and analyze the methods of corrosion control
- Understand how catalyst increases the reaction rate
- Summarize the variation in properties and reactivity of isotopes

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Course Outcomes (COs)

1. Apply the electrochemical concepts to determine the electrode potential of a metal
2. Analyze the working of batteries for the energy storage devices
3. Understand the mechanism of corrosion and suggest a method to control the corrosion
4. Illustrate reaction mechanisms and assess the role of catalyst in a chemical reaction
5. Analyze various types of nuclear transmutation including decay reactions

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
3	2	1	-	-	-	-	1	-	-	-	-	-	-	-	-
4	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
5	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I **6 Hours**

ELECTROCHEMISTRY

Origin of potential - electromotive force - electrical double layer - transport of charge within the cell - cell description - prediction of cell potentials

UNIT II **6 Hours**

ENERGY STORING DEVICES

Relation between electrical energy and energy content of a cell - reversible and irreversible cell - charging and discharging reactions in a reversible cell - current challenges in energy storage technologies

UNIT III **6 Hours**

METAL CORROSION AND ITS PREVENTION

Oxidation of metals: Electrochemical origin of corrosion - electromigration - electron transfer in the presence and absence of moisture - galvanic series. Strategies for corrosion control: Galvanic anode and impressed current.

UNIT IV **6 Hours**

CATALYSIS

Energy profile diagram for a chemical reaction - activation energy - role of catalyst - homogeneous and heterogeneous catalysis - types

UNIT V **6 Hours**

NUCLEAR REACTIONS

Radioactive and stable isotopes - variation in properties between isotopes - radioactive decay (alpha, beta and gamma) - half- life period - nuclear reactions - recent applications of radioactive isotopes

EXPERIMENT 1 **4 Hours**

Measure industrial effluent water pH and assess water quality against allowed standards.

EXPERIMENT 2 **4 Hours**

Iron (Fe^{2+}) in Bhavani River water: Potentiometric Analysis & Pollution Assessment (CPCB Standards).

EXPERIMENT 3 **4 Hours**

Construct a Zn-Cu electrochemical cell and validate the output by connecting the LED light.

EXPERIMENT 4 **5 Hours**

Evaluate the corrosion percentage in concrete TMT bars.

EXPERIMENT 5 **4 Hours**

Determination of the percentage of corrosion inhibition in plain-carbon steel using natural inhibitors

EXPERIMENT 6 **4 Hours**

Electroplating of copper metal on iron vessels for domestic application.

EXPERIMENT 7 **5 Hours**

Determination of acid-catalyzed hydrolysis kinetics in locally sourced fruit extracts

Practical: 30 Hours
Lecture: 30 Hours
Total: 60 Hours

Reference(s)

1. U. Hanefeld, L. Lefferts, Catalysis: An Integrated Textbook for Students, 2nd Edition, Wiley- VCH, 2017.
2. S. Vairam, Engineering Chemistry, 1st Edition, John Wiley & Sons, 2014.
3. Jain and Jain, Engineering Chemistry, 16th Edition, Dhanpat Rai Publishing Company, New Delhi, 2013.
4. P.H. Rieger, Electrochemistry, Second Edition (Reprint), Springer, Netherland, 2012.
5. H.J. Arnikar, Essentials of Nuclear Chemistry, 4th Edition (revised), New Age International Publishers, 2011.
6. E. McCafferty, Introduction to Corrosion Science, 1st Edition, Springer, 2010.

22GE002 COMPUTATIONAL PROBLEM SOLVING 3 0 0 3

Course Objectives

- Analyze the algorithm design techniques and development principles in solving the real life problems.
- Illustrate the different ways of organizing and storing the data in computing systems.
- Understand the basic network configuration and setup connections among different device systems.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

Course Outcomes (COs)

1. Apply and formulate algorithms, pseudo codes and flowcharts for problems.
2. Apply algorithmic solutions to simple computational problems and explore algorithmic approaches to problem solving.
3. Analyze the appropriate data structures for solving computing problems.
4. Analyze the various storage devices used in a computer system.
5. Evaluate the requirements for a given organizational structure and establish the connection between two or more computers to form a network.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	2	1	-	-	-	-	-	-	-	-	-	-	-	-
2	1	2	2	-	-	-	-	-	-	-	-	-	-	-	-
3	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
4	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
5	1	2	2	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I 6 Hours

VISUAL PROCESS MODELING

Scenario decomposition - logical sequencing - drawing flowchart - preparing visual process model

UNIT II 12 Hours

ALGORITHMIC DESIGN THINKING

Analysis - Verification - Brute force - Divide and conquer - Greedy - Backtracking.

UNIT III 12 Hours

DATA ORGANIZATION

Elementary Data Organization - Abstract Data Types - Fundamentals of Linear and Non Linear Data Structures.

UNIT IV **7 Hours**

DATA STORAGE

Flat File and Relational database- Data Read & Write in Local Storage, Server Storage and Cloudstorage –Database Query Methods.

UNIT V **8 Hours**

ELECTRO ANALYTICAL TECHNIQUES

Networking Components and Services - IP Addressing - Configuring and Managing the Campus Network – Network Security – Firewalls

Total: 45 Hours

Reference(s)

1. David D. Riley, Kennya. Hunt, "Computational thinking for the modern problem Solver", CRC Press Taylor &Francis Group, 20PSO 2
2. Anany Levitin, "Introduction to the Design and Analysis of Algorithms", Third Edition, Pearson Education Asia,2011.
3. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", 2nd Edition, Pearson Education,2016.
4. Abraham Silberschatz, Henry F. Korth and S. Sudarshan, "Database System Concepts", McGraw Hill, 20PSO 3
5. Behrouz A.Forouzan, "Data Communication and Networking", 5th Edition, Tata McGraw-Hill, 20PSO 2

22GE004 BASICS OF ELECTRONICS ENGINEERING 2 0 2 3

Course Objectives

- Understand the concept of energy transmission through mechanical, electrical and electromagnetic form.
- To Analyze the characteristics and electrical parameters of Diode and BJT
- To illustrate the applications of Diode and BJT for special signal conditioning.
- To apply the working principle of PN Junction Diode and BJT to design basic Digital Logic.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and 333333nalyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods
PSO 1 Use the analytical instruments and techniques to separate, purify and characterize biological compounds
.

Course Outcomes (COs)

1. Apply the need for electrical and electromagnetic signal transmission.
2. Analyze the working principle and characteristics of PN junction diode.
3. Analyze the working principle and characteristics of Bipolar Junction Transistor.
4. Analyze the working principle of PN Junction diode and BJT for designing basic Digital Logic functions.
5. Evaluate the energy conversion needs and working principle of Special purpose electronic devices

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	2	2	1	-	-	-	-	-	-	-	-	2	-	-
2	3	2	3	2	-	-	-	-	-	-	-	-	2	-	-
3	2	3	3	2	-	-	-	-	-	-	-	-	2	-	-
4	2	3	3	2	-	-	-	-	-	-	-	-	2	-	-
5	1	2	3	1	-	-	-	-	-	-	-	-	2	-	-

6 Hours

UNIT I

ENERGY TRANSFER AND SIGNALS

Energy Transmission through Mechanical, Electrical and Electromagnetic means, Signal as Energy Transmission, Complexity in signal transmission (Volume of Information, Distance and Time taken), Limitations of Mechanical Energy Transmission, Electrical and Electromagnetic Signal Transmission, Need for Conversion between Electrical and Mechanical Signals.

UNIT II 6 Hours

SIGNAL CONDITIONING USING DIODE

Need for Vacuum Tubes in the Evolution of Electronics, Overview of Vacuum Tubes, Diode and Triode, Limitations of Vacuum Tubes. Semiconductor Group in Periodic Table, Overview of Semiconductor Materials, Flow of electrical energy through PN Junction Diode, Signal Clipping, Signal Clamping and Signal Multiplication using PN Junction Diode, Limitations of PN Junction Diode

UNIT III 6 Hours

SIGNAL CONDITIONING USING DIODE

Need for controlling electrical signals, Principle of Bipolar Junction Transistor operation, Signal Switching and Amplification using BJT, Limitations of BJT, Principle of Field Effect Transistor operation.

UNIT IV **6 Hours**

LOGIC SYNTHESIS USING DIODE AND TRANSISTORS

Overview of Logic Gates, PN Junction and BJT as electronic switches, Digital Logic Synthesis using Diode and Transistor: Diode Logic, Resistor Transistor Logic, Diode Transistor Logic, Transistor Logic.

UNIT V **6 Hours**

DEVICES FOR SPECIAL REQUIREMENTS

Voltage Regulation using Zener Diode, Variable Capacitance using Varactor Diode, Electrical Energy to Light Energy conversion using Light Emitting Diode, Light to Energy to Electrical Energy conversion using Solar Cell.

EXPERIMENT 1 **6 Hours**

Design a voltage multiplier to convert the low voltage from the mains power supply to the high voltage to operate the microwave oven.

EXPERIMENT 2 **6 Hours**

Design and construct regulated DC power supply for Mobile phone charger.

EXPERIMENT 3 **6 Hours**

Design and construct an audio amplifier circuit to play the mobile music in a huge speaker.

EXPERIMENT 4 **6 Hours**

Design and construct Switching circuit for the Pump to control over flow and drain condition for overhead tank using PN junction diode.

EXPERIMENT 5 **6 Hours**

Design and construct BJT based circuit to implement two way connection for stair case light application.

Practical: 30 Hours
Lecture: 30 Hours
Total: 60 Hours

Reference(s)

1. Thomas L. Floyd ,Electronic Devices: Electron Flow Version, Ninth Edition, Prentice Hall, 2012.
2. J Millman, C. Halkias & Satyabrata JIT, Electronic Devices and Circuits, Tata McGraw-Hill, 2007.
3. L Robert Boylestead, Louis Nashelsky, Electronic Devices and Circuit Theory, Pearson Education 2006.
4. David A. Bell, Electronic Devices and Circuits, Prentice Hall of India, 2003.
5. Adel S. Sedra & Kenneth C. Smith, Micro Electronic Circuits Theory and Applications, Sixth Edition, Oxford University Press, 20PSO 1
6. Behzad Razavi, Microelectronics, Wiley India Pvt. Ltd.; 2nd edition (2018).

22GE005 **ENGINEERING DRAWING** **1 0 2 2**

Course Objectives

- To provide knowledge on fundamentals of engineering drawings and conic sections.
- To impart skill on orthographic projections of points and lines.
- To familiarize on projection of planes and simple solids.
- To provide knowledge on section of solids and development of surfaces of simple solids.
- To impart skill on conversion of isometric view to orthographic projection and vice versa.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PSO 3 Conceive, Plan and Deploy societal projects for environmental protection using bioresources.

Course Outcomes (COs)

1. Apply the engineering drawing concepts as per industrial standards.
2. Analyze the orthographic projections of points and lines.
3. Analyze the projection of planes and simple solids.
4. Draw the section of solids and development of surfaces.
5. Draw the orthographic projection from isometric view and vice versa.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	-	-	-	-	-	-	2	-	2	-	-	-	-	2
2	2	-	-	-	-	-	-	2	-	2	-	-	-	-	2
3	1	-	-	-	-	-	-	2	-	2	-	-	-	-	2
4	1	-	-	-	-	-	-	2	-	2	-	-	-	-	2
5	1	-	-	-	-	-	-	2	-	2	-	-	-	-	2

UNIT I **7 Hours**

FUNDAMENTALS OF ENGINEERING DRAWING

Definition - standards - drawing tools - drawing sheets - scales - line and its types. Practices on lettering - numbering - dimension of drawings. Construction of conic sections - ellipse - parabola and hyperbola using eccentricity method.

UNIT II **9 Hours**

PROJECTION OF POINTS AND LINES

Principles of projection - projection of points in four quadrants - first angle projection of straight lines - perpendicular to one plane - parallel and inclined to both planes.

9 Hours

UNIT III

PROJECTION OF PLANES AND SOLIDS

Projection of simple planes and projection of simple solids - parallel - perpendicular and inclined to one plane using change of position method - inclined to both the planes

UNIT IV **9 Hours**

SECTION OF SOLIDS AND DEVELOPMENT OF SURFACES

Section of Solids - simple position with cutting plane parallel - perpendicular and inclined to one plane with true shape of section. Development of surfaces - simple and truncated solids.

UNIT V **11 Hours**

ORTHOGRAPHIC PROJECTIONS AND ISOMETRIC VIEW

Orthographic projections and isometric view of components used in engineering applications.

Total: 45 Hours

Reference(s)

1. N. D. Bhatt and V. M. Panchal, Engineering Drawing, Charotar Publishing House Pvt. Limited, 2019.
2. K.V. Natarajan, A Text Book of Engineering Graphics, Dhanalakshmi Publishers, 2020
3. K Venugopal, Engineering Drawing and Graphics, Sixth edition, New Age International, 2021
4. Basant Agarwal, Mechanical drawing, Tata McGraw-Hill Education, 2021
5. Engineering Drawing Practice for Schools & Colleges, Bureau of Indian Standards-Sp46, 2013

22HS006 **TAMILS AND TECHNOLOGY** **1 0 0 1**

Course Objectives

- Analyse graffiti on potteries as a form of historical and cultural documentation during the Sangam Age.
- Investigate the building materials and the historical context of Hero stones during the Sangam Age by Analysing the details of stage constructions in Silappathikaram and their cultural significance.
- Examine ancient knowledge of oceans and its impact on Tamil society.

Programme Outcomes (POs)

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions..

Course Outcomes (COs)

1. Understand the significance of the weaving industry during the Sangam Age and its cultural importance.
2. Understand the significance of dams, tanks, ponds, and sluices in the agricultural and irrigation practices of the Chola Period.
3. Explore the architectural designs and structural construction methods used in household materials during the Sangam Age.
4. Explore the art of shipbuilding in ancient Tamil culture and its role in maritime trade and transportation.
5. Trace the development of scientific terminology and vocabulary in Tamil language.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
2	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
3	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
4	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
5	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-

UNIT I **3 Hours**

WEAVING AND CERAMIC TECHNOLOGY

Weaving Industry during Sangam Age - Ceramic technology - Black and Red Ware Potteries (BRW) - Graffiti on Potteries.

UNIT II **3 Hours**

DESIGN AND CONSTRUCTION TECHNOLOGY

Designing and Structural construction House and designs in household materials during Sangam Age - Building materials and Hero stones of Sangam age - Details of Stage Constructions in Silappathikaram - Sculptures and Temples of Mamallapuram - Great Temples of Cholas and other worship places - Temples of Nayaka Period - Type study (Madurai Meenakshi Temple) - Thirumalai Nayakar Mahal - Chetti Nadu Houses, Indo - Saracenic architecture at Madras during British Period

UNIT III **3 Hours**

MANUFACTURING TECHNOLOGY

Art of Ship Building-Metallurgical studies-Iron industry-Iron smelting, steel-Copper and gold-Coins as source of history- Minting of Coins-Beads making-industries Stone beads -Glass beads-Terracotta beads-Shell beads-bone beats-Archeological evidences-Gem stone types described in Silappathikaram.

UNIT IV **3 Hours**

AGRICULTURE AND IRRIGATION TECHNOLOGY

Dam, Tank, ponds, Sluice, Significance of Kumizhi Thoompu of Chola Period, Animal Husbandry-Wells designed for cattle use- Agriculture and Agro Processing-Knowledge of Sea-Fisheries- Pearl-Conche diving- Ancient Knowledge of Ocean-Knowledge Specific Society.

UNIT V **3 Hours**

SCIENTIFIC TAMIL AND TAMIL COMPUTING

Development of Scientific Tamil-Tamil computing-Digitalization of Tamil Books-Development of Tamil Software-Tamil Virtual Academy-Tamil Digital Library-Online Tamil Dictionaries-Sorkuvai Project.

Total: 15 Hours

Reference(s)

1. Dr. K. K. Pillay , Social Life of Tamils, A joint publication of TNTB & ESC and RMRL
2. Dr. S. Singaravelu, Social Life of the Tamils - The Classical Period, International Institute of Tamil Studies.
3. Dr. S. V. Subatamanian , Dr.K.D. Thirunavukkarasu, Historical Heritage of the Tamils, International Institute of Tamil Studies.
4. Dr. M. Valarmathi, The Contributions of the Tamils to Indian Culture, International Institute of Tamil Studies
5. Keeladi - Sangam City Civilization on the banks of river Vaigai, Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu
6. Dr. K. K. Pillay, Studies in the History of India with Special Reference to Tamil Nadu.

22HS009	**COCURRICULAR / EXTRACURRICULAR ACTIVITY**	**L**	**T**	**P**	**C**
		0	**0**	**2**	**-**

Pre-requisite	**Assessment Pattern**	
• NIL	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	100
	Semester End Examinations	NA

Course Objectives

- To develop Interpersonal and Leadership Skills
- To Foster Personal Growth and Time Management
- To enhance Community Engagement and Social Responsibility

Programme Outcomes (POs)

PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
PO9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO12	**Life-long Learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
PSO1	Use the analytical instruments and techniques to separate, purify and characterize biological compounds
PSO2	Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors
PSO3	Conceive, Plan and Deploy societal projects for environmental protection using bio-resources

Course Outcomes (COs)

The students will be able to

CO1	Build leadership skills and teamwork capabilities by engaging in group activities through organization and participation of events
CO2	Demonstrate the technical, creative, and interpersonal skills through active participation in technical events.
CO3	Exhibit balanced academics with diverse cultural, sports, and literary activities, showcasing improved time management and organizational skills.
CO4	Enhance the social responsibility and community engagement by participating in outreach and extension activities.
CO5	Gain practical experience and industry insights through field visits, industrial training, and internships.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO 2	PSO 3
1	-	-	-	-	-	-	-	3	3	3	-	2	2	3	3
2	-	-	-	-	-	-	-	3	3	3	-	2	-	-	2
3	-	-	-	-	-	-	-	3	3	2	-	2	3	3	-
4	-	-	-	-	-	-	-	2	2	2	-	2	3	2	3
5	-	-	-	-	-	-	-	3	3	3	-	2	2	-	2

Every student shall be required to undergo a minimum of 40 hours of Co-curricular / Extracurricular activities organized through society chapters, technical and non-technical Club activities during the II semester, failing which he/she shall not be permitted to appear for the VIII Semester examination. Such students are permitted to appear for the Semester End examinations only after completing the requirements. The attendance of the courses / events shall be maintained on the regular basis by the concerned Co-coordinators and made available in the Office of the Controller of Examinations before the commencement of Semester end examinations of Semester II.

The following co-curricular and extra-curricular activities are conducted on a regular basis and is compulsory for all students. The students' performances are assessed on the basis of their participation and organization of events in voluntary services, performance in technical and nontechnical events, games and sports, performance in literary activities, performance in cultural activities and their participation in District/Regional/State/National and International level events.

Co-Curricular activity

Technical events organized through departments, Special labs, Clubs, Society and Chapters etc. includes but not limited to Workshop, Seminar, Conference, Symposium Technical Contest Competition, Field visit, Industrial Training, and Internships.

Extracurricular activity

Non-Technical Events Organized through departments, Special labs, Clubs, Society and Chapters etc. includes but not limited to NSS Camp, NCC Camp, YRC activity, Yoga, Sports and games, Cultural events, Outreach activity and Extension activity.

Total	**40 Hours**

22BT301 FOURIER SERIES, TRANSFORMS AND BIOSTATISTICS 3 1 0 4

Course Objectives

- To understand the concept of periodic and non-periodic functions and their representations using Fourier analysis.
- To find Laplace transform of standard functions and solve initial value problems and integral equations using Laplace transforms.
- To apply the knowledge of testing of hypothesis for small and large samples which plays an important role in real life problems.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Course Outcomes (COs)

1. Use the properties of periodic and non-periodic vibrations to analyze with the help of Fourier analysis in biotechnology.
2. Identify the position of a particle using partial differential equations and solve certain types of partial differential equations.
3. Formulate a function in frequency domain for which the function defined in time domain through the techniques of Laplace transforms.
4. Predict the outcome of an experiment using the concepts of probability and its distributions.
5. Justify and validate a problem in biotechnology with the help of hypothesis testing.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
3	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
4	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
5	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I 10 Hours

FOURIER ANALYSIS

Fourier series for periodic functions- Dirichlets conditions - The Euler coefficients - General Fourier series. Fourier transforms- Properties of Fourier transform- Applications of Fourier series and transform analysis.

UNIT II 9 Hours

PARTIAL DIFFERENTIAL EQUATIONS

Formation of Partial Differential Equations by eliminating arbitrary constants and functions – Solutions of Standard types of first order partial differential equations – Lagrange’s linear equation – Linear partial differential equations of second order with constant coefficients of homogeneous type.

UNIT III **8 Hours**

LAPLACE TRANSFORM

Laplace Transform- Existence Condition -Transforms of Standard Functions - Unit step function, Unit impulse function- Properties- Transforms of Derivatives and Integrals - Initial and Final Value Theorems- Laplace transform of Periodic Functions - Inverse Laplace Transform- Convolution.

UNIT IV **8 Hours**

PROBABILITY THEORY

Probability: Basic concepts - Conditional probability - Bayes theorem - Random variables - Distributions: Binomial, Poisson and Normal distributions

UNIT V **10 Hours**

MATHEMATICAL STATISTICS

Sampling distributions: Statistical estimation of parameters, confidence intervals - Testing of hypotheses - Small and large samples - Applications to statistical quality control and reliability analysis.

Tutorial: 15 Hours
Lecture: 45 Hours
Total: 60 Hours

Reference(s)

1. Kreyszig Erwin, Advanced Engineering Mathematics, 7th Edition, John Wiley, 1993.
2. Johnson Richard A. and Bhaltacharyya Gouri K., Statistics, Principles and Methods, 3rd Edition, John Wiley, 1996.
3. Neil Peter V., Advanced Engineering Mathematics, 4th Edition, PWS-Kent, 1995.
4. James Glyn Advanced Modern Engineering Mathematics, Addison-Wesley, 1993.
5. Milton J. S. and Arnold Jesse C., Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences, McGraw Hill Inc, 3rd Edition, 1995

22BT302 **BIOCHEMISTRY** **3 0 2 4**

Course Objectives

- To learn the biomolecules in the biological system.
- To study the mechanism and role of enzymes in metabolic pathways.
- To analyze the biomolecules qualitatively and quantitatively.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PSO2 Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.

Course Outcomes (COs)

1. Apply the classification, structure, function and properties carbohydrates and lipids.
2. Analyze the structures, functions and classification of proteins and nucleic acids.
3. Analyze the concepts of buffers, and principles and energetics of chemical reactions in metabolic pathways.
4. Analyze the metabolism and energetic of carbohydrates and lipids in human system.
5. Evaluate the metabolism of proteins, amino acids, nucleic acids, pyrimidine and purines in human body.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	3	-	-	-	-	-	-	-	-	-	-	-		-
2	2	2	-	-	-	-	-	-	-	-	-	-	-	1	-
3	-	3	3	-	2	-	1	-	-	-	-	-	-	-	-
4	-	-	2	-	3	-	2	-	1	-	2	-	-	2	-
5	-	-	2	-	2	-	2	-	2	-	1	-	-	-	-

9 Hours

UNIT I

CARBOHYDRATES AND LIPIDS

Biomolecules-Introduction. Classification, structure, nomenclature, properties, functions and qualitative analysis of carbohydrates and lipids.

UNIT II **9 Hours**

PROTEINS AND NUCLEIC ACIDS

Amino acids- classification, structure and configuration. Pyrimidines, Purines, nucleosides, nucleotides- Structures. Classification, structure, properties and functions of proteins and nucleic acids. Lipoproteins- types and function. -Higher order structures of proteins and nucleic acids and their importance.

UNIT III **9 Hours**

METABOLISM INRODUCTION AND ENERGETICS

Buffering system, biological buffers. Metabolism - anabolism, catabolism and amphibolism; Chemistry of metabolism; coenzymes and their roles in metabolism- concepts of bioenergetics.

UNIT IV **9 Hours**

CARBOHYDRATES AND LIPID METABOLISM

Glycolysis and Krebs cycle, Pentose Phosphate Pathway (HMP Shunt), Cori cycle. Glycogen synthesis and breakdown, Electron transport chain and oxidative phosphorylation. Biosynthesis and degradation of lipids- fatty acids, phospholipids, cholesterol and lipoproteins.

UNIT V **9 Hours**

NITROGEN METABOLISM

Catabolism of Proteins, amino acids, nucleotides, pyrimidines and purines. Glucose-Alanine cycle. Biosynthesis of nucleotides-de novo and salvage pathways for purines and pyrimidine. Health disorders in nitrogen metabolism.

EXPERIMENT 1 **6 Hours**

Assess the carbohydrates content of the Burger.

EXPERIMENT 2 **6 Hours**

Assess the amino acids in natural beverages.

EXPERIMENT 3 **6 Hours**

Evaluate the nutritional profile of traditional foods like peanut candy& coconut burfi.

EXPERIMENT 4 **6 Hours**

Evaluate the saponification number of essential oil from extracted from herbs like Cloves, sunflower.

EXPERIMENT 5 **6 Hours**

Evaluate the Nucleic acid contents of Onion/Banana.

Practical: 30 Hours
Lecture: 45 Hours
Total: 75 Hours

Reference(s)

1. D. L. Nelson and M. M. Cox, Lehninger's Principles of Biochemistry, 6th edition WHF reeman & Co., 2012.
2. J. Tymoczko, J. Berg and L. Stryer, Biochemistry- A Short Course, Freeman and Company, 2009.
3. D. Voet and J. G. Voet, Biochemistry, John Wiley and Sons Inc., 2010.
4. C. K. Mathews, K. E. Van Holde and K. G. Ahern, Biochemistry, Pearson Education PrivateLtd., 2000.
5. www.ocw.mit.edu
6. Manickam , S. Sadasivam, Biochemical Methods, 3 rd Edition, New Age International Pvt Ltd Publishers, 2009.

22BT303 ENGINEERING THERMODYNAMICS 3 1 0 4

Course Objectives

- To study the fundamentals of thermodynamics and zeroth law.
- To provide the knowledge on first law of thermodynamics.
- To impart the knowledge on second law of thermodynamics and entropy.
- To study the thermodynamic properties of pure substances and its phase change processes.
- To learn about gas power cycles and properties of gas mixtures.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PSO1 Design, analyze and evaluate the performance of mechanical systems

PSO2 Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors

Course Outcomes (COs)

1. Apply the basic concepts and Zeroth law of thermodynamics.
2. Apply the first law of thermodynamics to closed and open systems.
3. Analyze the problems related to cycles and cyclic devices using second law of thermodynamics.
4. Analyze the thermodynamic properties of pure substances and its phase change processes.
5. Evaluate the air standard performance of heat engines and properties of gas mixtures.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	-	-	-	-	-	-	-	-	-	-	-	3	-
2	3	3	-	-	-	-	1	-	-	-	-	-	2	3	-
3	3	3	-	-	-	-	2	-	-	-	-	-	-	3	-
4	3	3	-	-	1	-	2	-	-	-	-	-	2	3	-
5	3	3	2	-	1	2	2	-	-	-	-	-	2	3	-

UNIT I 8 Hours

INTRODUCTION AND ZEROTH LAW OF THERMODYNAMICS

Macroscopic and Microscopic approaches, energy, heat, work. Thermodynamic system – Types, properties, functions, states,processes and cycle. Zeroth law of thermodynamics - temperature scale,perfect gas scale

UNIT II **8 Hours**
FIRST LAW OF THERMODYNAMICS

First law of thermodynamics, Application of first law - Closed systems and Open systems, Thermodynamic processes in closed systems, Steady state flow processes in open systems.

UNIT III **9 Hours**
SECOND LAW OF THERMODYNAMICS

Limitations of first law of thermodynamics, Second law of thermodynamics - Kelvin - Planck and Clausius statements, Reversible and irreversible processes, Carnot theorem, Carnot engine, Clausius inequality, Entropy, Availability and irreversibility. Heat Engine, heat pump and refrigerator.

UNIT IV **10 Hours**
PROPERTIES OF PURE SUBSTANCES

Glycolysis and Krebs cycle, Pentose Phosphate Pathway (HMP Shunt), Cori cycle. Glycogen synthesis and breakdown, Electron transport chain and oxidative phosphorylation. Biosynthesis and degradation of lipids- fatty acids, phospholipids, cholesterol and lipoproteins.

UNIT V **10 Hours**

GAS MIXTURES AND GAS POWER CYCLES

Thermodynamics and properties of ideal gas mixture and perfect gas mixture - Dalton's law of partial pressure, Amagat's law. Psychrometric properties and processes - Psychrometric chart. Air standard cycles Otto, Diesel and Dual cycles- mean effective pressure and air standard efficiency.

Tutorial Hours: 15 Hours
Lecture: 45 Hours
Total: 60 Hours

Reference(s)

1. Y. Cengel and Boles, Thermodynamics - An Engineering Approach, Tata McGraw Hill Publishing Company Pvt. Ltd, New Delhi, 2019.
2. P.K. Nag, Engineering Thermodynamics,Tata McGraw Hill Publishing Company Pvt. Ltd, NewDelhi, 2018.
3. J.P.Holman, Thermodynamics, Tata McGraw Hill Publishing Company Pvt Ltd., NewDelhi,2016.
4. R.K. Rajput, Engineering Thermodynamics, Laxmi Publications Pvt.Ltd., New Delhi,2017.
5. Gordon J. Van Wylen, Richard E. Sonntag, Fundamentals of Classical Thermodynamics, December 31st 1978, John Wiley & Sons.
6. https://onlinecourses.nptel.ac.in/ noc22-ch01

22BT304 **MICROBIOLOGY** **3 0 2 4**

Course Objectives

- To develop skills of the Students in the identification of microbes, structure.
- To understand the microbial nutrition and Metabolism.
- To acquire prerequisite knowledge for all Bioprocess Technology processes.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PSO1 Design, analyse and evaluate the performance of mechanical systems.
PSO3 Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Apply the nomenclature, techniques and applications of microscopes and principles of staining techniques.
2. Analyze the structure and multiplications of Microbes.
3. Analyze the microbial nutrition, Growth and metabolism of microbes.
4. Evaluate the microbial control and host interaction.
5. Create the production of Bio fertilizers and antibiotics.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	-	2	-	-	-	2	-	1	-	-	-	1	-	-
2	2	-	2	-	-	-	3	-	2	-	-	-	1	-	-
3	1	-	3	-	-	-	1	-	2	-	-	-	-	-	-
4	2	-	3	-	-	-	2	-	2	-	-	-	-	-	-
5	2	-	2	-	-	-	1	-	2	-	-	-	-	-	2

UNIT I **9 Hours**

INTRODUCTION

Classification and nomenclature of microbes; Principle and applications of Microscopy - Light, dark field, phase contrast and fluorescence; principles of staining techniques - Gram, acid fast, capsule, flagella, endospore and Lacto phenol cotton blue.

UNIT II **9 Hours**

STRUCTURE AND MULTIPLICATION OF MICROBES

Colony morphology and arrangement of bacterial cells; Structure and multiplication of bacteria, fungi (Rhizhopus). viruses (TMV); life history of Mycoplasma, Actinomycetes (Streptomyces), Yeast, Bacteriophages and viruses (TMV).

UNIT III **9 Hours**

MICROBIAL NUTRITION, GROWTH AND METABOLISM

Nutritional requirements and media for bacterial growth; bacterial growth curve, nutritional classification of organisms; methods to quantitate bacterial growth, preservation techniques; Bacterial metabolism - respiration and fermentation (lactic acid and ethanol).

UNIT IV **9 Hours**

MICROBIAL CONTROL AND HOST INTERACTION

Physical and chemical methods of microbial control; antimicrobial drugs - mode of action and drug resistance, antibacterial, antifungal and antiviral agents; mechanisms of pathogenicity - mode of entry, penetration of host defences and damage.

UNIT V **9 Hours**

INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY

Biofertilizers, bio pesticides, production of alcohol, amoxicillin; bioremediation; leaching of ores by microbes; microbial treatment of wastewater - aerobic and anaerobic methods.

EXPERIMENT 1 **3 Hours**

Culturing of microorganisms - in broth, plates (pour plate and streak plate) and slant.

EXPERIMENT 2 **6 Hours**

Bacterial growth curve.

EXPERIMENT 3 **3 Hours**

Indole and Citrate utilization tests.

EXPERIMENT 4 **3 Hours**

Methyl red and Voges-Proskauert test.

EXPERIMENT 5 **3 Hours**

Lactophenol cotton blue staining.

EXPERIMENT 6 **4 Hours**

Gram staining, Endospore staining and Flagella staining.

EXPERIMENT 7 **4 Hours**

MPN test for identification of coliform bacteria.

EXPERIMENT 8 **4 Hours**

Antibiotic sensitivity assay and Minimum inhibitory Concentration.

Practical: 30 Hours
Lecture: 45 Hours
Total: 75 Hours

Reference(s)

1. L. M. Prescott, J. P. Harley and D. A. Klein, Microbiology, Wm. C. BrownPublishers, 2004.
2. M. J. Pelczar, E. C. S. Chan and N. R. Krein, Microbiology, Tata McGraw-Hill, 2002.
3. G. J. Tortora, B. R. Funke and C. L. Case, Microbiology, Addison Wesley Longman, Inc. 2001
4. R. M. Atlas and Renk, Principles of Microbiology, McGraw-Hill Higher Education,1995.
5. Subhash Chandra Pariija, Textbook of Microbiology and Immunology, Elsevier,2016
6. Coates, A., Hu, Y., Bax, R. and Page, C., 2002. The future challenges facing the development of new antimicrobial drugs. Nature reviews Drug discovery, 1(11), pp.895-910.
7. https://archive.nptel.ac.in/courses/102/103/102103015/

22BT305 PROCESS CALCULATIONS AND UNIT OPERATIONS 3 1 0 4

Course Objectives

- To provide students the basic knowledge on chemical calculations and its application for material balance.
- To impart the basic concepts of unit operation.
- To understand the different unit operations and processes carried out in the chemical and biochemical industries.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PSO1. Use the analytical instruments and techniques to separate, purify and characterize biological Compounds.

Course Outcomes (COs)

1. Apply the various basic chemical calculations and its application.
2. Apply the quantification of the process using material and energy balance.
3. Analyze and differentiate various size reduction equipment and measurement of the particle size.
4. Evaluate various types of mixers, flow patterns and scale up criteria for mixing and agitation.
5. Create the equipment for filtration and sedimentation operation.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
2	-	2	3	-	-	-	-	-	-	-	-	-	2	-	-
3	-	2	3	-	-	-	-	-	-	-	-	-	1	-	-
4	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
5	3	-	2	-	-	-	-	-	-	-	-	-	1	-	-

UNIT I 9 Hours

BASICS OF CHEMICAL CALCULATION

Stoichiometry & chemical equations; Units, dimensions & conversions; Basic chemical calculations - mole, weight & volume %, Henry's law, Raoult's law and their applications to different systems.

UNIT II 9 Hours

MATERIAL AND ENERGY BALANCE

Material Balance without Chemical reaction-distillation, evaporation, drying & fermenter, recycle, bypass and purging operations; Energy balance- Sensible heat, latent heat.

UNIT III **9 Hours**
MECHANICAL OPERATIONS - SOLIDS HANDLING, SIZING AND SCREENING

Properties of particulate solids, Screening- Determination of particle size, Screen analysis, Surface area measurements, Size reduction of solids- laws, stages of reduction, operating variables, intermediate and fine size reduction, Sieve analysis, Power driven machines - Crushers, ball mills, conveyers.

UNIT IV **9 Hours**
MIXING AND AGITATION

Introduction to agitation and mixing of liquids, Mixing - types of mixers- ribbon and muller mixer, Mixing and bioreaction interactions-flow regimes with and without baffles, Agitation equipment, flow patterns in agitator, Power required for agitated vessels- power number and power number calculation, Scale up criteria for mixing and agitation equipment.

UNIT V **9 Hours**
FILTRATION AND SEDIMENTATION

Filtration- Principles of cake filtration, Filter medium and filter aids, Constant rate filtration and constant pressure filtration. Batch and continuous filtration, Filtration equipment- plate and frame, leaf filter, rotary drum, Sedimentation and Settling theory, Equipment for sedimentation- thickeners, clarifiers centrifugation.

Tutorial: 15 Hours
Lecture: 45 Hours
Total: 60 Hours

Reference(s)

1. N. Anantharaman and V. Venkataramani, Process Calculation, Prentice Hall of India,2005.
2. C. J. Geankoplis, Transport Processes and Unit Operations, Prentice Hall of India, 2007.
3. W. L. McCabe, J.C. Smith and P. Harriott, Unit Operations in Chemical Engineering, Tata McGraw-Hill Professional, 2005.
4. M. Coulson and J. F. Richardson, Coulson and Richardson's Chemical Engineering, Vol. 2, Butterworth Heineman, 2004.
5. G. K. Roy, Fundamentals of Heat and Mass Transfer, Kanna Publications, 2004.

22HS004 HUMAN VALUES AND ETHICS 2 0 0 2

Course Objectives

- Understand the concept of good values and comprehend the importance of value-based living.
- Recognize the culture of peace through education.
- Identify and apply the practices for value development and clarification.

Programme Outcomes (POs)

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Course Outcomes (COs)

1. Apply the importance of human values and ethics in life.
2. Analyze the importance of harmonious living in a diverse society.
3. Analyze the sensitivity to the crying needs of society such as ungodliness, corruption, poverty, and suffering, and play a vital role in eradicating them.
4. Evaluate intellectually mature, morally upright, ethically correct, and spiritually inspired decisions.
5. Create a correct balance between professional excellence and social commitment.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	-	-	3	2	1	-	-	-	-	-
2	-	-	-	-	-	-	-	3	2	1	-	-	-	-	-
3	-	-	-	-	-	-	-	3	2	1	-	-	-	-	-
4	-	-	-	-	-	-	-	3	2	1	-	-	-	-	-
5	-	-	-	-	-	-	-	3	2	1	-	-	-	-	-

UNIT I 6 Hours
COURSE INTRODUCTION - NEED, BASIC GUIDELINES AND ANALYSIS
Importance of Human Values & Ethics in 21st Century - Understanding the theory of basic human values and ethics - Openness to change - Self enhancement - Conservation - Self transcendence - Schwartz Value Survey: Self-Assessment.

UNIT II 6 Hours
EMBRACING THE COMMON ETIQUETT
Altruism- Integrity - Freedom - Justice - Honesty - Truthfulness - Responsibility – Compassion.

UNIT III 6 Hours
CONTINUOUS HAPPINESS AND PROSPERITY
An overview on basic Human Aspirations - Understanding and living in harmony at various levels of life - Embracing self- love and wellness - Understanding harmony in the family and society.

UNIT IV 6 Hours
UNIVERSAL HUMAN VALUES AND PROFESSIONAL ETHICS
Reflection on growing global multifold problems: poverty, pollution, hunger, disease, unemployment, caste system, child labour, gender equality, politics and violence. Understanding the challenges in cultural, personal, social, political, and economic environment.

UNIT V **6 Hours**

UNDERSTANDING HARMONY IN THE NATURE AND EXISTENCE - WHOLE EXISTENCE AS CO- EXISTENCE

Understanding the harmony in Nature - Holistic perception of harmony at all levels of existence - Practice Exercises and Case Studies will be taken up in Practice Sessions.

Total: 30 Hours

Reference(s)

1. Martin, G. The Little Book of Ethics: A Human Values Approach. Australia: G.P. Martin. 2011.
2. Gupta, N. L. Human Values for The 21St Century. India: Anmol Publications Pvt. Limited. 2002.
3. Mishra, A. Happiness Is All We Want. India: Bloomsbury Publishing.2017.
4. Universal Human Values. (n.p.): Booksclinic Publishing. 2023.
5. A Textbook on Professional Ethics and Human Values. India: New Age International (P) Limited.2007.

22HS005 SOFT SKILLS AND EFFECTIVE COMMUNICATION 0 0 2 1

Course Objectives

- Communicate proficiently in formal discussions at the workplace.
- Describe experiences and events, and briefly give reasons and explanations for opinions and plans.
- Interact with a degree of fluency and spontaneity that results in efficacious communication
- Convey agreement and disagreement in a polite but firm manner
- Communicate with coherence and imagination in both written and spoken formats.

Programme Outcomes (POs)

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Course Outcomes (COs)

1. Enhance confidence in expressing thoughts in grammatically proper language and etiquette in waiting for the opportunity to provide input
2. Effectively communicate in English on formal occasions and proficiency in the use of link words and other discourse markers
3. Provide constructive feedback and file logical complaints
4. Analyse the understanding of oral and written communication in real-world situations.
5. Apply the improved spelling and punctuation in writing and heightened understanding of tone, pitch and stress in oral formats.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
2	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
3	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
4	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
5	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-

UNIT I 10 Hours

SELF-EXPRESSION

Group discussion/ Peer discussion - Communicating decisions and opinions - Tone, Pitch, Stress - Agreeing, Disagreeing, Suggesting, Speculating - Comparing and Contrasting - Comparatives and Superlatives - Discourse markers – Interjections - Decision making - Synthesis - Higher order thinking Group discussion/Peer discussion – Effective Communication Types of communication - Written vs Spoken - Contractions Intonation Stress Active voice - Question tags - Confidence and body language Guided writing- Outlining Main Points - Group discussion/Peer discussion - Avoiding common errors Reduction of MTI - Common errors - Barriers to communication Accent

UNIT II 10 Hours

CREATIVE EXPRESSION

JAM, Debate, Review writing, Social media posts Synonyms - Antonyms Cloze test Phrasal verbs spotting errors Collocation - Commonly mispronounced.

UNIT III **10 Hours**

FORMAL EXPRESSION

Writing: Giving written feedback, Review writing, and Letter of complaint. Speaking: Giving constructive feedback and offering suggestions, asking for inputs, commenting politely on appropriate phrases - Giving written feedback Review writing, and Letter of complaint. Critical reasoning - Modal verbs - Polite ways to express negatives

Total: 30 Hours

Reference(s)

1. Word Power Made Easy by Norman Lewis, W. R. Goyal Pub. & Distributors, 2009.
2. Sasikumar, V, et al., A Course in Listening & Speaking Foundation Books, 2005.
3. Murphy, Raymond. English Grammar in Use: A Self-Study Reference and Practice Book for Intermediate Students: with Answers. Cambridge: Cambridge University Press, 1985.
4. Prasad, Hari Mohan. A Handbook of Spotting Errors, Mcgraw Hill Education, 2010.
5. Personality Development & Soft Skills, Barun K. Mitra, Oxford University Press, 2012
6. Business English by Ken Taylor, Orient Blackswan, 2011

22BT401 BIOORGANIC CHEMISTRY 3 0 2 4

Course Objectives

- To provide students with a basic understanding of weak interaction, stereo chemistry and structures of simple biomolecules, proteins and nucleic acids.
- To introduce and understand the mechanism of enzyme action, protein folding and unfolding and their biological significances.
- To acquire/ demonstrate their basic knowledge and skill on the kinetics, mechanism and function of proteins/ enzyme action and improve their self-learning and understanding skills on biochemical engineering and promote employability in biotech research areas.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.

Course Outcomes (COs)

1. Apply the mathematical models, stereochemistry of nucleophilic substitution reaction and types of catalysis to understand the structure, properties and functions of biomolecules.
2. Analyze the enzyme structure and their stereo specificity of action.
3. Analyze the kinetics and mechanism for enzymatic reaction and understand allosteric regulation.
4. Evaluate the higher order structural level, stability and sequencing in protein and nucleic acids and their chemical method of synthesis.
5. Evaluate the protein folding-unfolding kinetics and know the importance of molecular chaperons.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	-	3	2	-	-	1	-	-	-	-	-	-	-
2	2	2	-	3	2	-	-	-	-	-	-	-	-	1	-
3	3	2	-	3	1	-	-	-	-	-	-	-	-	-	-
4	4	2	-	3	1	-	-	2	-	-	-	-	-	2	-
5	5	2	-	3	1	-	-	2	-	-	-	-	-	-	-

UNIT I 9 Hours
INTRODUCTION

Historical connection between organic and biological chemistry , nonbonding interactions and simplified equations representing these energies- stereochemistry of nucleophilic substitution reactions- ester formation and hydrolysis, analogy between chemical and biochemical reactions, chemistry of living cells, Types of Catalysis mechanisms for electrophilic, nucleophilic and covalent catalysis with typical examples. Potential energy diagram-Hammond spostulate.

UNIT II **9 Hours**

ENZYMES:STRUCTURE,STEREOCHEMISTRY

Stereo specific enzymatic reactions-fumarase catalyzed reactions. NAD dependent oxidation and reduction reactions-chiral methyl group. The dehydrogenases-the proteases-lysozyme-ribonucleases.

UNIT III **9 Hours**

ENZYME KINETICS

Transition state analogues - reaction rates. Michaelis-Menton Kinetics. Derivation of rate equation for equilibrium and non-equilibrium models. Mechanism of enzyme action. Energetics of enzyme catalyzed reaction. Significances of change in enthalpy, free energy, entropy in enzyme kinetics. Kinetics of multi-site co-operative enzymes-sequential (Koshland -Nemethy-Filmer (KNF) and Concerted (Monod-Changeux-Wyman model) models.

UNIT IV **9 Hours**

SYNTHESIS AND SEQUENCING OF PROTEINS AND NUCLEIC ACIDS

Chemical synthesis of proteins, different types of secondary structural elements in proteins, stability of proteins - stability -activity trade off. Chemical synthesis of nucleotides and poly nucleotides. Chemical and enzymatic methods for sequencing of proteins and nucleic acids.

UNIT V **9 Hours**

PROTEIN FOLDING

Protein folding pathways, folding kinetics-basic methods - two state kinetics - multistate kinetics, transition states in protein folding-1H- 2H exchange studies in protein-Linderstrom-Lang model-folding of peptides-CI2 folding. Molecular chaperons-heat shock proteins- GroEL-GroES-mechanism of action.

EXPERIMENT 1 **6 Hours**

Synthesis, purification by crystallization and identification (melting point) of aspirin.

EXPERIMENT 2 **6 Hours**

Preparation of 5,10,15,20-tetrakisphenylporphyrin.

EXPERIMENT 3 **6 Hours**

Synthesis of ethyl acetate by Fischer esterification and its purification by distillation.

EXPERIMENT 4 **6 Hours**

Extraction of lycopene from tomato.

EXPERIMENT 5 **6 Hours**

Preparation of oleic acid from olive oil.

Practical: 30 Hours
Lecture: 45 Hours
Total: 75 Hours

Reference(s)

1. A. Fersht, Structure and Mechanism in Protein Science: A Guide to Enzyme Catalysis and Protein Folding, New York: W.H.Freeman and company,1999.
2. H.Dugas, Bioorganic Chemistry,SpringerVerlag,1999.
3. D.L.Nelson and C.M.M.Lehninger,PrinciplesofBiochemistry,W.H.Freeman&Co.,2005.
4. C.K.Mathews,K.E.VanHolde,andK.G.Ahern,Biochemistry,PearsonEducation,Indian Reprint,2003
5. F.Campbell, Biochemistry,Thomson Books, Indian Reprint,2007.

22BT402 **HEAT AND MASS TRANSFER** **3 0 2 4**

Course Objectives

- To familiarize conduction heat transfer mechanisms.
- To expose the mechanisms of free and forced convection.
- To develop the shape factor algebra for black body radiation and grey body radiation.
- To demonstrate the phase change heat transfer and determine the performance of heat exchanging devices.
- To infer diffusion and convective mass transfer.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern Tool Usage**:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

PSO2. Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors.

Course Outcomes (COs)

1. Apply the heat conduction equation to compute the rate of heat transfer in one and two - dimensional systems and composite systems
2. Assess the convection phenomena and determine the heat transfer rate in free and forced convection
3. Determine the heat transfer rate in radiation and compare the thermal performance of heat exchangers using LMTD or NTU approach
4. Execute mass transfer rate in diffusion mass transfer applications
5. Evaluate convective mass transfer process and apply mass transfer principles in food and bioprocessing

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	2	2	1	-	2	-	-	-	-	-	-	3	-
2	2	3	2	2	1	-	2	-	-	-	-	-	-	3	-
3	3	3	2	2	-	-	2	-	-	-	-	-	-	3	-
4	2	3	2	2	-	-	2	-	-	-	-	-	-	3	-
5	2	3	2	2	-	-	2	-	-	-	-	-	-	3	-

UNIT I **8 Hours**

CONDUCTION

Introduction – Steady State Conduction in one and two – dimensional systems. Composite systems. Extended surfaces.

UNIT II **8 Hours**

CONVECTION

Basic concepts - Heat transfer coefficients, Boundary layers. Forced convection - External and Internal flows, correlations, Natural convection- Logarithmic Mean Temperature Difference.
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UNIT III **11 Hours**

RADIATION AND HEAT EXCHANGERS

Radiation heat transfer – concept of black and grey body - monochromatic Total emissive power– Kirchhoff’s law – Planck’s law - Stefan-Boltzmann’s law –Heat exchangers – parallel, counter and cross flow- Heat transfer efficiency using LMTD and NTU – overall coefficient of heat transfer in shell and tube heat exchanger for food products.

UNIT IV **10 Hours**

INTRODUCTION TO MASS TRANSFER

Basics of mass transfer- Fick's laws of diffusion- mechanisms of mass transfer-Molecular diffusion, Fick's first and second laws, steady-state and non-steady-state diffusion, diffusion in solids and liquids, diffusion coefficients.

UNIT V **8 Hours**

MASS TRANSFER

Fundamentals of convective mass transfer, boundary layer theory, mass transfer coefficients in laminar and turbulent flow, Knudsen diffusion, dimensionless numbers, applications of mass transfer in bio and food industries.

EXPERIMENT 1 **3 Hours**

Determination of thermal conductivity for one dimensional steady state conduction.

EXPERIMENT 2 **3 Hours**

Determination of heat transfer co-efficient by unsteady heat transfer.

EXPERIMENT 3 **3 Hours**

Determination of heat transfer co-efficient by natural convection.

EXPERIMENT 4 **3 Hours**

Determination of heat transfer co-efficient by forced convection.

EXPERIMENT 5 **3 Hours**

Determination of Stefan-Boltzmann constant.

EXPERIMENT 6 **3 Hours**

Determination of emissivity using emissivity apparatus.

EXPERIMENT 7 **3 Hours**

Determination of overall heat transfer for film wise and drop wise condensation.

EXPERIMENT 8 **3 Hours**

Determination of overall heat transfer co-efficient for a parallel and counter flow heat exchanger.

EXPERIMENT 9 **3 Hours**

Experimentation on mass transfer.

EXPERIMENT 10 **3 Hours**

Determination of overall heat transfer co-efficient for a fluidized bed heat transfer.

Practical: 30 Hours
Lecture: 45 Hours
Total: 75 Hours

Reference(s)

1. Yunus A.Cengel, Heat and Mass Transfer: Fundamentals and Application, Tata McGrawHill publishing Company private limited, New Delhi, 6th edition, 2020.
2. J. P. Holman, Heat Transfer, Tata McGraw Hill publishing Company private limited, NewDelhi, 10th edition, 2010.
3. C. P. Kothandaraman and S. Subramanyan, Fundamentals of Heat and Mass Transfer,New Age International private limited, New Delhi, Rev.3rd edition, 2006.
4. Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, David P. DeWitt, Principles of Heat and Mass Transfer, ISBN: 978-1-119-38291-1 October 2017.
5. R. K. Rajput, Heat and Mass Transfer, S Chand and Company, New Delhi, 2018.
6. Robert E. Treybal, Mass-transfer operations. McGraw-Hill Book Company, Inc.,, 3rd edition, 2017
7. Dutta, B.K., Heat transfer: principles and applications. 2nd Edition, PHI Learning Pvt. Ltd.. 2023

22BT403 CELL AND MOLECULAR BIOLOGY 3 0 2 4

Course Objectives

- To understand the concept of the cell division and signaling pathway.
- To expose students to various molecular events in prokaryotes.
- To create deeper understanding on regulation of genes activities.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO1 Use the analytical instruments and techniques to separate, purify and characterize biological compounds.

PSO2 Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.

Course Outcomes (COs)

1. Apply the concepts of cell structure, and functions of organelles and the cell cycle.
2. Apply the mechanisms of transport, receptors and cell signaling.
3. Analyze the mechanism of DNA replication &transcription in prokaryotes.
4. Analyze the process of translation and DNA repair system in prokaryotes.
5. Evaluate the concept of gene regulation and its significance in prokaryotes.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	3	-	2	-	-	-	-	-	-	-	-	1	1	-
2	3	3	-	2	-	-	-	-	-	-	-	-	1	1	-
3	3	-	-	1	-	-	-	-	-	-	-	1	1	2	-
4	3	-	-	1	-	-	1	-	-	-	-	-	1	2	-
5	3	-	-	1	-	-	-	-	-	-	-	-	1	1	-

UNIT I 9 Hours

MEMEBRANE ORGANIZATION AND CELL CYCLE

Biological membrane organization- membrane proteins &cytoskeletal proteins, Types of cell division – mitosis, meiosis and asynthetic fission, cell cycle and molecules that control cell cycle; cell cycle and cancer. Receptors: Cytosolic, Nuclear and membrane bound receptors; Receptor Mechanism; Autocrine, paracrine and endocrine models of action; Receptor components: Neurotransmitters, agonists and antagonists.

UNIT II 9 Hours

TRANSPORT ACROSS CELL MEMBRANES AND SIGNAL TRANSDUCTION

Ligand-gated and Voltage-gated ion channels; Channel components (permeases, proton pumps & ATPase); Channels examples (sodium potassium pump, Ca^{2+} ATPase pumps); Channel mechanism: endocytosis, exocytosis & receptor-mediated endocytosis; co-transport (symport, antiport); Signal amplifications; different models of signal amplification; Second messengers - cAMP, Inositol phosphates, DAG, cGMP, G proteins, Ca; Protein kinases, serine threonine kinases.

UNIT III **9 Hours**

DNA REPLICATION & TRANSCRIPTION

Physical and chemical structure of DNA & RNA; Properties of genetic material; Prokaryotic DNA polymerases; DNA replication in prokaryotes; Prokaryotic RNA polymerase & Transcription.

UNIT IV **9 Hours**

GENETIC CODE & TRANSLATION

The genetic code- salient features; Wobble base pair & Aminoacyl- tRNA synthetases; Post transcriptional modification - mRNA processing; Translation in prokaryotes; DNA damage & DNA repair; Inhibitors of translation.

UNIT V **9 Hours**

REGULATION OF GENE ACTIVITY

Principles of gene regulation and operon concept; Transcriptional regulation - lac operon, arabinose operon & tryptophan operon; attenuation; autoregulation; Feedback inhibition and allosteric control.

EXPERIMENT 1 **5 Hours**

Mitosis in onion root tip.

EXPERIMENT 2 **5 Hours**

To isolate genomic DNA from Bacteria.

EXPERIMENT 3 **5 Hours**

To isolate genomic DNA from plant & animal tissue.

EXPERIMENT 4 **5 Hours**

To quantify DNA using UV spectrophotometer / DNA nano drop.

EXPERIMENT 5 **5 Hours**

To digest DNA using restriction enzymes.

EXPERIMENT 6 **5 Hours**

To identify DNA molecule using agarose gel electrophoresis.

Practical: 30 Hours
Lecture: 45 Hours
Total: 75 Hours

Reference(s)

1. G. M. Malacinski, Freifelder's Essentials of Molecular Biology,Narosa Publishing House,2005.
2. J. K. Pal and S. S. Ghaskadbi, Fundamentals of Molecular Biology, Oxford University Press, New Delhi, 2011.
3. J. Watson, T. Baker, S. Bell, A. Gann, M. Levine and R. Losick, Molecular Biology of the Gene, Pearson Education, Inc., 2008.
4. J. E. Krebs, E. S. Goldstein and S. T. Kilpatrick, Lewin Genes X, Sudbury, MA:Jones & Bartlett Publishers, 2009.
5. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts and P. Walter, Molecular Biology of the Cell, Garland Science, 2008.
6. H. Lodish, A. Berk, C. A. Kaiser, M. Krieger, M. P. Scott, A. Bretscher, H. Ploegh, and P. Matsudaira, Molecular Cell Biology, W. H. Freeman & Co., 2007

22BT404 INSTRUMENTATAL METHODS OF ANALYSIS 3 0 2 4

Course Objectives

- To expose students with electrical and electronic components used in the analytical instruments.
- To learn and understand the principles and operation of different instrumentation techniques.
- To know the different molecular spectroscopic techniques and their analytical applications

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PSO1. Use the analytical instruments and techniques to separate, purify and characterize biological compounds.

Course Outcomes (COs)

1. Apply the function of electrical and optical component in analytical instruments and their calibration.
2. Apply the spectroscopic techniques to identify, estimate and characterize analytes.
3. Analyze the thermal behavior of materials using thermal analysis.
4. Analyze chromatographic and electrophoretic techniques to separate, purify and quantify molecules.
5. Evaluate the different types of electrodes and electro analytical techniques for sensing and quantifying analytes.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	1	-	-	-	-	-	-	-	-	-	3	-	-
2	3	2	3	2	2	-	-	-	-	-	-	-	2	-	-
3	3	2	2	1	2	-	-	-	-	-	-	-	2	-	-
4	3	3	3	2	2	-	-	-	-	-	-	-	2	-	-
5	3	1	2	1	1	-	-	-	-	-	-	-	1	-	-

UNIT I 9 Hours

BASICS OF MEASUREMENT AND OPTICAL METHODS

Classification of instrumental methods - calibration methods for instruments - electrical components in circuits and their function - signal to noise ratio - signal - noise enhancement- software and hardware techniques. General design of optical instruments - sources of radiation - wavelength selectors - materials for optical components and sample holders. Radiation transducers.

UNIT II **9 Hours**

MOLECULAR SPECTROSCOPY

Types of optical instruments- Fourier transform measurements -Theory and advantages. Measurement of transmittance and absorbance- Beer's law - Derivation and types of Deviation. Spectrophotometer analysis - qualitative and quantitative absorption measurements - types of spectrometers - UV - visible, IR, Raman and NMR- theory, instrumentation and applications.

UNIT III **9 Hours**

THERMAL METHODS

Thermo-gravimetric analysis (TGA), differential thermal analysis (DTA), differential scanning calorimetry (DSC) theory, instrumentation and applications.

UNIT IV **9 Hours**

SEPARATION METHODS

Introduction to chromatography - models - ideal separation - retention parameters - van – deemter equation - GC-MS - stationary phases - detectors - Kovats indices- HPLC - pumps - columns- Detectors and instrumentation. Size exclusion, hydrophobic interaction, supercritical chromatographic techniques. Ion exchange, affinity - theory, instrumentation and applications. Capillary electrophoresis.

UNIT V **9 Hours**

ELECTRO ANALYTICAL TECHNIQUES

Electrodes, reference electrodes, ion selective electrodes and pH meter. Potentiometry, Voltammetry, coulometry and amperometry- theory, instrumentation and applications in life sciences.

EXPERIMENT 1 **3 Hours**

Ultraviolet Absorption Spectroscopy.

EXPERIMENT 2 **4 Hours**

Visible Absorption Spectroscopy.

EXPERIMENT 3 **4 Hours**

Column chromatography.

EXPERIMENT 4 **4 Hours**

Thin Layer chromatography.

EXPERIMENT 5 **3 Hours**

Gel filtration or size exclusion chromatography.

EXPERIMENT 6 **4 Hours**

Ion exchange chromatography.

EXPERIMENT 7 **4 Hours**

High performance liquid chromatography.

EXPERIMENT 8 **4 Hours**

Affinity chromatography.

Practical: 30 Hours
Lecture: 45 Hours
Total: 75 Hours

Reference(s)

1. H. H. Willard, and L. L. Merrit, Instrumental Methods of Analysis, Prentice Hall of India,2005.
2. D. A. Skoog, J. F. Holler and T. A. Nieman, Principles of Instrumental Analysis, Thomson, 2006.
3. G. W. Ewing, Instrumental Methods of Chemical Analysis, Mc Graw Hill, 1985.
4. R. D. Braun, Introduction to Instrumental Analysis, Pharma Book Syndicate, Adithiya Art Printers, 1987
5. NPTEL Course: Modern Instrumental Methods of Analysis; https://nptel.ac.in/courses/103108100

22BT405 **PLANT TISSUE CULTURE** **2 0 2 3**

Course Objectives

- To gain ample knowledge on different plant culture types involved.
- To learn the techniques involved in plant tissue culturing.
- To have an exposure on the various real time applications of culturing techniques in GM crop production and sustainability

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO1 Use the analytical instruments and techniques to isolate, purify and characterize biological compounds.

PSO3 Conceive, Plan and Deploy societal projects for global welfare using Bio-resource.

Course Outcomes (COs)

1. Apply the biology behind plant tissue culture techniques.
2. Analyze the need of various physio chemical conditions in PTC.
3. Analyze the recent methodologies of plant tissue and cell culture to develop a whole plant.
4. Analyze the commercial significance of plant tissue culture.
5. Evaluate the need of various interdisciplinary domains in Plant tissue culture procedures

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	1	-	2	-	-	1	-	-	-	1	1	-	-	1
2	1	-	3	2	-	1	1	-	-	1	2	1	-	-	-
3	-	2	1	-	2	-	-	1	1	-	1	-	1	-	-
4	1	-	-	2	-	1	-	-	1	-	-	1	-	-	2
5	-	-	2	-	3	-	-	1	-	-	-	1	-	-	2

UNIT I **6 Hours**

BIOLOGY OF PLANT TISSUE CULTURE

Basics of plant cell, Cellular differentiation, dedifferentiation & redifferentiation, Totipotency, Cellular plasticity, Organogenesis and Embryogenesis, Somoclonal variation, History of plant tissue culture.

UNIT II **6 Hours**

COMPONENTS IN TISSUE CULTURE PROCEDURES

Explants: types and sterilization techniques, Equipment and accessories for Plant tissue culture, Laboratory organization, Micro and macro nutrients, Vitamins, solidifying agents, Plant growth hormones, Role of adsorbents and antioxidants in PTC, Antibiotics in Plant tissue culture.

UNIT III **6 Hours**

TISSUE CULTURE TECHNIQUES

Need for variety of techniques in PTC, *in-vitro* seed germination, Micropropagation, Suspension culture, Callus culture, Somatic embryogenesis, Protoplast cultures, Hairy root culture.

UNIT IV **6 Hours**

COMMERCIAL APPLICATIONS OF PLANT TISSUE CULTURE

Disease free seed production technology, Hybridization & mutant selection, Secondary metabolite production, GMO & transgenic Crops, organ culture for production of active ingredients in food and cosmetics, Regulations in PTC derived plantlets.

UNIT V **6 Hours**

ADVANCEMENTS IN PLANT TISSUE CULTURE

Automation in plant tissue culture, Artificial Intelligence models in optimization procedures, CRISPR mediated gene editing using PTC techniques, Molecular farming & edible vaccines.

EXPERIMENT 1 **4 Hours**

Plant tissue culture laboratory organization

EXPERIMENT 2 **4 Hours**

Tissue culture medium stock preparation

EXPERIMENT 3 **4 Hours**

Explant selection and sterilization techniques

EXPERIMENT 4 **4 Hours**
Medium preparation, sterilization and explant inoculation

EXPERIMENT 5 **4 Hours**
Hardening and Acclimatization

EXPERIMENT 6 **5 Hours**
Protoplast preparation and isolation

EXPERIMENT 7 **5 Hours**
Agrobacterium infiltration: Syringe & vacuum infiltration

Practical: 30 Hours
Lecture: 30 Hours
Total: 60 Hours

Reference(s)

1. M. K. Razdon, Introduction to Plant Tissue Culture, Oxford &IBH Publishing Company, 2006.
2. S. Narayanaswamy, Plant Cell & Tissue Culture, Tata Mc Graw-Hill, 2008.
3. A. Slater, N. Scott and M. Fowler, Plant Biotechnology: The genetic manipulation of plants, Oxford University Press, 2003.
4. Sharma, R.C., Sharma, I., Kaur, D.J. and Bala, R., 2011. Disease free seed production of wheat in Punjab: Achievements. *Journal of Wheat Research*, *3*(2).
5. Loyola-Vargas, V.M. and Ochoa-Alejo, N., 2018. An introduction to plant tissue culture: advances and perspectives. *Plant cell culture protocols*, pp.3-13.

22HS007 **ENVIRONMENTAL SCIENCE** **2 0 0 0**

Course Objectives

- Understand the interdisciplinary and holistic nature of the environment
- Identify the significance of natural resources and environment on the quality of life and stimulate the quest for sustainable development
- Assess the socio-economic, political and ethical issues in environmental science

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Course Outcomes (COs)

1. Apply principles of natural resource management to analyze exploitation cases in forestry, water, minerals, and agricultural sectors, assessing their environmental impacts.
2. Analyze the different types of ecosystems and biodiversity, its values and also role of professionals in protecting the environment from degradation
3. Analyze the existing environmental challenges related to pollution and its management
4. Analyze the impacts of unsustainable practices, waste management, climate change, and water conservation on environmental sustainability
5. Analyze the impact of population and human activities on environment

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
3	2	2	-	-	-	-	1	-	-	-	-	-	-	-	-
4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I **6 Hours**

NATURAL RESOURCES

Forest resources: Use - over exploitation - deforestation - case studies. Water resources: Use - over utilization of surface and ground water - conflicts over water. Mineral resources: Use - exploitation - environmental effects of extracting and using mineral resources - case studies. Food resources: Effects of modern agriculture - fertilizer-pesticide problems (eutrophication, blue baby syndrome, biomagnification). Energy resources: renewable (solar, wind, and hydro).

UNIT II **6 Hours**

ECOSYSTEMS AND BIODIVERSITY

Concept of an ecosystem: Structure and function of an ecosystem - producers - consumers - decomposers - food chains - food webs and ecological pyramids - Types of ecosystem: Introduction - characteristic features: desert ecosystem. Biodiversity - value of biodiversity - threats to biodiversity - endangered and endemic species - Conservation of biodiversity: In-situ and ex-situ conservation of biodiversity.

UNIT III **6 Hours**

ENVIRONMENTAL POLLUTION

Pollution: Definition - causes - effects - control measures of air pollution - water pollution: (Sewage water treatment by activated sludge and trickling filter process) - noise pollution- thermal pollution. Disaster management: causes - effects - control measures of floods - earthquake

UNIT IV **7 Hours**

SOCIAL ISSUES AND ENVIRONMENT

Sustainable development : Definition - Unsustainable to sustainable development - solid waste management - causes - effects - 5R Principles (landfills, incineration, composting). Water conservation- rain water harvesting - watershed management. Climate change - global warming - acid rain - ozone layer depletion. E-waste

UNIT V **5 Hours**

HUMAN POPULATION AND ENVIRONMENT

Human population: Population growth - characteristics - variation among nations - population explosion-value education - HIV / AIDS. Role of information technology in environment and human health - occupational safety and health administration (OSHA)

Total: 30 Hours

Reference(s)

1. Anubha Kaushik and C.P. Kaushik, Environmental Science and Engineering, 4th Edition, New Age International Publishers, New Delhi, 2014.
2. T.G.Jr. Miller and S. Spoolman, New Environmental Science, 14th Edition, Wadsworth Publishing Co, New Delhi, 2014.

A. K. De, Environmental Chemistry, 7th Edition, New age international publishers, New Delhi, 2014.

3. Raven, P.H , Hassenzahl, D.M. and Berg, L.R., Environment, 8th edition. John Wiley & Sons, 2012.
4. Pepper I.L, Gerba C.P. and Brusseau M.L, Environmental and Pollution Science. Academic Press, 2011.

22HS008 ADVANCED ENGLISH AND TECHNICAL EXPRESSION 0 0 2 1

Course Objectives

- To enable students to achieve proficiency in academic writing
- Effectively use the language to persuade others
- Appreciate the nuances of the language and engage an audience
- Use advanced tools of language to improve communicative competence
- Prepare for professional demands at the workplace
- Give concrete expression to the plans and goals

Programme Outcomes (POs)

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Course Outcomes (COs)

1. Infer the clarity in articulating the objectives and aims and improved proficiency in using the English language
2. Communicate effectively and with good interpersonal skills; speak in public, engage the audience, and lead a group discussion
3. Critically evaluate the ethics of persuasive appeals and confidence to influence opinion
4. Analyse a specific piece of information; take in what is read, and use good writing techniques with proper grammar and syntax in all formal situations
5. Create awareness and empathy to emotional signals in communication

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
2	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
3	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
4	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
5	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-

UNIT I 15 Hours

CREATIVE EXPRESSION

Proposals & Grant applications, Argumentative essays & editorials, Sales Pitches, Campaigning, Commercials/advertisements, effectively answering the famous interview question: 'Why should we hire you?' Sentence and paragraph formation - Rhetorical questions - Emphasis & effective repetition - Empathetic expression, knowing the audience, capturing attention - Creating Memes, Comic Strips, Stand-up comedy, Caption writing, and Limericks, Vocabulary and slang words for comedy - Similes & Metaphors - Homophones, homonyms, alliteration, wordplay.

UNIT II 15 Hours

FORMAL EXPRESSION

Writing: Action plans, Cover letters, Mind-Mapping, Paragraph writing Logical reasoning - SVA - Advanced level Style: Clarity, Concision, Coherence, Evocativeness, Efficacious Vocabulary - Conditional Clause - Be verbs. Tenses- advanced - Opening and closing sentences - Action plans, Anecdotal references, order of communication/ narration, complete communication- Wh-questions - Effective beginning and closing - Rhetorical questions - Appraising target audience - Pronunciation, Enunciation, Tone, Pace and Volume. - Writing: SOPs,Research objectives, Thesis Statement, Indexing, Scholarly Articles, Academic Writing, Executive Summary, Survey . Questionnaires, Citations and Bibliography - Reading: Quantitative & qualitative analysis, Analysis and paraphrasing of reference materials Speaking: Commentate live events, give instructions to operate machines/ conduct experiments Listening: Informational listening, Reflective listening, - Discriminative listening - Connective words - prefixes and Suffixes - Quoting and paraphrasing Proofreading - Directed writing and writing formats - Note taking - Active verbs.

Total: 30 Hours

Reference(s)

1. Sangeeta Sharma et.al. Communication Skills for Engineers and Scientists, PHI Learning Pvt. Ltd, 2011
2. Murphy, Raymond. English Grammar in Use: A Self-Study Reference and Practice Book for Intermediate Students: with Answers. Cambridge: Cambridge University Press, 1985.
3. Business Correspondence and Report Writing by Prof. R.C. Sharma & Krishna Mohan, Tata McGraw Hill & Co. Ltd., 2001
4. Personality Development, Harold R. Wallace &L.Ann Masters, Cengage Learning, New Delhi
5. Developing Communication Skills by Krishna Mohan, Meera Bannerji- Macmillan India Ltd. 1990, Delhi
6. English Grammar, Composition and Usage by N.K.Agrawal&F.T.Wood, Macmillan India Ltd., New Delhi

22HS010	SOCIALLY RELEVANT PROJECT	L	T	P	C
		0	0	2	-

Pre-requisite	Assessment Pattern	
• NIL	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	100
	Semester End Examinations	NA

Course Objectives

- To develop Problem-Solving Skills
- To enhance Research and Analytical Abilities
- To promote Social Responsibility and Ethical Awareness

Programme Outcomes (POs)

PO2	**Problem Analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/ Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and the cultural, societal, and environmental considerations.
PO5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
PO9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO12	**Life-long Learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
PSO1	Use the analytical instruments and techniques to separate, purify and characterize biological compounds
PSO2	Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors
PSO3	Conceive, Plan and Deploy societal projects for environmental protection using bioresources

Course Outcomes (COs)

The students will be able to

CO1	Interact with society conduct a field surveys and identify societal issues.
CO2	Analyze societal problems using engineering principles.
CO3	Develop plan and provide optimal solutions for social issues using their engineering knowledge and skills.
CO4	Prepare comprehensive reports on their findings and proposed solutions.
CO5	Enhance the social responsibility and ethical considerations in engineering.
CO6	Develop community interaction and managerial skills

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO 2	PSO 3
1	-	2	-	-	2	-	-	3	3	3	-	2	-	-	2
2	-	3	-	-	-	-	-	3	3	3	-	2	-	2	2
3	-	-	3	-	2	-	-	3	3	2	-	2	-	-	-
4	-	-	-	-	-	-	-	2	2	2	-	2	2	3	-
5	-	-	-	-	-	-	-	3	3	3	-	2	-	2	3
6	-	-	-	-	-	-	-	2	1	2	-	2	2	-	-

Students have to interact with society, conduct a field survey and identify the issues / problems available in the society. Analyze the issues using engineering knowledge, skills and attitude and provide the optimal solutions to solve the social issues and submit the report.

Total	**40 Hours**

22BT501 **GENETIC ENGINEERING** **3 0 2 4**

Course Objectives

- To familiarize students on various enzymes and vectors used in genetic engineering.
- To give exposure on cloning techniques and their applications.
- To create deeper understanding on various techniques of gene manipulation.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the Limitations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
PSO1.Use the analytical instruments and techniques to separate, purify and characterize biological compounds.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.

Course Outcomes (COs)

1. Apply the microbial enzymes for constructing recombinant DNA.
2. Apply the vectors for cloning and expression of gene of interest.
3. Analyze the mechanism of construction of DNA libraries.
4. Analyze the molecular techniques used in genetic engineering.
5. Evaluate the applications of genetic engineering in biotechnology.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	1	-	-	2	-	-	-	-	-	-	-	1	-	-
2	2	-	-	-	3	-	-	1	-	-	-	-	1	-	-
3	3	-	-	-	2	-	-	1	-	-	-	-	-	2	-
4	2	1	-	-	3	-	-	-	-	-	-	-	-	2	-
5	2	-	-	-	-	3	-	1	-	-	-	-	-	2	-

UNIT I **9 Hours**

ENZYMES USED IN GENETIC ENGINEERING

Nuclease - exonucleases and endonucleases, Restriction enzymes- nomenclature, types, applications, Restriction endonuclease - blunt and sticky ends, RNases, DNA Ligase, Polymerases, DNA Modifying enzymes - alkaline phosphatase, polynucleotide kinase and terminal deoxynucleotidyl transferase.

UNIT II **9 Hours**

VECTORS FOR GENE CLONING AND EXPRESSION

Cloning and expression vectors, Plasmids (pBR322, pUC & pET), Plasmid Copy Number, Phage vectors (λ DNA vectors & M13 phage vector), Combinational vectors (Cosmids & Phagemids), Shuttle vectors, Artificial chromosomes (bacterial and yeast artificial chromosomes), Viral vectors (SV 40, Adenovirus & Retrovirus).

UNIT III **9 Hours**

CONSTRUCTION OF LIBRARIES

Linkers, adaptors and homopolymer tailing, Construction of genomic library, cDNA construction - hairpin loop strategies, Directional and non-directional cDNA synthesis, Construction of full length cDNA library- Oligo capping, Okayama and Berg method of cDNA cloning, Screening of libraries.

UNIT IV **9 Hours**

TECHNIQUES FOR GENETIC ENGINEERING

Polymerase chain reactions, RAPD, RFLP, Molecular beacons and Taqman assay, Nucleic acid sequencing, Southern and northern blotting, Gene transfer technologies.

UNIT V **9 Hours**

APPLICATIONS OF GENETIC ENGINEERING

Gene therapy- ex vivo and in vivo, Genetic engineering in medicine - recombinant therapeutics and biopharmaceuticals, antibiotics, vaccines; Genetic engineering in agriculture - biopesticides, herbicides; Applications in environment- bioremediation or environment clean-up.

EXPERIMENT 1 **2 Hours**

Primer designing using online tools

EXPERIMENT 2 **5 Hours**

Gene amplification by PCR and its confirmation by agarose gel electrophoresis

EXPERIMENT 3 **5 Hours**

Restriction & ligation of vector and the amplified DNA

EXPERIMENT 4 **4 Hours**

Competent cell preparation

EXPERIMENT 5 **4 Hours**

Transformation of recombinant vector into *E. coli* by Heat shock / electroporation

EXPERIMENT 6 **5 Hours**

Confirmation of recombinant transformed clones using Blue White screening

EXPERIMENT 7 **5 Hours**

Isolation of recombinant plasmid DNA using alkaline lysis method

Practical: 30 Hours
Lecture: 45 Hours
Total: 75 Hours

Reference(s)

1. Smita Rastogi and Neelam Pathak, Genetic Engineering, Oxford University Press, 2009
2. T.A.Brown, Gene Cloning an Introduction, U.K: Blackwell Publishers, 2001
3. R.W.Old and S.B.Primrose, Principles of Gene Manipulation: An Introduction to Genetic engineering, Blackwell Science Publications, 2001
4. B.D.Singh, Biotechnology, Kalyani Publishers, 2010
5. https://archive.nptel.ac.in/courses/102/103/102103013/#

22BT502 BIOPROCESS ENGINEERING 3 0 2 4

Course Objectives

- To understand the fundamentals of bioreactor design for efficient production of biomolecules and monitoring of bioprocesses in industry.
- To plan a research career or to work in the biotechnology industry with strong foundation about bioreactor design and scale-up.
- To apply modelling and simulation of bioprocesses to reduce costs and to enhance the quality of products and systems.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO2. Process designing and production of novel biomolecules for the agricultural, environmental and healthcare sectors.

PSO3. Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Apply the bioprocess and sterilization kinetics.
2. Apply stoichiometric calculations to predict bioprocess efficacy.
3. Analyze the productivity in a bioreactor for the given metabolite.
4. Evaluate the structured models and metabolic pathways in product formation.
5. Evaluate simulated bioprocesses for automatic control with reduced costs and enhanced product quality.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	1	1	-	2	-	-	3	-	-	-	-	-	-	-
2	3	3	-	-	-	-	-	-	-	2	-	-	-	-	-
3	3	3	3	3	2	-	-	-	-	-	-	-	-	-	-
4	-	-	2	3	3	-	-	1	-	-	2	2	-	3	2
5	1	3	-	-	2	-	-	-	-	-	-	-	-	-	-

UNIT I **9 Hours**

MEDIA DESIGN AND STERILIZATION

Basic configuration of bioreactor and ancillaries, medium requirements for bioprocesses, Medium formulation of optimal growth and product formation, Medium optimization methods, Thermal death kinetics of microorganisms, Heat and filter sterilization of liquid media, Air sterilization, Design of sterilization equipment.

UNIT II **9 Hours**

METABOLIC STOICHIOMETRY AND ENERGETICS

Stoichiometry of cell growth and product formation, Elemental balances, Degrees of reduction of substrate and biomass, Available electron balances, Yield coefficients of biomass and product formation, Energetic analysis of microbial growth and product formation, Thermodynamic efficiency of growth.

.

UNIT III **9 Hours**

BIOREACTOR DESIGN AND SCALE UP

Batch, Fed batch and continuous cultivation – Feeding Strategies and Microbial Kinetics, Rheology of fermentation fluids, Transport phenomena in bioprocess systems, Oxygen mass transfer rate determination methods, Stirred tank reactor, Plug flow reactor, Fluidized bed reactor, Bubble column, Air lift reactor, Photo bioreactor, Bioreactors on a chip, Scale up criteria for bioreactors.

UNIT IV **9 Hours**

MODELLING OF BIOPROCESSES

Monod's model, Multiple substrate models, Models of growth associated product formation kinetics, Compartmental models, Models of cellular energetics and metabolism, Single cell models, Models of gene expression and regulation, Models of plasmid expression and replication.

UNIT V **9 Hours**

BIOPROCESS SIMULATION

Major subsystems of a process simulator, General architecture of on-line simulation system, Dynamic simulation of batch, fed batch, steady and transient culture metabolism, Model simulation using MATLAB-SIMULINK and ISIM software packages.

EXPERIMENT 1 **4 Hours**

Sterilization of bioreactor.

EXPERIMENT 2 **4 Hours**

Estimation of growth kinetic parameters of bacterial cells.

EXPERIMENT 3 **4 Hours**

Determination of Volumetric Oxygen Transfer Coefficient (K_La) in fermentation system.

EXPERIMENT 4 **4 Hours**

Determination of mixing time in a stirred tank reactor.

EXPERIMENT 5 **4 Hours**

Estimation of cell maintenance coefficient and true growth yield by studying the mass and energy balance during cell growth.

EXPERIMENT 6 **5 Hours**

Determination of Residence Time Distribution (RTD) for a CSTR.

EXPERIMENT 7 **5 Hours**

Studies on the kinetics of immobilized enzyme and immobilized cells.

Practical: 30 Hours
Lecture: 45 Hours
Total: 75 Hours

Reference(s)

1. Michael L. Shuler and Fikret Kargi, Bioprocess Engineering - Basic Concepts, Pearson New International Edition, 20PSO 2
2. Pauline M. Doran, Bioprocess Engineering Principles, Academic Press Limited, 20PSO 1
3. Peter F. Stanbury, Allan Whitaker and Stephen J. Hall, Principles of Fermentation Technology, Butterworth Heinemann publications, 1995.
4. Harvey W. Blanch, S. Douglas and Clark, Biochemical Engineering, New York: Marcel Dekker Inc., 1997.
5. Shijie Liu, Bioprocess Engineering - Kinetics, Sustainability, and Reactor Design, Elsevier Science, 20PSO 1
6. Kim Gail Clarke, Bioprocess Engineering - An Introductory Engineering and Life Science Approach, Elsevier Science, 2010.

22BT503 **ANIMAL TISSUE CULTURE** **3 0 2 4**

Course Objectives

- To impart the knowledge on basic concepts of cell culture techniques
- To gain theoretical and practical knowledge on animal cell culture in vitro
- To have an exposure of real time applications of culturing techniques

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.

Course Outcomes (COs)

1. Apply the fundamental knowledge of cell culture techniques and their competency in culture techniques.
2. Apply the various culture media available for different cell lines.
3. Apply the knowledge of developing cell lines from primary cell culture.
4. Analyze the efficiency of developed cell line cultures.
5. Analyze the potential benefits of cell lines in disease management.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	-	2	-	-	2	2	3	-	-	-	-	-	2	-
2	2	-	3	-	-	2	2	2	-	-	-	-	-	-	-
3	3	-	2	-	-	3	2	3	-	-	-	-	-	1	-
4	2	-	3	-	-	2	1	2	-	-	-	-	-	1	-
5	2	-	2	-	-	3	2	3	-	-	-	-	-	2	-

UNIT I **9 Hours**

INTRODUCTION TO TISSUE CULTURE

Introduction, history and development of tissue culture; equipment's for tissue culture; Aseptic techniques; Layout of tissue culture laboratory, Safety guidelines.

UNIT II **9 Hours**

CELL CULTURE MEDIA AND STERILIZATION

Cell culture media components; types of cell culture media; biological and defined media; serum free media and balanced salt solution; sterilization techniques- hydrophobic, hydrophilic method of sterilization, filter sterilization.

UNIT III **9 Hours**

CELL CULTURE TECHNIQUES

Development of primary culture and passaging; development of suspension culture; cell line development, finite and continuous cell lines-Hayflick limit; cell line designations; Routine maintenance; cell line immortalization.

UNIT IV **9 Hours**

CELL CULTURE CHARACTERIZATION AND MAINTENANCE

Cell line characterization methods; cryopreservation and maintenance; common cell culture contaminants; cell viability and cytotoxicity assays.

UNIT V **9 Hours**

APPLICATIONS OF CELL CULTURE

Recombinant protein production; gene and stem cell therapy; gene transfer methods; viral and non-viral methods; transgenic animal production.

EXPERIMENT 1 **3 Hours**

Organizing animal tissue culture laboratory.

EXPERIMENT 2 **3 Hours**

Cell culture media preparation & sterilization.

EXPERIMENT 3 **3 Hours**

Establishment of primary culture - Cell line.

EXPERIMENT 4 **3 Hours**

Passaging of primary culture- Cell line.

EXPERIMENT 5 **6 Hours**

In vitro cytotoxicity and genotoxicity assays.

EXPERIMENT 6 **6 Hours**

Gene Expression Studies – RT PCR.

EXPERIMENT 7 **6 Hours**

Protein Expression Studies- Western blot.

Practical: 30 Hours
Lecture: 45 Hours
Total: 75 Hours

Reference(s)

1. Freshney, Culture of Animal Cells, 5th Edition, Wiley-Liss, 2005
2. Ed. John R.W. Masters, Animal Cell Culture - Practical Approach, 3rd Edition, Oxford University Press, 2000.
3. Ed. Martin Clynes, Animal Cell Culture Techniques. Springer, 1998.
4. Yao, T. and Asayama, Y., 2017. Animal-cell culture media: History, characteristics, and current issues. *Reproductive medicine and biology*, *16*(2), pp.99-117.
5. https://onlinecourses.nptel.ac.in/noc22_bt64/preview

22BT504 **BIOINFORMATICS** **3 0 2 4**

Course Objectives

- To understand the theory and background of commonly available bioinformatics tools.
- To navigate through internet-based biological databases and genomic browsers.
- To use online resources for biological applications.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO1. Use the analytical instruments and techniques to separate, purify and characterize biological compounds.

Course Outcomes (COs)

1. Apply the importance of biological databases and their usage.
2. Apply the knowledge of bioinformatics in analysis of biological information.
3. Analyze the evolutionary concepts to build phylogenetic tree.
4. Analyze the concepts of systems biology for various applications.
5. Evaluate the drug designing techniques with online resources.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	1	2	2	-	-	-	-	-	-	2	2	-	-
2	2	2	1	2	2	-	-	-	-	-	-	2	2	-	-
3	2	2	1	2	2	-	-	-	-	-	-	2	2	-	-
4	3	2	1	2	2	-	-	-	-	-	-	2	2	-	-
5	3	2	1	2	2	-	-	-	-	-	-	1	1	-	-

UNIT I **9 Hours**

INTRODUCTION TO BIOINFORMATICS

Introduction to bioinformatics, Basics of database, Biological databases, Protein and Nucleic Acid Databases, PDB, NCBI, Swissprot, KEGG, Uniprot, CATH, SCOP NDB, RNA Structurome DB, Database management models

UNIT II **9 Hours**

SEQUENCE ALIGNMENT

Pairwise sequence alignments - basic concepts of sequence alignment, local and global alignments, Dot Plot, scoring matrices, Multiple Sequence Alignment – CLUSTAL W, T-COFFEE, Genetic Algorithm, HMM.

UNIT III **9 Hours**

PHYLOGENETIC ANALYSIS

Basic concepts in systematics, taxonomy and phylogeny; molecular evolution; nature of data used in Taxonomy and Phylogeny, Definition and description of phylogenetic trees and various types of trees. Phylogenetic Tree construction Methods: Distance Methods, Parsimony, Maximum likelihood Methods Tree evaluation: Jackknifing, Bootstrapping.

UNIT IV **9 Hours**

INTRODUCTION TO SYSTEMS BIOLOGY

Introduction to systems biology, Systems theory, Advantages over reductionist approach, Biological networks - metabolic, signaling & regulatory network, Flux analysis MFA & FBA, Bottom-up approach, Top-down approach, Applications - Metabolic engineering, Synthetic biology.

UNIT V **9 Hours**

ADVANCED BIOINFORMATICS

Data mining, Clustering & Classification, Basics of Machine learning, Next Generation Sequence Analysis, High Throughput Sequence Analysis, Computer aided drug design, Quantitative structure activity relationship (QSAR) for drug designing.

EXPERIMENT 1 **4 Hours**

Retrieving files and information from biological databases (NCBI, PDB, PubChem).

EXPERIMENT 2 **3 Hours**

Sequence alignment -BLAST, FASTA, Clustal Omega.

EXPERIMENT 3 **5 Hours**

Molecular phylogenetic analysis.

EXPERIMENT 4 **4 Hours**

Gene annotation and gene finding.

EXPERIMENT 5 **4 Hours**

Molecular modeling of protein and its visualization.

EXPERIMENT 6 **5 Hours**

Computer aided drug design with online tools.

EXPERIMENT 7 **5 Hours**

Network construction and visualization.

Practical: 30 Hours
Lecture: 45 Hours
Total: 75 Hours

Reference(s)

1. David B. Mount: Bioinformatics. Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press, New York, 2001.
2. Andreas D. Baxevanis, B. F. Francis Ouellette: Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Volume 39, John Wiley, 1998.
3. Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, Chapman & Hall, 2006.
4. James Tisdall, Beginning Perl for Bioinformatics. O'Reilly & Associates,2000.
5. https://archive.nptel.ac.in/courses/102/106/102106065/

22BT507 **MINI PROJECT I** **0 0 2 1**

Course Objectives

- To identify the problem statement and apply the engineering concepts to find the solution.
- To improve the analysing capability of the students.
- To increase the exuberance in finding the solution to various problems.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to ones own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PSO1. Use the analytical instruments and techniques to separate, purify and characterize biological compounds.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using bio-resources.

Course Outcomes (COs)

1. Formulate a real world problem, identify the requirement and develop the design solutions.
2. Identify technical ideas, strategies and methodologies.
3. Utilize the new tools, algorithms, and techniques that contribute to obtaining the solution of the project.
4. Test and validate through conformance of the developed prototype and analysis of the cost-effectiveness.
5. Prepare the report and present oral demonstrations.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	1	1	2	-	-	2	2	2	-	-	1	1	1
2	1	2	1	1	2	-	-	2	2	2	-	-	1	1	1
3	1	2	1	1	2	-	-	2	2	2	2	-	1	1	1
4	1	2	1	1	2	-	-	2	2	2	2	-	1	1	1
5	1	2	-	-	2	-	-	2	2	2	-	-	1	1	1

22BT601 **DOWNSTREAM PROCESSING** **3 0 2 4**

Course Objectives

- To introduce the methods of separation technology.
- To expose the students to technique of product purification.
- To have depth knowledge and hands on experience in downstream process.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO2 Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.

Course Outcomes (COs)

1. Apply the separation techniques used in downstream process for the purification of biomolecules.
2. Apply techniques of insoluble removal and predict the parameters used in bulk product isolation.
3. Analyze the parameters involved in the separation techniques for large scale operations.
4. Apply the techniques of high-resolution product purification based on product characteristics and cost effectiveness.
5. Evaluate the techniques of final product formulation.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	-	-	2	-	-	-	-	-	-	1	-	2	-
2	1	2	2	-	3	-	-	-	-	-	-	2	-	2	-
3	1	2	2	-	3	-	-	-	-	-	-	2	-	3	-
4	2	-	-	-	3	-	-	-	-	-	-	2	-	2	-
5	2	-	2	-	3	3	-	-	-	-	-	2	-	1	-

UNIT I **9 Hours**

DOWNSTREAM PROCESSING IN BIOTECHNOLOGY

Introduction to downstream processing; Principles and characteristics of bio-molecules and bioproducts, Rheology of fermentation broth; Cell disruption for product release – mechanical, enzymatic and chemical methods; Pre-treatment and stabilisation of bio-products.

UNIT II **9 Hours**

PHYSICAL METHODS OF SEPARATION

Unit operations for solid - liquid separation - Flocculation and sedimentation; Centrifugation – batch, continuous, basket, tubular bowl, disk and ultra-centrifugation; Filtration - conventional and cross flow filtration.

UNIT III **9 Hours**

ISOLATION OF PRODUCTS

Adsorption; liquid-liquid extraction; aqueous two-phase extraction; membrane separation –microfiltration, ultrafiltration, nano filtration, reverse osmosis, electrolysis, dialysis, pervaporation; precipitation of proteins by different methods.

UNIT IV **9 Hours**

PRODUCT RESOLUTION AND FRACTIONATION

Chromatography - principles, instrumentation and types - adsorption, reverse phase, ion- exchange, size exclusion, hydrophobic interaction, gas chromatography, high performance chromatography, Bio-affinity chromatography; Electrophoresis and the methodologies.

UNIT V **9 Hours**

FINISHING OPERATIONS FOR FINAL PRODUCT

Principles, practices and equipments of Crystallization; Drying; Lyophilization, Sterilization, Optimization of additives.

EXPERIMENT 1 **4 Hours**

Cell Disruption by Physical method.

EXPERIMENT 2 **4 Hours**

Cell Disruption by Chemical method.

EXPERIMENT 3 **4 Hours**

Microfiltration using tangential flow separation.

EXPERIMENT 4 **4 Hours**

Precipitation of proteins.

EXPERIMENT 5 **4 Hours**

Aqueous two phase extraction of biological molecules.

EXPERIMENT 6 **5 Hours**

High resolution purification using HPLC.

EXPERIMENT 7 **5 Hours**

Drying of bioproducts using different dryers.

Lecture: 45 Hours
Laboratory: 30 Hours
Total: 75 Hours

Reference(s)

1. P. A. Belter, E. L. Cussler and Wei-Shou Hu, Bioseparations - Downstream Processing for Biotechnology, Wiley Interscience, 1988.
2. B. Sivasankar, Bioseparations - Principles and Techniques, Prentice Hall of India Pvt. Ltd., 2007.
3. R. G. Harrison, P. Todd, S. R. Rudger and D. P. Petrides, Bioseparation Science and Engineering, Oxford University Press, 2003.
4. Product Recovery in Bioprocess technology, BIOTOL series, Butterworth Heinemann,2006.
5. https://archive.nptel.ac.in/courses/102/106/102106022/
6. Khoo, K. S., Chew, K. W., Yew, G. Y., Leong, W. H., Chai, Y. H., Show, P. L., & Chen, W. H. (2020). Recent advances in downstream processing of microalgae lipid recovery for biofuel production. Bioresource technology, 304, 122996.

22BT602 **IMMUNOLOGY** **3 0 2 4**

Course Objectives

- To understand the concepts of immune system and the structure, functions and properties of different cell types and organs that comprise the immune system.
- To comprehend the range of immunological agents and the strategies that may be used to prevent and combat infectious diseases.
- To understand transplantation and autoimmunity.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8. Ethics: Apply ethical principles and commit to professional ethics, responsibilities, and norms of the engineering practice.
PSO2 Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.

Course Outcomes (COs)

1. Apply the structure, function and properties of different cell types and organs in the immune system and the types of immune response.
2. Apply the structure, function and differentiation of the cells involved in humoral immune response and the production of monoclonal and polyclonal antibodies.
3. Analyze the development and differentiation of T-cells and the mechanism involved in cell-mediated immune response.
4. Analyze the immune responses against microbial infections, allergy and hypersensitivity and the process of cytokine and complement activation
5. Analyze the autoimmune disorder and graft rejection during organ transplantation and will be able to provide a possible solution.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1	2	3	-	-	-	-	-	-	-	-	-	-	2	-
3	1	2	3	-	-	-	-	-	-	-	-	-	-	2	-
4	-	2	3	2	-	-	2	-	-	-	-	-	-	2	-
5	-	-	3	-	-	2	-	1	-	-	-	-	-	2	-

UNIT I **9 Hours**

INTRODUCTION TO IMMUNE SYSTEM

Organisation and classification of immune system – immune cells and organs; innate and acquired immunity; Toll receptors and responses, classification of antigens – chemical and molecular nature; haptens, adjuvants; cytokines; complement pathway, antigen presenting cells; major histocompatibility complex.

UNIT II **9 Hours**

HUMORAL AND CELLULAR IMMUNITY

Development, maturation, activation, regulation, differentiation and classification of T-cells and B cells, antigen processing and presentation, theory of clonal selection, TCR; Antibodies: structure and functions; Antibodies: genes and generation of diversity; antigen-antibody reactions.

UNIT III **9 Hours**

IMMUNITY AGAINST PATHOGENS AND TUMORS

Inflammation; protective immune responses to virus, bacteria, fungi and parasites; tumor antigens, tumor immune response, tumor diagnosis, tumor immunotherapy.

UNIT IV **9 Hours**

IMMUNE TOLERANCE AND HYPERSENSITIVITY

Immune tolerance, Immuno deficiencies; Transplantation – genetics of transplantation; laws of transplantation; Allergy and hypersensitivity – Types of hypersensitivity, Autoimmunity, Auto immune disorders and diagnosis.

UNIT V **9 Hours**

APPLIED IMMUNOLOGY

Monoclonal antibodies, engineering of antibodies; Classification of Vaccines, methods of vaccine development, immunodiagnostic methods (Immuno diffusion ELISA, FACS), immune modulatory drugs.

EXPERIMENT 1 **4 Hours**

Blood grouping and Blood Typing (ABO).

EXPERIMENT 2 **4 Hours**

Detection of Salmonella antibody in serum (Widal test).

EXPERIMENT 3 **4 Hours**

Ouchterlony double immunodiffusion (ODD).

EXPERIMENT 4 **4 Hours**

Radial immuno diffusion (RID).

EXPERIMENT 5 **4 Hours**

Rocket immuno electrophoresis (RIE).

EXPERIMENT 6 **5 Hours**

Enzyme-linked Immunosorbent assay (ELISA)

EXPERIMENT 7 **5 Hours**

SDS PAGE & Western Blotting.

Lecture: 45 Hours
Practical: 30 Hours
Total: 75 Hours

Reference(s)

1. A David Male, Jonathan Bros toff, David Roth and Ivan Roitt, Immunology, Mosby Publication, 2006.
2. Ashim K. Chakravarty, Immunology and Immunotechnology , Oxford University Press India Publication, 2006.
3. Thomas J. Kindt, Barbara A. Osborne and Richard A. Goldsby, Kuby Immunology, W.H. Freeman & Company, 2006.
4. P. M. Lydyard, A. Whelan and M. W. Fanger, BIOS Instant Notes in Immunology, Taylor & Francis Publication, 2011.
5. Judith A Owen, Jenni Punt, Sharon A Stanford, Patricia P Jones, Janis Kuby, Kuby Immunology 7th Edition,New York : W.H. Freeman, 2013.

22BT603 ENZYME AND PROTEIN ENGINEERING 3 0 2 4

Course Objectives

- To provide students with a basic understanding of classification, nomenclature, mechanism and specificity of enzyme-coenzyme action, extraction, purification and characterization of enzymes.
- To understand enzyme immobilization methods, kinetics of free, immobilized and allosteric enzymes.
- To learn the stability, dynamics, structure/function relationships, folding of proteins and rational drug design.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to ones own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.

Course Outcomes (COs)

1. Apply and gain knowledge on enzyme, coenzyme and their classification.
2. Apply the different methods of Production and Purification of enzymes from various sources.
3. Apply the theoretical and practical aspects of enzyme kinetics for promoting research.
4. Analyze the tertiary and quaternary structure of proteins.
5. Evaluate the role of structure function relationship of proteins.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	3	-	-	-	-	-	-	-	-	-	-	-	2	-
2	1	2	3	2	-	-	-	-	-	-	-	-	-	1	-
3	3	3	1	-	-	-	-	-	-	-	-	-	-	2	-
4	2	3	1	1	-	-	-	-	-	-	2	-	-	1	-
5	2	3	3	-	-	-	-	-	-	-	2	-	-	1	-

UNIT I 9 Hours
INTRODUCTION TO ENZYMES AND PROTEIN

Nomenclature and Classification of enzymes. Mechanism and specificity of enzyme action - Units for enzyme activity - Coenzymes-Classification, Coenzymes in metabolic pathways, metal- activated enzyme and metalloenzyme; enzymes without cofactors, Abzymes, synzymes, non- protein enzymes and thermophilic enzymes. pH and temperature effect on enzyme activity.

UNIT II **9 Hours**

ENZYMES: EXTRACTION, PURIFICATION AND IMMOBILIZATION

Production and purification of crude enzyme extracts from plant, animal and microbial sources; methods of characterization of enzymes; development of enzymatic assays, Physical and chemical techniques for enzyme immobilization adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding.

UNIT III **9 Hours**

KINETICS OF ENZYME

Single and multisubstrate enzyme catalysed reaction- MM kinetics-turnover number-catalytic efficiency- ping- pong bi-bi mechanism, random - order mechanism and compulsory order mechanisms; Types of inhibition & models for substrate and product inhibition. Immobilized enzyme kinetics - Analysis of Film and Pore Diffusion Effects on Kinetics of immobilized Enzyme Reactions.

UNIT IV **9 Hours**

PROTEIN ARCHITECTURE AND STRUCTURE

Primary structure: peptide mapping, peptide sequencing -automated Edman method. Secondary structure: Alpha, beta and loop structures and methods to determine Super-secondary structures, topology diagrams, prediction of substrate binding sites. Tertiary structure: Domains, folding, denaturation and renaturation, Quaternary structure: Modular nature, formation of complexes.

UNIT V **9 Hours**

STRUCTURE-FUNCTION RELATIONSHIP

DNA-binding proteins: prokaryotic transcription factors, Helix-turn-Helix motif in DNA binding, Trp Repressor, Eukaryotic transcription factors - Membrane proteins: General characteristics, Transmembrane segments, prediction. Immunoglobulins: IgG Light chain and heavy chain architecture - Abzymes and Enzymes: Serine proteases, understanding catalyticdesign by engineering trypsin, chymotrypsin and elastase.

EXPERIMENT 1 **4 Hours**

Identification of enzyme from different sources.

EXPERIMENT 2 **4 Hours**

Production of crude enzyme extracts from plant, animal and microbial sources.

EXPERIMENT 3 **4 Hours**

Purification of crude enzyme extracts.

EXPERIMENT 4 **4 Hours**

Determination of enzyme activity.

EXPERIMENT 5 **4 Hours**

Optimization of pH and temperature for enzyme activity.

EXPERIMENT 6 **5 Hours**

Immobilization of enzymes.

EXPERIMENT 7 **5 Hours**

Determination of Km and Vmax of enzymes.

Lecture: 45 Hours
Laboratory: 30 Hours
Total: 75 Hours

Reference(s)

1. Wiseman, Alan. Hand book of Enzyme Biotechnology, 3rd ed., Ellis Harwood 1995
2. Chaplin and Bucke, Enzyme Technology, Cambridge University Press, 1990
3. Price and Stevens, Fundamentals of Enzymology, Oxford University Press,
4. Blanch, H.W., Clark, D.S. Biochemical Engineering, Marcel Dekker, 1997
5. Branden C. and Tooze J., Introduction to Protein Structured Garland Publishing, 1999.
6. Creighton T.E. Proteins, 2ndEdition. W.H. Freeman, 1993.
7. Nadar, S.S., Rao, P. and Rathod, V.K., 2018. Enzyme assisted extraction of biomolecules as an approach to novel extraction technology: A review. *Food Research International*, *108*, pp.309-330.
8. Liu, J.J., Gasmalla, M.A.A., Li, P. and Yang, R., 2016. Enzyme-assisted extraction processing from oilseeds: Principle, processing and application. *Innovative Food Science & Emerging Technologies*, *35*, pp.184-193.

22BT607 **MINI PROJECT II** **0 0 2 1**

Course Objectives

- To identify the problem statement and apply the engineering concepts to find the solution.
- To improve the analysing capability of the students.
- To increase the exuberance in finding the solution to various problems.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to ones own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PSO1.Use the analytical instruments and techniques to separate, purify and characterize biological compounds.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using bioresources.

Course Outcomes (COs)

1. Formulate a real-world problem, identify the requirements, and develop the design solutions.
2. Identify technical ideas, strategies, and methodologies.
3. Utilize the new tools, algorithms, and techniques that contribute to obtaining the solution of the project.
4. Test and validate through conformance of the developed prototype and analysis of the cost-effectiveness.
5. Prepare the report and present oral demonstrations.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	1	1	2	-	-	2	2	2	-	-	1	1	1
2	1	2	1	1	2	-	-	2	2	2	-	-	1	1	1
3	1	2	1	1	2	-	-	2	2	2	2	-	1	1	1
4	1	2	1	1	2	-	-	2	2	2	2	-	1	1	1
5	1	2	-	-	2	-	-	2	2	2	-	-	1	1	1

22BT701 GENOMICS AND PROTEOMICS 3 0 2 4

Course Objectives

- To understand the background of genomes and proteomes used in providing new insights in biotechnology tools.
- To explore the genome and protein sequence analysis and determination.
- To formulate genome related hypothesis and design an experimental plan for testing and analysis.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PSO1. Use the analytical instruments and techniques to separate, purify and characterize biological compounds.

Course Outcomes (COs)

1. Apply the importance of genomes and proteomes.
2. Apply the knowledge in genomic approaches for Biotechnology applications.
3. Apply the knowledge in proteomic approaches for Biotechnology applications.
4. Analyze the advanced genome-proteome based concepts.
5. Evaluate genome and proteomic approaches in systems biology and other medical applications.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	1	-	-	-	-	-	-	-	-	-	1	-	-
2	2	2	1	-	-	-	-	-	-	-	-	-	2	-	-
3	2	2	1	-	-	-	-	-	-	-	-	-	1	-	-
4	3	2	1	-	-	-	-	-	-	-	-	-	2	-	-
5	3	2	1	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I 9 Hours

INTRODUCTION

Introduction to genomes, transcriptomes and proteomes; Organisation and structure of genomes; DNA sequencing methods; Recombinant DNA technology; Human genome project; Overview of Protein structure; Introduction to omics: Genomics, Proteomics, Transcriptomics, Metabolomics, Fluxomics.

UNIT II 9 Hours

GENOMICS

Introduction and scope of genomics, Next generation sequencing methods, Genetic Mapping, Physical Mapping, Integration of mapping methods, Gene variation and Single Nucleotide Polymorphisms (SNPs),Expressed sequenced tags (ESTs), Gene- disease association, Polymorphism, Social, Legal and Ethical Implications of Human Genome Research.

UNIT III **9 Hours**

PROTEOMICS

Introduction and scope of proteomics, Protein separation techniques: ion-exchange, size- exclusion and affinity chromatography techniques, Polyacrylamide gel electrophoresis, Isoelectric focusing (IEF), Two dimensional PAGE for proteome analysis, Introduction to mass spectrometry, Protein sequencing, Protein modifications and proteomics.

UNIT IV **9 Hours**

ADVANCED PROTEOMICS AND GEMOMICS

Comparative genomics, Functional genomics, Structural genomics, Personal Genomics, Protein engineering, DNA and Protein chips, Functional proteomics, Quantitative proteomics, Structural proteomics, DNA Protein interactions, Protein-Protein interactions, HTP Analysis.

UNIT V **9 Hours**

APPLICATIONS OF GENOMICS AND PROTEOMICS

Systems and Synthetic biology, Genomics based drug design, Predictive Medicine, Cytogenomics, Clinical and biomedical application of proteomics, Applications of proteome analysis to drug.

EXPERIMENT 1 **5 Hours**

Genome viewers, SNP Analysis.

EXPERIMENT 2 **5 Hours**

Proteome Analysis.

EXPERIMENT 3 **5 Hours**

Structures of protein-protein and protein-DNA complexes.

EXPERIMENT 4 **5 Hours**

Enzyme activity assay.

EXPERIMENT 5 **5 Hours**

Protein Separation by SDS-PAGE.

EXPERIMENT 6 **5 Hours**

Drug Design and Simulation.

Practical: 30 Hours
Lecture: 45 Hours
Total: 75 Hours

Reference(s)

1. T.A.Brown, Genomes3, Garl and Science, 2007.
2. D.C.Libeler, Introduction to Proteomics: Tools for the New Biology, HumanaPress,2006
3. Arthur M. Lesk, Introduction to Protein Science-Architecture, Function and Genomics, Oxford University Press, 2004.
4. Peter Sudbery, Human Molecular genetics, Benjamin-Cummings Publishing Company,2010
5. S.R. Pennington, and M.J. Dunn, Proteomics: from Protein Sequence to Function First, Viva Books Private Limited, 2002
6. S.B.Primrose and R.M.Twyman, Principles of Genome Analysis and Genomics, Blackwell Publishing Co., 2005.
7. Righetti, P.G., 2004. Determination of the isoelectric point of proteins by capillary isoelectric focusing. *Journal of chromatography A*, *1037*(1-2), pp.491-499.
8. Aslam, B., Basit, M., Nisar, M.A., Khurshid, M. and Rasool, M.H., 2016. Proteomics: technologies and their applications. *Journal of chromatographic science*, pp.1-15.

22BT702 **BIOPHARMACEUTICAL TECHNOLOGY** **3 0 2 4**

Course Objectives

- To introduce diverse sources and classes of biopharmaceuticals.
- To expose students to various modes of drug delivery.
- To build deeper understanding of application of biotechnology tools in the world of medicine.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PSO1. Use the analytical instruments and techniques to separate, purify and characterize biological compounds.

PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.

Course Outcomes (COs)

1. Apply the difference between chemical and bio-based pharmaceuticals.
2. Apply the knowledge of biological effects of bioactive substances for their use as therapeutics.
3. Analyze the need for formulation of biopharmaceuticals.
4. Analyze various criteria for selection of drug carriers that result in effective drug delivery.
5. Evaluate drug action based on the difference in physiological functions of a host.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	1	-	-	-	-	-	-	-	-	-	-	2	-
2	1	2	3	-	-	-	-	-	-	-	-	-	-	2	-
3	3	1	2	-	-	-	-	-	-	-	-	-	-	3	-
4	2	1	3	-	-	-	-	-	-	-	-	-	1	2	-
5	2	1	2	-	-	-	-	-	-	-	-	-	1	2	-

UNIT I **9 Hours**

INTRODUCTION

Pharmaceutical Drug – API, Excipient; Physicochemical properties of a drug; Generic and Branded drug; Biosimilar - Global and Indian scenario, advantages and issues concerned with the use of biosimilar; Routes of Drug Administration.

UNIT II **9 Hours**

FORMULATION OF BIOPHARMACEUTICALS

Rational for formulation of biotherapeutics (Lipinski's rule of 5); Formulation of excipients – solubility enhancers (Apparent and Free), Permeability enhancer, anti-aggregating agents, buffers, cryoprotectants, antioxidants; Methods to enhance shelf-life of protein based therapeutics, Preservatives and packaging techniques.

UNIT III **9 Hours**

CONVENTIONAL DOSAGE FORMS AND NOVEL DRUG DELIVERY SYSTEMS (NDDS)

Conventional dosage forms – Solid – Tablet, Capsule and Powder; Semi-Solid – Ointments, Creams, Lotions and Gels; Liquid – Solution, Suspension, Syrup and Emulsion; Gaseous – Aerosols and Sprays; Novel Drug Delivery Systems - Liposomes, Dendrimers, Microspheres, Nanoparticles and Micelles.

UNIT IV **9 Hours**

PHARMACOKINETIC PARAMETERS

Pharmacokinetics – ADME; Absorption, Mechanism involved & Factors affecting absorption; Distribution, Mechanism involved & Factors affecting distribution, Metabolism, Mechanism involved (Phase I and II) & Factors affecting metabolism, Elimination, Mechanism involved & Factors affecting elimination; Bioavailability and Bioequivalence.

UNIT V **9 Hours**

PHARMACODYNAMIC PARAMETERS

Receptor Mediated and Non-Receptor Mediated Drug action; Agonists and Antagonists; Types of Drug Action; Site of Drug Action; Dosage; Factors affecting the efficiency of a drug.

EXPERIMENT 1 **5 Hours**

Synthesis of Paracetamol.

EXPERIMENT 2 **5 Hours**

Isolation of Lycopene.

EXPERIMENT 3 **5 Hours**

Isolation of Hesperidin.

EXPERIMENT 4 **5 Hours**

Synthesis of Methyl Salicylate.

EXPERIMENT 5 **5 Hours**

Isolation, Screening and Quantification of Bioactive Compounds from Natural Source.

EXPERIMENT 6 **5 Hours**

Preparation of Blank and Loaded Liposome for Drug Delivery.

Practical: 30 Hours
Lecture: 45 Hours
Total: 75 Hours

Reference(s)

1. Daan J A Crommelin, Pharmaceutical Biotechnology, Taylor & Francis Group, 2nd Edition, 2010.
2. Gary Walsh, Biopharmaceuticals: Biochemistry and Biotechnology, John Wiley & Sons, Inc., 2nd Edition, 2003.
3. Rodney J. Y. Ho, Biotechnology and Biopharmaceuticals: Transforming Proteins and Genes into Drugs, John Wiley & Sons, Inc., 2nd Edition, 20PSO 1
4. Gary Walsh, Pharmaceutical Biotechnology: Concepts and Applications, John Wiley &Sons, Inc., 2007.
5. Oliver Kayser and Heribert Warzecha, Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications, John Wiley & Sons, Inc., 2nd Edition.

22BT707 PROJECT WORK I 0 0 4 2

Course Objectives

- Work in teams to propose, formulate, and solve a challenging open-ended design problem of significant scope, depth, and breadth.
- Understand and incorporate engineering standards and multiple realistic constraints, within realistic design time, budget, and performance objectives.
- Develop a prototype of the proposed design and demonstrate the prototype in accordance with the specifications.
- Effectively communicate information relating to all aspects of the design process in written, oral, and graphical form.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to ones own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
PSO1. Use the analytical instruments and techniques to separate, purify and characterize biological Compounds.
PSO2. Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using bio resources.

Course Outcomes (COs)

1. Formulate a real world problem, identify the requirement and develop the design solutions.
2. Improve technical presentation and communication skills.
3. Utilize the new tools, algorithms, techniques that contribute to obtain the solution of the project.
4. Test and validate through conformance of the developed prototype and analysis the cost effectiveness.
5. Prepare report and present oral demonstrations.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	2	3	3	1	3	3	3	3	3	-	2	3	3	3
2	2	2	3	3	1	3	3	3	3	3	-	2	3	3	3
3	2	2	3	3	3	3	3	3	3	3	2	2	3	3	3
4	2	2	3	3	3	3	3	3	3	3	2	2	3	3	3
5	2	2	-	-	2	-	-	3	3	3	-	2	3	3	3

Total: 75 Hours

22BT801 PROJECT WORK II 0 0 20 10

Course Objectives

- Work in teams to propose, formulate, and solve a challenging open-ended design problem of significant scope, depth, and breadth.
- Understand and incorporate engineering standards and multiple realistic constraints, within realistic design time, budget, and performance objectives.
- Develop a prototype of the proposed design and demonstrate the prototype in accordance with the specifications.
- Effectively communicate information relating to all aspects of the design process in written, oral, and graphical form.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6 The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO1. Use the analytical instruments and techniques to separate, purify and characterize biological Compounds.

PSO2. Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors.

PSO3. Conceive, Plan and Deploy societal projects for environmental protection using bio resources.

Course Outcomes (COs)

1. Formulate a real world problem, identify the requirement and develop the design solutions
2. Improve technical presentation and communication skills
3. Utilize the new tools, algorithms, techniques that contribute to obtain the solution of the project
4. Test and validate through conformance of the developed prototype and analysis the cost effectiveness
5. Prepare report and present oral demonstrations

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	2	3	3	1	3	3	3	3	3	-	2	3	3	3
2	2	2	3	3	1	3	3	3	3	3	-	2	3	3	3
3	2	2	3	3	3	3	3	3	3	3	2	2	3	3	3
4	2	2	3	3	3	3	3	3	3	3	2	2	3	3	3
5	2	2	-	-	2	-	-	3	3	3	-	2	3	3	3

Total: 180 Hours

LANGUAGE ELECTIVES

22HS201 COMMUNICATIVE ENGLISH II 1 0 2 2

Course Objectives

- Command over the English language for day-to-day transactions.
- Improve listening and reading skills
- Increase ability to comprehend complex content
- Enhance confidence in expressing with clarity and elegance
- Enthusiastic and reflective use of the language through sufficient and focused practice
- Articulate fluently and confidently in challenging situations

Programme Outcomes (POs)

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outcomes (COs)

1. Engage with the English language in functional contexts
2. Express in both descriptive and narrative formats
3. Interpolate and make effective use of the English Language in Business contexts
4. Actively read and comprehend authentic text
5. Express opinions and communicate experiences.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	-	-	-	3	3	-	3	-	-	-
2	-	-	-	-	-	-	-	-	3	3	-	3	-	-	-
3	-	-	-	-	-	-	-	-	3	3	-	3	-	-	-
4	-	-	-	-	-	-	-	-	3	3	-	3	-	-	-
5	-	-	-	-	-	-	-	-	3	3	-	3	-	-	-

UNIT I 15 Hours

SELF-EXPRESSION

Personal Goals and Values - Being a Team Player-Expressing strengths and weaknesses-Abstract nouns - Adjectives-Active Listening skills-Note making-Pronunciation and Accent Personal goals and values - Reading for Gist and Details-Professional ethics-Reported Speech- Conjunctions Reading skills - phonemics, word/phrase recognition, sight words Personal Goals and Values- Conditional clauses- Hypothetical questions and answers-Sentence Structure-Simple Present Tense-Perfect tense

UNIT II 15 Hours

CREATIVE EXPRESSION

Instructive and Expository Expression - Creating brochures, catalogues, and manuals for products/ services, giving directions, Process writing, Sequencing experiments, Concept Explanation-Reported speech-Voice Sentence equivalence Proofreading.

UNIT III **15 Hours**

FORMAL EXPRESSION

Notices and Announcements-Writing: Creating notices and circulars for events, announcing college tours and lost and found-Varied Vocabulary - Gender Sensitive Vocabulary, Non-discriminatory Vocabulary, Concise Vocabulary-Paragraph writing - Effective titles, topics and supporting sentences, calling in registrations and queries. Effective communication- Understanding purpose, reach and target audience, achieving complete communication Punctuation - Capitalization, Numeration, Use of proper nouns and articles-Spelling-Reading: Analyzing and interpreting notices and circulars-Understanding the gist of short real-world notices, and messages. Culling out keywords Information words vs Supporting words-Interpreting Abbreviations, Acronyms and Short-forms-Listening: Analyzing and interpreting announcements Decoding - Screening for salient points-Note making-Raising queries for clarification-Speaking: Announcements-Giving complete information-Pronunciation and Enunciation Pace, Intonation, and Pitch-Conducting Events-Speaking: Master of ceremonies, Short speeches - welcome speech, the vote of thanks/ valedictory speech, award-acceptance speech Writing: Invitations, Preparation of script/draft after interviewing someone. Adjectives-Pronunciation/ Punctuation Precision and Concision-Politeness markers.

Total: 45 Hours

Reference(s)

1. Sasikumar, V, et.al. A Course in Listening & Speaking FoundationBooks, 2005.
2. Murphy, Raymond. English Grammar in Use: A Self-Study Reference and Practice Book for Intermediate Students: with Answers. Cambridge: Cambridge University Press, 1985.
3. Prasad, Hari Mohan. A Handbook of Spotting Errors. Mcgraw Hill Education, 2010.
4. Reynolds, John. Cambridge First Language English. 2018th ed., Hodder Education, 2018.
5. Wiggins, Grant P., and Jay McTighe. Understanding by Design. Association for Supervision and Curriculum Development, 2008.

22HSH01 **HINDI** **1 0 2 2**

Course Objectives

- To help students acquire the basics of Hindi
- To teach them how to converse in Hindi on simple day- to -day situations
- To help students understand a simple technical text in Hindi

Programme Outcomes (POs)

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Course Outcomes (COs)

1. Construct simple sentences and use vocabulary required for day- to -day conversation.
2. Distinguish and understand the basic sounds of Hindi language.
3. Apply appropriate grammar to write and speak in Hindi language
4. Comprehend the conversation and give correct meaning
5. Take up Hindi examinations conducted by Dakshin Bharat Hindi Prachar Sabha

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
2	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
3	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
4	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
5	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-

UNIT I **9 Hours**

VOWELS AND CONSONANTS

Hindi Alphabet: Introduction (Self introduction) - Vowels - Consonants - Plosives - Fricatives - Nasalsounds - Vowel Signs - Chandra Bindu & Visarg -Table of Alphabet -Vocabulary.

UNIT II **9 Hours**

NOUNS

Nouns: Genders -Masculine & Feminine -Reading Exercises

UNIT III **9 Hours**

PRONOUNS AND TENSES

Pronouns and Tenses - Categories of Pronouns - Personal Pronouns - Second person (you & honorific) - Definite & Indefinite pronouns - Relative pronouns - Present tense - Past tense - Future tense -Assertive & Negative Sentences - Interrogative Sentences.

UNIT IV **9 Hours**

CLASSIFIED VOCABULARY

Classified Vocabulary: Parts of body -Relatives Spices Eatables -Fruit & Vegetables -Clothes -Directions - Seasons Professions.

UNIT V **9 Hours**

CONVERSATIONS

Speaking - Telling the times -Saying the Numbers from 1 to 50 Speaking practice for various occasions.

Total: 45 Hours

Reference(s)

1. B.R. Kishore, Self Hindi Teacher for Non-Hindi Speaking People, Vee Kumar Publications (P) Ltd., New Delhi, 2009.
2. Hindi Prachar Vahini - 1
3. Videos, Stories, Rhymes and Songs.

22HSG01 GERMAN 1 0 2 2

Course Objectives

- To help students appear for the A1 level Examination
- To teach them how to converse fluently in German in day-to-day scenarios

Programme Outcomes (POs)

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Course Outcomes (COs)

1. Listen and identify individual sounds of German
2. Use basic sounds and words while speaking
3. Read and understand short passages on familiar topics
4. Use basic sentence structures while writing
5. Illustrate basic grammar and appropriate vocabulary in completing language tasks

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
2	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
3	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
4	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
5	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-

UNIT I **9 Hours**

Introduction to German language: Alphabet - Numbers - Greetings - Days and Seasons- Working with Dictionary.

UNIT II **9 Hours**

Nouns - articles - Speaking about one self - Listening to CD supplied with the books, paying special attention to pronunciation

UNIT III **9 Hours**

Regular & Irregular verbs - Personal pronouns - family - Introduction to types of sentences

.

UNIT IV **9 Hours**

Question words-Types of Questions - Nominative case- Verb Conjugation - country - nationalities

UNIT V **9 Hours**

Verbs - to be & to have - conjugation - Hobbys - Framing basic Questions and answers

Total: 45 Hours

Reference(s)

1. Kursbuch and Arbeitsbuch, NETZWERK A1 DEUTSCH ALS FREMDSPRACHE, Goyal Publishers & Distributers Pvt. Ltd., New Delhi, 2015
2. Langenscheidt Eurodictionary - German - English / English - German, Goyal Publishers &Distributers Pvt. Ltd., New Delhi, 2009
3. Grundkurs, DEUTSCH Lehrbuch Hueber Munichen, 2007

22HSJ01 **JAPANESE** **1 0 2 2**

Course Objectives

- To train students for N5 Level Examination
- To teach them use basic Japanese sentences in day-to-day conversation
- To make students familiar with the Japanese cultural facets and social etiquettes

Programme Outcomes (POs)

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Course Outcomes (COs)

1. Recognize and write Japanese alphabet
2. Speak using basic sounds of the Japanese language
3. Apply appropriate vocabulary needed for simple conversation in Japanese language
4. Apply appropriate grammar to write and speak in Japanese language
5. Comprehend the conversation and give correct meaning

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
2	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
3	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
4	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
5	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-

UNIT I **9 Hours**

SELF INTRODUCTION / DEMONSTRATIVES / NOUN MODIFIERS

Introduction to Japanese Japanese script - Pronunciation of Japanese (Hiragana (Katakana) Long vowels Pronunciation of in,tsu,ga -Letters combined with ya,yu,yo - Daily Greetings and Expressions - Numerals. Speaking: Self Introduction -Listening: Listening to Greetings, Listening to specific information: Numbers, Time.

UNIT II **9 Hours**

TIME EXPRESSION / VERBS - PAST

Introduction to time -Introduction of verbs -Listening to specific information.

UNIT III **9 Hours**

ADJECTIVES

Word Sentence -Introduction to Adjectives -Technical Japanese Vocabulary -Pair Activity Day to day situational conversation Listening to Japanese Alphabet Pronunciation -Simple Conversation

UNIT IV **9 Hours**

CONJUGATION OF II ADJECTIVE

Past tense of Noun sentences and Na adjective sentences -Past tense of ii adjective sentences -houga adjective desu -Technical Japanese Vocabulary -Individual Activity - Listening to conversation with related particles.

UNIT V **9 Hours**

CONJUGATION OF VERBS - TE FORM / TA FORM / NAI FORM / PLAIN FORM

N gahoshidesu - V masu form tai desu - Verb te form - Technical Japanese Vocabulary -Listening to different Counters, simple conversations with verbs and adjectives.

Total: 45 Hours

Reference(s)

1. Minna no Nihongo Japanese for Everyone Elementary Main Textbook1-1, Goyal Publishers and Distributors Pvt. Ltd., Delhi, 2007.
2. Minna no Nihongo Japanese for Everyone Elementary Main Textbook1-2 Goyal Publishers and Distributors Pvt. Ltd., Delhi, 2007.

22HSC01 **CHINESE** **1 0 2 2**

Course Objectives

- To help students appear for HSK Level 1 Exam
- To help students acquire the basics of Chinese language
- To teach the students how to converse in Chinese in various situations

Programme Outcomes (POs)

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Course Outcomes (COs)

1. Listen and identify individual sounds of Chinese
2. Use basic sounds and words while speaking
3. Read and understand short passages on familiar topics
4. Use basic sentence structures while writing
5. Understand and use basic grammar and appropriate vocabulary in completing language tasks

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-

UNIT I **9 Hours**

Hello
Initials and Finals of Chinese b,p,m,f,d,,n,l,g,k,h,j,q,x Tones Four
Chinese Syllables Tone S

UNIT II **9 Hours**

Thank you -
Initials and Finals of Chinese The Neutral Tone
Rules of Tone Marking and Abbreviation

UNIT III **9 Hours**

What's your name - In the school; -In the classroom; -In the school The Interrogative Pronoun
The Sentence
Interrogative Sentences with

UNIT IV **9 Hours**

She is my Chinese teacher - In the library
The Interrogative Pronouns The Structural Particle
The interrogative Particle

UNIT V **9 Hours**

Her daughter is 20 years old this year - The Interrogative Pronoun
Numbers below 100 Indicating a Change
The Interrogative Phrase

Total: 45 Hours

22HSF01 **FRENCH** **1 0 2 2**

Course Objectives

- To prepare the students for DELF A1 Examination
- To teach them to converse fluently in French in day-to-day scenarios

Programme Outcomes (POs)

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Course Outcomes (COs)

1. To help students acquire familiarity in the French alphabet & basic vocabulary
2. listen and identify individual sounds of French
3. Use basic sounds and words while speaking
4. Read and infer short passages on familiar topics
5. Interpret and use basic grammar and appropriate vocabulary in completing language tasks

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
2	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
3	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
4	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
5	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-

UNIT I **9 Hours**

ENTRER EN CONTACT

La langue francaise, alphabets, les numeros, les jours, les mois.- Grammaire Les verbes s 'appeler,etre, avoir, les articles definis, indefinis -Communication - Saluer, s''informer sur quelquun, demander de se presenter - Lexique - Les alphabets, les nationalites, l''age, les pays, les couleurs, les jours de la semaine, les mois de l''annee, les professions

UNIT II **9 Hours**

PARTAGER SON LIEU DE VIE

Les francais et leur habitat, des habitations insolites -Grammaire - Verbes - Conjugaison : Present (Avoir / etre / ER, IR, RE : Regulier et Irregulier) - Adjectifs les propositions de lieu - Communication - Chercher un logement, decrire son voisin, s''informer sur un logement - Lexique - L'habitat, les pieces, l 'equipement, la description physique

UNIT III **9 Hours**

VIVRE AU QUOTIDIEN

Grammaire - Articles contractes, verbes vouloir, pouvoir, devoir, adjective interrogative, future proche Communication- Exprimer ses gouts, parler de ses loisirs, justifier un choix, exprimer une envie – Lexique--le temps libre et les loisirs, les saisons, les activites quotidiennes, le temps (le matin, le soir, la nuit)

UNIT IV **9 Hours**

OMPRENDRE SON ENVIRONNEMENT - OUVRIR LA CULTURE

Grammaire Verbes Finir, Sortir, les adjectifs demonstratifs, le passe compose, l imparfait Communication Propose a quelqu un de faire quelque chose, raconter une sortie au passe, parler d un film Lexique Les sorties, la famille, l art, les vetements et les accessoires

UNIT V **9 Hours**

GOUTER A LA CAMPAGNE

Grammaire La forme negative, les verbes acheter, manger, payer, articles partitifs, le pronom en de quantite

Communication Accepter et refuser une invitation, donner des instructions, commander au restaurant Lexique Les services et les commerces, les aliments, les ustensiles, l argent

Total: 45 Hours

Reference(s)

1. Grammaire Progressive du Francais, CLE International, 2010
2. Saison1, Marie Noelle Cocton et al, Didier, 2014.
3. Preparation a l examen du DELF A1 Hachette
4. Reussir le DELF A1 Bruno Girardeau
5. Website: Francais Linguaphone Linguaphone Institute Ltd., London, 2000.
6. Francais Harrisonburg : The Rosetta Stone : Fairfield Language Technologies, 2001

PROFESSIONAL ELEECTIVES

22BT001 FERMENTATION TECHNOLOGY 3 0 0 3

Course Objectives

- To understand the principles and types of fermentation processes, including their kinetics, and to analyze fermentation stoichiometry.
- To explore microbial metabolism, medium optimization, and aseptic techniques for efficient fermentation processes.
- To gain expertise in fermentation process design, equipment, and downstream processing techniques for industrial applications.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.

PSO3. Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Apply microbial growth and metabolism principles to optimize fermentation processes.
2. Apply fermentation system design concepts for efficient metabolite production.
3. Analyze biological mechanisms to improve industrial fermentation efficiency.
4. Analyze bioreactor operations to optimize scale-up and process enhancement.
5. Evaluate microorganisms for large-scale industrial bioproduct production.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	-	2	-	1	-	-	-	-	-	-	-	-	-	-
2	1	-	2	-	2	-	-	-	-	-	-	-	-	2	-
3	-	-	2	2	2	2	-	-	-	-	-	-	-	-	1
4	-	-	2	2	2	-	1	-	-	-	-	-	-	2	1
5	2	1	3	-	2	-	-	-	-	-	-	-	-	-	-

UNIT I **9 Hours**

INTRODUCTION TO FERMENTATION

Definition, History, and Importance of Fermentation, Types of Fermentation based on oxygen requirement and physical state of the medium, Fermentation Process: Substrate, Microorganism, and Enzymes, Fermentation kinetics: Monod model and growth phase kinetics, Stoichiometric analysis of fermentation processes.

UNIT II **9 Hours**

MICRO-ORGANISMS AND METABOLIC PATHWAYS IN FERMENTATION

Microorganisms in Fermentation: Bacteria, Yeast, Mold, Co-culture and mixed microbial fermentations, Microbial Metabolism: Respiration, and Fermentation; Metabolic Pathways: Glycolysis (Embden-Meyerhof Pathway), Alcoholic Fermentation, Lactic Acid Fermentation and Butyric Acid Fermentation, Nutrient Requirements and Medium Optimization, Sterilization and Aseptic Techniques.

UNIT III **9 Hours**

FERMENTATION PROCESSES, EQUIPMENT AND SCALE UP

Fermentation Process types: Batch, Continuous, and Fed-Batch Fermentation, Fermenter parts and its functions, Fermentation Monitoring and Control Systems: Mixing, Aeration, pH and Temperature Control, Bioreactor Design and Operation ,Fermentation Safety: Hazards, Regulations, and Best Practices, Scale up of Bioreactors.

UNIT IV **9 Hours**

DOWNSTREAM PROCESSING IN FERMENTATION

Recovery Techniques: Centrifugation, Filtration, and Sedimentation in Fermentation Processes, Product Isolation: Chromatographic and Electrophoretic Methods for Fermentation Products, Final Product Processing: Crystallization and Lyophilization of Fermentation-Derived Compounds, Quality Control and Assurance in Fermentation Product Recovery.

UNIT V **9 Hours**

INDUSTRIAL APPLICATIONS OF FERMENTATION TECHNOLOGY

Food Fermentation: Bread, Beer, Wine, Pharmaceutical Fermentation: Riboflavin (B2), Cobalamin (B12), Penicillin and Streptomycin; Biofuel Production: Ethanol and Butanol, Acids and Solvent Production: Acetone, Citric Acid and Lactic Acid.

Total: 45 Hours

Reference(s)

1. Emt.el-Mansi & CFA. Bryce Fermentation Microbiology & Biotechnology, Taylor & Francis Ltd. (2004).
2. Stanbury, P.F., A. Whitaker & S.J. Hall. Principles of fermentation technology Oxford Press. (1997).
3. Arnold L. Demain & Julian E. Davis. Industrial Microbiology & Biotechnology, ASM Press. (2004).
4. Vogel. H.C., Todaro. C.L., "Fermentation and Biochemical Engineering Handbook - Principles, Process design, and Equipment", Noyes Publications, 1997

22BT002 INDUSTRIAL MICROBIOLOGY 3 0 0 3

Course Objectives

- To provide student with firm understanding of the techniques involved in fermentation process and reactor systems.
- To understand the significance of bioresources and its role in microbial biotechnology.
- To discuss the treatment techniques pertaining to environmental biotechnology.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Apply the microbes and media and optimize culture conditions.
2. Analyze the fermenters for maximum production of biomass and bio products.
3. Analyze the various biomolecules of microbial origin.
4. Evaluate the industrially important bio products.
5. Evaluate the bio active compounds of pharmaceutical importance.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	-	3	2	-	-	-	-	-	-	-	-	-	2	2
2	3	-	3	2	-	-	-	-	-	-	-	-	-	2	2
3	2	-	3	3	-	-	-	-	-	-	-	-	-	2	2
4	2	-	3	2	-	-	-	-	-	-	-	-	-	3	3
5	3	-	3	3	-	-	-	-	-	-	-	-	-	3	3

UNIT I **9 Hours**

PURIFICATION AND QUNTIFICATION OF MICROBES

Isolation, identification and methods of purification of microbial strains; Quantification of microorganisms - direct and indirect methods; preservation of microbial cultures, genetic improvement of microbial strains.

UNIT II **9 Hours**
FERMENTATION TECHNOLOGY

Types of bioreactors; operation of bioreactors; media for industrial fermentation, solid substrate fermentation, primary and secondary metabolites; principles of microbial growth, culture system.

UNIT III **9 Hours**
BIOTRANSFORMATION

Biotransformation -reactions, techniques, product recovery; biotransformation of steroids, antibiotics, arachidonic acid, glycerol; biotransformation for the production of ascorbic acid, indigo.

UNIT IV **9 Hours**

MICROBIAL PRODUCTION

Alcohols (Ethanol & Butanol), acetone, Production of citric acid, Acetic acid, Succinic acid, Vinegar,Lactic acid & Industrial production of Vitamins (B2, B12, Ascorbic acid).

UNIT V **9 Hours**

PHARMACEUTICAL MICROBIOLOGY

Industrial production of Insulin, human growth hormone, monoclonal antibodies, Interferons & antibiotics (Penicillin, Streptomycin).

Total: 45 Hours

Reference(s)

1. U. Sathyanarayana, Biotechnology,Kolkata: Books and Allied (P) Ltd., 2005.
2. W. Crueger and A. Crueger, Biotechnology: A Textbook: of Industrial Microbiology, Panima Publishing Corporation, 2003.
3. P. F. Stanbury, A. Whitaker and S. J. Hall, Principles of Fermentation Technology, Butterworth- Heinemann (Elsevier Science), 2005.
4. C. Ratledge and B. Kristiansen, Basic Biotechnology, Cambridge University Press, 2001.
5. L. M. Prescott, J. P. Harley and D. A. Klein, Microbiology, Wm. C. Brown Publishers, 2004.
6. Sultana, N., 2018. Microbial biotransformation of bioactive and clinically useful steroids and some salient features of steroids and biotransformation. *Steroids*, *136*, pp.76-92.
7. https://archive.nptel.ac.in/courses/102/105/102105058/

22BT003 **ENVIRONMENTAL BIOTECHNOLOGY** **3 0 0 3**

Course Objectives

- To develop a basic knowledge on the global issues pertaining to environment.
- To analyze the various techniques involved in treating the wastes.
- To understand the process of biodegradation and bioremediation.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PSO2. Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Analyze the challenges and problems associated with the climatic issues with the current environmental scenario.
2. Analyze the various biological treatment methods to treat the wastewater.
3. Analyze the various waste minimization techniques and control measures that help to reduce wastes.
4. Analyze the various hazardous waste minimization techniques and control measures that help to reduce hazardous wastes.
5. Evaluate various biodegradation and bioremediation methods and their performance in eliminating wastes.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	3	-	2	-	-	-	-	-	-	-	-	-	2	2
2	2	2	-	2	-	-	-	-	-	-	-	-	-	2	2
3	2	3	-	2	-	-	-	-	-	-	-	-	-	2	2
4	2	3	-	2	-	-	-	-	-	-	-	-	-	3	3
5	2	2	-	2	-	-	-	-	-	-	-	-	-	3	3

UNIT I **9 Hours**
INTRODUCTION

Climate change, Greenhouse gases and their sources, ozone depletion. Effects of industrial activity- acid rain, smog, global warming and eutrophication, Radiation hazards. Introduction to treatment of liquid and solid wastes; Contributions of Biotechnology to waste treatment and environmental management.

UNIT II **9 Hours**
BIOLOGICAL WASTE WATER TREATMENT
Characteristics of wastewaters, Preliminary and primary wastewater treatments, Secondary treatment- Aerobic lagoons or ponds, trickling filters, activated sludge process, fluidized bed, Anaerobic treatment- Anaerobic ponds, anaerobic reactors, UASB, Tertiary treatment- removal of suspended solids, oil and grease, nitrogen removal, phosphorus removal.

UNIT III **9 Hours**

SOLID WASTE MANAGEMENT

Solid wastes - types of solid wastes, characteristics of solid wastes, segregation, collection, transportation. Disposal methods - Sanitary land filling, Recycling, composting, Incineration, Waste minimization techniques. Recovery of energy from solid wastes.

UNIT IV **9 Hours**

HAZARDOUS WASTE MANAGEMENT

Hazardous Wastes- Sources & Classification, physicochemical properties, Hazardous Waste Control & Treatment. Hospital Waste Management, Disaster Management.

UNIT V **9 Hours**

BIODEGRADATION

Biodegradation of macromolecules; xenobiotics; Bioremediation of metal contaminated soils, spilled oil and grease deposits, synthetic pesticides. Phytotechnology-terrestrial phytosystems, metal phytoremediation, Phytotechnology-aquatic photosystems, algal treatment system.

Total: 45 Hours

Reference(s)

1. Alan Scragg, Environmental Biotechnology, Oxford University Press Inc., 2007.
2. Bimal C. Bhattacharyya and B. Rintu, Environmental Biotechnology, Oxford University Press Inc., 2007
3. P. R. Yadav, and Rajiv Tyagi, (2006) .Environmental Biotechnology, Discovery Publishing house
4. InduShekhar Thakur, (2006) Environmental Biotechnology- Basic concepts and application, I.K International, Pvt. Ltd., 2006
5. https://onlinecourses.nptel.ac.in/noc23_bt60/preview

22BT004 BIOENERGY AND BIOFUELS 3 0 0 3

Course Objectives

- To introduce the basic concepts, principles, potentials and limitations of biological energy sources.
- To introduce various form of energy derivation such as liquid, gas from biological sources.
- To know and understand contemporary issues pertaining to the energy and environment.\

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PSO2. Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using Bioresources.

Course Outcomes (COs)

1. Apply the concepts in biomass conversion to derive energy from them.
2. Apply the principles of alcohol-based biofuels production and evaluate their environmental impact.
3. Analyze the technologies and processes involved in gaseous biofuels production and their applications.
4. Analyze the technologies involved in plant-based biofuels production and the use of co-products.
5. Evaluate the performance and challenges of microbial fuel cells in renewable energy generation.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	-	2	-	1	-	3		-	-	-	-	-	-	-
2	1	-	2	-	2	-	3	2	-	-	-	-	-	2	-
3	-	-	2	2	2	2	3		-	-	-	-	-	-	3
4	-	-	2	2	2	1	3	2	-	-	-	-	-	2	3
5	2	-	3	-	2	-	3		-	-	-	-	-	-	-

UNIT I 9 Hours

INTRODUCTION TO BIOENERGY AND BIOFUELS

Overview of Bioenergy - Definition, importance, and role of bioenergy in the global energy landscape. Comparison of bioenergy with other renewable energy sources (solar, wind, hydro). Biomass as a Source of Bioenergy; Types of biomass; Chemical composition and energy potential of different biomass types. Biofuels Overview - Types of biofuels and its importance and their applications. Biomass Conversion Technologies, Future prospects and Challenges in bioenergy development.

UNIT II **9 Hours**

ALCOHOL BASED BIOFUELS

Introduction to Alcohol-Based Biofuels, Types of alcohol biofuels, Feedstocks for Alcohol based biofuels production, Ethanol Production Processes and steps involved in Ethanol, Butanol and Methanol Production, Economic feasibility of alcohol biofuel production. Environmental impact: Carbon neutrality and emissions reduction. Challenges in Alcohol-Based Biofuels - Scale-up issues, feedstock availability, and cost-effectiveness.

UNIT III **9 Hours**

GASEOUS BIOFUELS

Introduction to gaseous biofuels and their types; Biogas production: Feedstocks, anaerobic digestion, and biogas digester technologies (fixed-dome, floating-drum, tubular digesters); Biohydrogen production via dark fermentation and photofermentation, key microorganisms, and pathways; Syngas production through biomass gasification; Applications, challenges, and future prospects of gaseous biofuels.

UNIT IV **9 Hours**

PLANT BASED BIOFUELS

Overview of plant-based biofuels and feedstocks for biodiesel production, including oilseed crops, non-edible oils, and microalgae; Biodiesel production through transesterification, refining techniques, and quality standards (ASTM and EN); Co-products like glycerol and oil cake: production, applications, and uses; Cost analysis, market trends, and environmental aspects such as carbon neutrality and land use concerns.

UNIT V **9 Hours**

MICROBIAL FUEL CELLS

Introduction to Microbial Fuel Cells (MFCs): Definition, principles, and comparison with conventional energy systems; Role of electrogenic bacteria, electron transfer mechanisms, and substrates; Components of MFCs: Anode, cathode, membranes, and electrode materials; Types, designs of MFCs and applications in electricity generation from wastewater; Challenges, technical limitations, and future prospects.

Total: 45 Hours

Reference(s)

1. Chahal.D.S. Food, Feed and Fuel from Biomass. Oxford & IBH Publishing Co. Pvt LTD.
2. Caye Drapcho, John Nghiem and Terry Walker, Biofuels Engineering process technology, McGraw Hill Professional, 2008.
3. Klass, D.L. Biomass for Renewable Energy, Fuels, and Chemicals, Academic Press, 1998.
4. Soetaert, Wim, and Vandamme, Erik (Editors). Biofuels, Wiley, 2009.
5. Pandey, Ashok, et al. Biomass, Biofuels, Biochemicals: Advances in Bioenergy, Elsevier, 2019.
6. Lee, James W. Advanced Biofuels and Bioproducts, Springer, 2013.
7. Demirbas, A. Biofuels: Securing the Planet's Future Energy Needs, Springer, 2009.
8. Yebo Li and Samir Kumar Khanal, Bioenergy: Principles and Applications, Wiley, 2016.
9. Gupta, Vijay Kumar, and Suib, Steven L. Biofuels from Algae, Elsevier, 2013.

22BT005 BIOREACTOR DESIGN, MODELING AND SIMULATION 3 0 0 3

Course Objectives

- To introduce the importance of modelling and simulation in bioprocess.
- To expose students to mathematical model for modelling a bioprocess.
- To create models and simulate bioprocess for improving the quality of process.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PSO1. Able to design new concepts in the domains of Microelectronics and Communication Engineering.
PSO2. Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using Bioresources.

Course Outcomes (COs)

1. Apply the principles of bioprocess modeling and simulation.
2. Apply the knowledge of mathematical models in biochemical engineering systems.
3. Analyze the modelling for reactors.
4. Analyze the modelling for fermenters.
5. Evaluate the application of Superpro Designer, MATLAB and SIMULINK in the bioprocess systems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	2	1	-	-	-	-	-	-	-	-	-	-	-	-
2	2	3	3	-	-	1	-	-	-	-	-	-	1	-	-
3	2	2	3	-	-	-	-	-	-	-	-	-	1	-	-
4	2	3	3	-	-	-	-	-	-	-	-	-	1	3	1
5	2	3	3	-	3	1	-	-	-	-	-	-	1	3	3

UNIT I 9 Hours

INTRODUCTION TO MODELING AND SIMULATION

Basic principles of Modeling, definition of Modeling and simulation, Fundamental laws, Continuity equation, energy equation, equation of motion, transport equation, equation of state, Phase and chemical equilibrium, chemical kinetics, Model building, application of mathematical modeling.

UNIT II **9 Hours**

MODELS FOR BIOCHEMICALENGINEERING SYSTEMS

Models based on Mass, component, energy and force balance: Batch reactors, PFR, CSTR, Gravity flow systems, Reactors in series, Concept of Heated tanks.

UNIT III **9 Hours**

MODELING OF REACTORS

Modeling of fermentation Batch reactor, Fed batch reactor, modeling a continuous culture: Chemostat, Chemostat with recycles, substrate limited growth in Chemostat.

UNIT IV **9 Hours**

MODELING OF FERMENTERS

Modeling of suspended growth reactors, activated sludge systems, theory on agitated and sparged bioreactor, tower-aerobic and anaerobic bioreactors.

UNIT V **9 Hours**

SUPERPRO DESIGNER, MATLAB AND SIMULINK: APPLICATION IN BIOPROCESS SYSTEMS

Introduction to SuperPro Designer for Material and Energy Balance with and without reaction, solving problems using MATLAB by numerical integration, Euler and fourth order Runge Kutta methods, Simulation - Simulation of gravity flow tank - Simulation of CSTR in series.

Total: 45 Hours

Reference(s)

1. Luben W.L. Process Modelling Simulation and Control for Chemical Engineers, McGraw Hill, International New York, 1990.
2. Franks RGE. Mathematical Modeling in Chemical Engineering, John Wiley and Sons, Inc., New York, 2004.
3. Biquette W.B. Process Dynamics- Modeling analysis with simulation, Prentice Hall; 1 edition January 15, 1998.
4. William J. Palm. Introduction to Matlab 7 for Engineers, III, McGraw Hill 2005.
5. Kenneth J. Beers. Numerical Methods for Chemical Engineering Applications in MATLAB, Massachusetts Institute of Technology, Cambridge University press 2007 edition.

22BT006 BIOPROCESS CONTROL AND INSTRUMENTATION 3 0 0 3

Course Objectives

- To familiarize students with the various types of instrumentation used in bioprocessing and the techniques for accurate measurement.
- To develop an understanding of control strategies and their applications in optimizing bioprocess performance.
- To equip students with skills to model and simulate bioprocess systems for effective control and decision-making.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PSO1. Use the analytical instruments and techniques to isolate, purify and characterize biological compounds.

PSO2. Process designing and production of novel biomolecules for the agricultural, environmental and healthcare sectors.

PSO3. Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Apply the principles of control systems to design and analyze bioprocess control strategies effectively.
2. Utilize various instrumentation techniques for accurate measurement and monitoring of key parameters in bioprocessing.
3. Analyze and evaluate control strategies for fermentation processes, including feedback and feedforward control mechanisms.
4. Model and simulate bioprocess systems using software tools to optimize performance and improve process outcomes.
5. Assess real-world applications of control systems and instrumentation in industrial bioprocessing, demonstrating the impact on efficiency and product quality.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	2	1	-	-	-	-	-	-	-	-	-	-	-	-
2	2	3	3	-	-	1	-	-	-	-	-	-	1	-	-
3	2	2	3	-	-	-	-	-	-	-	-	-	1	-	-
4	2	3	3	-	-	-	-	-	-	-	-	-	1	3	1
5	2	3	3	-	3	1	-	-	-	-	-	-	1	3	3

UNIT I **9 Hours**
INTRODUCTION TO BIOPROCESS CONTROL
Overview of bioprocess control systems, types of control systems, basic control loop elements (sensors, controllers, actuators), control strategies (open-loop vs. closed-loop), and importance of control in bioprocessing.

UNIT II **9 Hours**
INSTRUMENTATION IN BIOPROCESSING

Types of instruments used in bioprocessing, measurement techniques (pH, temperature, pressure, flow), data acquisition systems, and signal processing. Calibration and validation of instruments.

UNIT III **9 Hours**
CONTROL SYSTEMS IN BIOPROCESSES

Control of fermentation processes, feedback control, feedforward control, PID control strategies, and their applications in batch and continuous bioprocesses.

UNIT IV **9 Hours**
MODELING AND SIMULATION OF BIOPROCESS SYSTEMS

Mathematical modeling of bioprocesses, dynamic modeling, use of simulation software for process design, and optimization of bioprocess control systems.

UNIT V **9 Hours**
APPLICATIONS OF CONTROL SYSTEMS IN BIOPROCESSING

Case studies of bioprocess control, implementation of control strategies in industrial bioprocesses, and advancements in bioprocess instrumentation and control technologies.

Total: 45 Hours

References

1. McCarty, P. L. & Siegrist, R. L. (2003). Biological Wastewater Treatment, 2nd ed. CRC Press.
2. Lee, J. M. (1996). Biochemical Engineering, Prentice Hall.
3. Stephanopoulos, G. (1995). Chemical Process Control: An Introduction to Theory and Practice, Prentice Hall.
4. Shankar, R. & Raghunathan, S. (2010). Bioprocess Control: Modeling and Control of Bioprocesses, Springer.
5. B. K. Bandyopadhyay, & S. Ghosh. (2008). Instrumentation and Control in Chemical Engineering, PHI Learning Pvt. Ltd.

22BT007 TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS 3 0 0 3

Course Objectives

- To enable students to apply fundamental knowledge about Heat, Mass and Momentum Transfer in real time problems.
- To provide knowledge on application of transport operations.
- To familiarize the students about various boundary conditions in heat, mass and momentum transport.
- To provide knowledge and training to students to apply basic equations of change from heat, mass and momentum transport to solve problems.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PSO3. Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources.

Course Outcomes (COs)

1. Apply the Newtonian and Non-Newtonian fluids with suitable examples.
2. Apply the transport properties of gases and liquids.
3. Analyze the problems in momentum, heat and mass transfer through shell balance.
4. Analyze the suitable boundary conditions to solve shell balance equations.
5. Evaluate the transport equations to solve steady flow and heat transfer problems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	-	2	-	-	-	3	-	-	-	-	-	-	-	1
2	2	-	-	-	-	-	1	-	-	-	-	-	-	-	3
3	1	-	-	-	-	-	3	-	-	-	-	-	-	-	2
4	2	-	-	-	-	-	3	-	-	-	-	-	-	-	3
5	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-

UNIT I 9 Hours

INTRODUCTION TO MOMENTUM TRANSPORT

Mass conservation principle of macro and microscopic systems; Newton's Law of viscosity-Non-Newtonian Fluid Models- Pressure and Temperature dependency of viscosity. Equation of motion.

UNIT II 9 Hours

INTRODUCTION TO HEAT TRANSPORT

Fourier's Law – Newton's Law of cooling-Temperature and pressure dependency of thermal conductivity.

UNIT III 9 Hours

INTRODUCTION TO MASS TRANSPORT

Mass flux; continuity equation; Fick's Law of binary diffusion - Temperature and pressure dependency of diffusivity. Shell momentum balances and boundary conditions for momentum, heat and mass transport

UNIT IV **9 Hours**

STATES OF SYSTEMS

Steady state – Diffusion across tubular walls, radial diffusion; unsteady state; pseudo steady state approximation.

UNIT V **9 Hours**

FLOW AND TRANSPORT IN BIOLOGICAL SYSTEMS

Laminar flow, capillary flow, couette flow, pulsatile flow, turbulent flow, Friction factor, simultaneous concentration gradient and velocity gradient.

Total: 45 Hours

Reference(s)

1. Transport Phenomena in Biological Systems, by Truskey, Yuan and Katz, Pearson Prentice Hall (2009).
2. Introduction to Microfluidics, by Patrick Tabeling, Oxford University Press (2005).

22BT008 ASTROBIOLOGY AND ASTROCHEMISTRY 3 0 0 3

Course Objectives

- To understand the origin, evolution and future life in our solar system.
- To analyze the key mechanisms and chemical reaction in the space.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO3. Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources.

Course Outcomes (COs)

1. Apply the in-depth comprehension and mastery of the fundamental concepts and methodology of astrobiology.
2. Apply the chemical process in interstellar medium.
3. Analyze the synthesis and modeling of astrochemistry.
4. Analyze the chemical markers for extraterrestrial life.
5. Evaluate the life metabolism and energy in space.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	-	2	-	-	-	3	-	-	-	-	1	-	-	1
2	2	-	-	-	-	-	1	-	-	-	-	2	-	-	3
3	1	-	-	-	-	-	3	-	-	-	-	1	-	-	2
4	2	-	-	-	-	-	3	-	-	-	-	1	-	-	3
5	1	-	-	-	-	-	1	-	-	-	-	1	-	-	-

UNIT I 9 Hours

MOLECULAR UNIVERSE

Introduction to atomic structure, chemical elements, energy level spectroscopy, hydrogen bonding.

UNIT II 9 Hours

CHEMICAL PROCESS IN INTERSTELLUAR MEDIUM

Phases of interstellar medium, molecular clouds, birth and death of starts, evolution of matter, Molecular connection and life origin.

UNIT III 9 Hours

SYNTESIS AND MODELLING OF ASTROCEMISTRY

Astrochemical models, formation of stars, chemical networks, reaction barriers, Gas phase synthesis.

UNIT IV **9 Hours**

CHEMICAL MARKERS FOR EXTRATERRESTIAL LIFE

Extraterrestrial samples, sample collection techniques, amino acids and life detection, chemical markers for bacteria and other extraterrestrial lives.

UNIT V **9 Hours**

LIFE METABOLISM AND ENERGY

Food selection in spaceflight and analog studies, Energy requirements, protein, carbohydrates, fat and fatty acids, and effects on physiology systems.

Total: 45 Hours

Reference(s)

1. Life in the Universe , by Jerffrey Bennett ,Seth Shostak, Nicholas Schneider, Meredith MacGregor, Princeton University Press Hall (2023).
2. Expanding Worldviews: Astrobiology, Big History and Cosmic Perspectives, Springer International Publishing (2021).
3. Handbook of Astrobiology, Vera M.Kolb, CRC Press, 1st Edition (2019).
4. Astrochemistry: From Big Bang to the present Day, Clarie Vallance,World Scientific (2017).
5. Astrochemisty and Astrobiology,lan W.M. Smith, Charles S. Cockell, Sydney Leach, Springer International Publishing (2012).

22BT009 **BIOPROSPECTING AND QUALITY ANALYSIS** **3 0 0 3**

Course Objectives

- To recall the basic concepts of Bioprospecting with respect to Biodiversity.
- To identify the different types of Bioprospecting such as microbial, plants and animals.
- To explain the quality aspects of Bioprospecting.

Programme Outcomes (POs)

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life- long learning in the broadest context of technological change.

PSO2. Process designing and production of novel biomolecules for the agricultural, environmental and healthcare sectors.

PSO3. Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Apply the importance of Bioprospecting and its phases.
2. Apply the knowledge of medicinal plants with pharma for new drug development.
3. Analyze the importance of marine resources and its application.
4. Evaluate the concepts of microbial prospecting in new product development.
5. Evaluate the quality aspects of the products developed through various Bioprospecting techniques.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	2	-	2	2	2	-	-	-	2	-	-	3
2	-	2	2	1	-	2	1	-	-	-	-	1	-	2	-
3	-	-	3	3	-	3	1	1	-	-	-	-	-	-	2
4	-	2	3	3	-	2	-	1	-	-	-	1	-	-	3
5	-	-	-	2	-	2	2	2	-	-	-	2	-	-	3

UNIT I **9 Hours**

INTRODUCTION

Bioprospecting – Definition; Introduction - Current practices in Bioprospecting for conservation of Biodiversity and Genetic resources; Bioprospecting Act- Introduction - Phases of Bioprospecting - Exemption to Act - Fields of Bioprospecting.

UNIT II **9 Hours**

MEDICINAL PLANTS BIOPROSPECTING/ PHARMACEUTICAL BIOPROSPECTING

New drug development; Assays in Bioprospecting - Antioxidant assay - NO free radical scavenging assay, Antigenotoxicity assay – MTT assay, Antiviral activities of plants – SRB assay.

UNIT III **9 Hours**

MARINE BIOPROSPECTING

Sources of marine planktons and their Bioprospecting; Isolation and cultivation of Marine bio resources; Isolation of Marine Yeast and its industrial applications; Bioactive chemicals from Seaweeds and their applications.

UNIT IV **9 Hours**

MICROBIAL BIOPROSPECTING

Isolation of Microbial metabolites and their bio-activity; Endophytic microbial products and their application in pharmaceutical industry such as antibiotics.

UNIT V **9 Hours**

QUALITY ANALYSIS

Introduction: Concept and evolution and scopes of Quality Control and Quality Assurance; Good Laboratory Practice; GMP; Overview of ICH Guidelines - QSEM, with special emphasis on Queries guidelines.

Total: 45 Hours

Reference(s)

1. Arora, R.K. and Nayar, E.R. (1984), Wild relatives of crop plants in India, NBPGR Science Monograph No.7.
2. Thakur, R.S., Puri, H.S. and Husain, A. (1969). Major medicinal plants of India, Central Institute of medicinal and aromatic plants, Lucknow.
3. Swaminathan, M.S. and Kocchar, S.L. (Es.) (1989). Plants and Society, MacMillan Publication Ltd.,
4. S Ram Reddy and M A Singara Charya -Microbial Diversity: Exploration and Bioprospecting.
5. Mukherjee,P.W. Quality Control of Herbal Drugs : An Approach to Evaluation of Botanicals.Business Horizons Publishers, New Delhi, India, 2002.
6. Siqueira, C.F.D.Q., Cabral, D.L.V., Peixoto Sobrinho, T.J.D.S., de Amorim, E.L.C., de Melo, J.G., Araújo, T.A.D.S. and de Albuquerque, U.P., 2012. Levels of tannins and flavonoids in medicinal plants: evaluating bioprospecting strategies. *Evidence-Based Complementary and Alternative Medicine*, *2012*(1), p.434782.

22BT010 **FOOD PROCESS AND TECHNOLOGY** **3 0 0 3**

Course Objectives

- To know the processing of foods from harvesting to packaging.
- To learn the preserving techniques of various food stuffs.
- To study the storage and packaging techniques of foods.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PSO1. Use the analytical instruments and techniques to isolate, purify and characterize biological compounds
PSO2. Process designing and production of novel biomolecules for the agricultural, environmental and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Analyze the processing techniques to avoid post-harvest losses.
2. Apply different preservation techniques to enhance shelf life of foods.
3. Analyze high temperature processing techniques to enhance the shelf life and quality of food product.
4. Analyze low temperature processing techniques to enhance the shelf life and quality of food product.
5. Evaluate the factors influencing food packaging and storage during long term storage of food.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	1	-	2	-	2	3	-	-	-	-	-	-	3	3
2	2	2	-	2	-	1	2	-	-	-	-	-	2	-	2
3	1	3	-	1	-	3	2	-	-	-	-	-	2	2	1
4	1	3	-	1	-	3	2	-	-	-	-	-	1	3	1
5	3	1	-	2	-	2	3	-	-	-	-	-	-	3	3

UNIT I **9 Hours**

POST-HARVEST TECHNOLOGY

Post-harvest losses, cleaning, grading and sorting types. Moisture content – free moisture, bound and unbound moisture, Role of moisture content - concept of water activity measurement – direct and indirect method, equilibrium moisture content, EMC determination methods, hysteresis effect. Theory and mechanism of drying, constant rate and falling rate drying, Thin layer and deep bed drying, methods of drying agricultural materials - batch and continuous drying.

UNIT II **9 Hours**

PRESERVATION OF FOOD BY SALT, SUGAR AND CHEMICALS

Preparation of Juices and pulps, concentrates. Theory of gel formation, Preparation of jam, jellies, marmalades. Chemistry of salt preservation - Sauerkraut, and vinegar production, minimal processing, hurdle technology.

UNIT III **9 Hours**

HIGH TEMPERATURE PROCSSSING/PRESERVATION

Methods of applying heat to food. Balancing, Pasteurization and Sterilization. Thermal death time relationships (D, Z and F values). Process calculations: general methods, Ball's formula method .Sterilization – methods and equipment, UHT sterilization.

UNIT IV **9 Hours**

LOW TEMPERATURE PROCESSING / PRESERVATION

Chilling, cold storage and freezing. Thermodynamics of food freezing. Phase diagrams. Formation of ice crystals and its types. Properties of frozen foods. Freezing-time calculations. Freeze concentration.

UNIT V **9 Hours**

PACKAGING AND STORAGE OF FOOD

Testing of packaging material, printing on packages, Bar codes, Nutrition labeling and legislative requirements. Vacuum and Inert Gas Packaging, Gas and water vapour transmission rates. Principles of active packaging, modified atmosphere packaging. Storage of food grains - factors affecting storage - Types of storage - bag and bulk storage - bag storage requirement. Storage under ambient conditions.

Total: 45 Hours

Reference(s)

1. P. J. Fellows, Food Processing Technology: Principles and practice, Third Edition Wood Head Publishing limited, 2009.
2. Paul Singh, R and Dennis R. Heldman, Introduction to Food Engineering, Fourth Edition. Academic Press, 2009.
3. K. M. Sahay, and K.K. Singh, Unit Operations of Agricultural Processing, Vikas Publishing House Pvt. Ltd., 2003.
4. R. L. Earle, Unit Operations in Food Processing, Pergamon Press, 1989.
5. Warren L. McCabe, Julian C. Smith, Peter Harriott, Unit Operations of Chemical Engineering, Seventh Edition, McGraw-Hill, 2005.

22BT011 MARINE BIOTECHNOLOGY 3 0 0 3

Course Objectives

- To provide information about the microbes available in aquatic environment, their role and interaction with the marine environment.
- To impart knowledge of biotechnological applications of marine organisms, important processes and impacts on the marine ecosystems and ways to control them.
- To identify the potential of bioactive molecules derived from marine organisms and its application in varied sectors.
- To impart a comprehensive understanding on marine fauna from basics to advances in the field of marine biotechnology.
- To teach sustainable use of aquatic resources with various approaches in biotechnology.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life- long learning in the broadest context of technological change.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources.

Course Outcomes (COs)

1. Apply the principle features of marine ecosystems and the microbial diversity in oceans.
2. Apply the by-products obtained from marine resources and categorize them as Pharmaceutics and Nutraceutics.
3. Apply the fundamental principles of aquaculture and integrate it with biotechnological procedures for sustainable production.
4. Analyze the causes of marine pollution, impacts and management technologies and can bring about solutions for conservation of Marine organisms.
5. Evaluate the uses of marine organisms, their significances, interactions, impacts and management technologies to come up with solutions for their control.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	-	-	-	-	-	-	-	-	-	2	-	-	-
2	1	3	-	-	-	-	-	-	-	-	-	1	-	1	-
3	1	-	-	3	-	-	-	-	-	-	-	2	-	1	-
4	-	-	-	-	3	-	-	2	-	-	-	2	-	-	1
5	-	-	-	-	3	-	-	2	-	-	-	2	-	-	1

UNIT I **9 Hours**

INTRODUCTION TO MARINE ENVIRONMENT

Marine microbial habitats and its classification, Specialized microorganisms, Extremophiles, Estuarine Ecosystems, Phytoplankton's, zooplanktons, nektons, benthos, marine mammals, marine algae, mangroves, coral reefs, deep sea animals and adaptation – intertidal zone – fauna and flora. Sea- ranching of economically important marine organisms.

UNIT II **9 Hours**

MARINE PHARMACEUTICS AND NUTRACEUTICS

Seafood microbiology, Spoilage factors in seafood; Toxins influencing food spoilage; Single cell protein (SCP), marine based nutraceuticals, Medicinal compound from marine flora and fauna – marine toxins, antiviral and antimicrobial agents. Sea food processing and Preservation; Freezing and cold storage.

UNIT III **9 Hours**

MARINE ECONOMICS - AQUACULTURE TECHNOLOGY

Bio-floc technology; Aquaponics; Zero water exchange aquaculture system; Aqua mimicry; Hydroponics; Raceway system of aquaculture; Bioremediation in Aquaculture systems; Microalgae- indoor and mass-culture methods, Biotechnological approaches for production of important microalgae and other commercial important products. Cultureof seaweeds: Porphyra culture – environmental diseases in culture systems & their prevention & control. Ecofriendly aquaculture practices; probiotics in aquaculture

UNIT IV **9 Hours**

MARINE POLLUTION AND BIO DETERIORATION

Sources of marine pollution, its dynamics, transport paths and agents. Domestic, industrial and agricultural discharges in the marine environment. Oil pollution: Sources, composition and its toxicity. Thermal and radioactive pollution: sources, effects and remedial measures. Solid dumping, mining and dredging operations: their toxic effects on marine ecosystem. Role of biotechnology in marine pollution control and its treatment. Biofouling and bio deterioration: Agents and protection methods, Ballast water, Red tides

UNIT V **9 Hours**

POTENTIAL OF MARINE BIOTECHNOLOGY

Applications of Marine Organisms, Marine viruses and Girus, Giant bacteria and their significance, Unculturable bacteria: occurrence, characteristics and exploitation, Barophilic organisms & their applications, Seaweeds for removal of metal pollutants, GFP, RFP characteristics and their applications, Green mussel adhesive protein, Chitosan: products and applications, Biomimetics.

Total: 45 Hours

Reference(s)

1. Munn, C.B. , (2004) Marine Microbiology: Ecology and Applications, BIOS Scientific Publisher.
2. Jeffrey S. Levinton, CD (2001). Marine Biology: Function, Biodiversity . Ecology (515pp).
3. Se-kwon Kim , (2015) Handbook of Marine Biotechnology, Springer.
4. Gautam, N,C, (2007) Aquaculture Biotechnology, Shree Publishers and Distributors.
5. Le Gal, Y., Ulber, R., &Antranikian, G. (2005). Marine Biotechnology (Vol. 96).
6. Naik, M., Dubey, S. (2017). Marine pollution and microbial bioremediation.

22BT012 BIODIVERSITY AND AGROFORESTRY 3 0 0 3

Course Objectives

- To recall the different types of biodiversity across the world.
- To identify the importance of population growth in each taxon and its respective diversity.
- To explain the basic concepts of Bioprospecting with respect to Biodiversity.

Programme Outcomes (POs)

PO2 Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life- long learning in the broadest context of technological change.

PSO2. Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors.

PSO3. Conceive, Plan and Deploy societal projects for environmental protection using bioresources.

Course Outcomes (COs)

1. Apply the importance of the Global Biodiversity in current scenario.
2. Apply the importance of the Population growth and effect of environment on the growth.
3. Analyze the concepts of animal and plant taxonomy.
4. Analyze the concepts of microbial taxonomy and its classification.
5. Evaluate the concepts of Bioprospecting with respect to Biodiversity.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	2	-	3	2	2	-	-	-	2	-	-	3
2	-	3	2	1	-	2	1		-	-	-	1	-	2	-
3	-	2	3	3	-	2	1	1	-	-	-	-	-	-	2
4	-	2	3	3	-	2		1	-	-	-	1	-	-	3
5	-	-	2	-	-	1	2	2	-	-	-	2	-	2	-

UNIT I 9 Hours

INTRODUCTION

Biodiversity -Types of Biodiversity - Biodiversity as a natural resource - Vegetational Zones -Zones of Faunal distribution - Major Biodiversity areas of the world - Biodiversity Hot Spots - Basic Taxonomy - Types of classification - Classification of bacteria, algae, fungi and plants (major families only) - Classification of Protozoans - Non-chordates (major classes with insects up to orders) and Chordates (major orders).

UNIT II **9 Hours**

ECOLOGY AND EVOLUTIONARY BIOLOGY

Population growth: Growth types and growth models, exponential and logistic models, Effect of environment on population growth - diversity distribution, factors affecting diversity, impact of exotic species. Neo-Darwinism: spontaneous mutation controversy, effects of natural selection on populations, Levels of selection, group selection controversy, selfish gene theory.

UNIT III **9 Hours**

NURSERY AND SEED TECHNOLOGY

Concept of nursery, temporary and permanent nursery, criteria for site selection, layout and design of beds, sowing techniques, soil mixtures, sowing manuring, fertilization in nursery, water management in nursery, scope of mechanism of nurseries: seedling protection from environmental and biological agents; Acceleration early growth of seedling. Bare root verses container seedling; Nursery disease, pests and their control; Quality of seed and pretreatment, germination, sanitation, seed storage, seed certification, seed source and elite seed trees.

UNIT IV **9 Hours**

MANAGEMENT AND PRODUCTIVITY IN AGROFORESTRY

Concept and classification of agroforestry systems and productivity, eco-zones and choice of system, system components and their integration, management of tree plantation, thinning, lopping, pruning etc.. Role tree architecture and management in agroforestry, recent trends in agroforestry

UNIT V **9 Hours**

ADVANCEMENTS IN PLANT TISSUE CULTURE

Applications -Microbes in Agriculture: Rhizosphere, Nitrogen fixation, Mycorrhiza, Cyanobacteria. Industrial Microbiology: Microbial Fermentation-Major industrial products from microbes. Beverages, Antibiotics, Secondary metabolites.

Total: 45 Hours

Reference(s)

1. An, S., & Verhoeven, J. T. (Eds.). (2019). Wetlands: Ecosystem Services, Restoration and Wise Use (Vol. 238). Springer.
2. Gabriel M. (2000) Biodiversity and conservation Oxford and IBH publishing company Pvt Ltd. New Delhi.
3. Pandey. Angiosperms: Taxonomy, Anatomy, Economic Botany & Embryology.
4. Ashlock., Principles of Animal Taxonomy.
5. M. Gadgil., A methodology manual for scientific inventorying, monitoring and conservation of Biodiversity.
6. S Ram Reddy and M A Singara Charya -Microbial Diversity: Exploration and Bioprospecting.
7. Tortora, G.J., Funke, B.R. and Case, C.L. (2019). Microbiology an Introduction. 13th Edition. Pearson Education, Inc.
8. Ram, H.M., 2000. Seed and Nursery Technology of Forest Trees.

22BT013 **BIOSENSORS** **3 0 0 3**

Course Objectives

- To understand the principle, operations and classification of biosensors.
- To introduce transducers and physiological property measurement using biosensor.
- To espouse the science and engineering by application of biosensors in various fields.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PSO2. Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using bio resources.

Course Outcomes (COs)

1. Apply electrode system for construction of biosensor.
2. Analyze the design of transducer for construction of biosensors.
3. Analyze bios elective materials and its application for construction of biosensor.
4. Evaluate the bio membrane for biosensor fabrications.
5. Evaluate the biosensor for the Industrial, analytical, medical and environmental application.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	-	-	-	2	-	-	-	-	-	-	-	-	2	2
2	2	-	2	-	1	-	-	-	-	-	-	-	-	2	2
3	3	-		-	3	-	-	-	-	-	-	-	-	2	2
4	3	-	2	-	3	-	-	-	-	-	-	-	-	2	2
5	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2

UNIT I **9 Hours**

ELECTROCHEMISTRY, CLASSIFICATION AND OPERATION

Electrochemistry single electrode potential- Nernst equation Tafel plot Electrical components DC and AC Circuits Operational amplifiers and functions Desired characteristics of biosensors: reliability, simplicity, cost, and related parameters. Classification and components of Biosensor - Advantages and limitations, biocatalysis based biosensors, Types of enzyme electrodes.

UNIT II **9 Hours**

TRANSDUCERS IN BIOSENSORS

Types of transducers, principles and applications - Calorimetric, acoustic, optical (absorption, fluorescence, bio/chemiluminescence, surface Plasmon resonance (SPR)), potentiometric / amperometric, conductrometric/ resistor metric, piezoelectric, semiconductor (ion sensitive field effect transistor (ISFET), enzyme field effect transistor (ENFET), impedimetric, mechanical and molecular electronics based transducers. Chemiluminiscence based biosensors.

UNIT III **9 Hours**

BIOSELECTIVE LAYERS

Bioselective layers: Enzymes; Oligonucleotides and Nucleic Acids; Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes); Membrane receptors and transporters; Microbial metabolism; Tissue and organelles (animal and plant tissue); Cell culture; Immuno receptors; Chemoreceptors; Methods for application of bio selective layers in desired patterns- pin-based spotting.

UNIT IV **9 Hours**

BIO MEMBRANES: MASS TRANSPORT AND FABRICATION

Mass transport: Mass transport effect of analytes to the surface of the biosensor transducer on the detected signal and associated kinetics. The design of micro fluid flow systems that interface with biosensors. Different assay types (Displacement, competitive, sandwich, and direct). Biosensor fabrication methods: self-assembled monolayers, Screen printing, photolithography, micro contact printing, micro- electromechanical system (MEMS).

UNIT V **9 Hours**

BIOSENSOR ENGINEERING AND APPLICATIONS

Applications- Case studies: Glucose, urea and cholesterol biosensors; Clark electrode, Implantable sensors for long-term monitoring; Drug development and detection; Industrial on-line monitoring, Environmental monitoring; Technological process control; veterinary, agriculture, Food quality control.

Total: 45 Hours

Reference(s)

1. Ursula Spichiger-Keller, Chemical Sensors and Biosensors for Medical and Biological Applications, Wiley-VCH, 1998.
2. D. A. Skoog, F. J. Holler and Nieman A. Timorthy, Principles of Instrumental analysis, 6th edition, 2006.
3. D. G. Buerk, Biosensors: Theory and Applications, Technomic, Lancaster, 1993.
4. Jon Cooper and Tony cass, Biosensors, Oxford University Press, 2000.
5. Vigneshvar, S., Sudhakumari, C.C., Senthilkumaran, B. and Prakash, H., 2016. Recent advances in biosensor technology for potential applications–an overview. *Frontiers in bioengineering and biotechnology*, *4*, p.11.

22BT014 **BIOMATERIALS** **3 0 0 3**

Course Objectives

- To summarize the classification of biomaterial, their bulk and surface properties and characterization to prepare the students to find a place in biomedical field.
- To interpret the various manufacturing processes and testing, cost, sterilization, packaging and regulatory issues of biomaterials.
- To motivate and facilitate students to undertake projects and research work in Biomaterials.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2 Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PSO2. Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using bio resources.

Course Outcomes (COs)

1. Apply the essential concepts, classifications and properties of biomaterials.
2. Apply the knowledge of different characterization techniques in biomaterial fabrication.
3. Analyze the bio compatibility of biomaterials under biological environment.
4. Analyze the need of tissue replacement implants in organ regeneration.
5. Evaluate the biological requirements for developing artificial organs.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2		-	2	-	-	2	-	-	-	-	-	-	2	2
2	2	2	-	1	-	-	2	-	-	-	-	-	-	2	2
3	3		-	3	-	-	2	-	-	-	-	-	-	2	2
4	3	2	-	3	-	-	2	-	-	-	-	-	-	2	2
5	-	-	-	-	-	-	2	-	-	-	-	-	-	2	2

UNIT I **9 Hours**

INTRODUCTION AND CLASSIFICATION

Introduction and classifications; Metals: different types, properties and interaction with the tissue, Polymers, classification and properties, Ceramics: Types, properties and interactions with the tissue, Composites: matrix and reinforcing agents/fillers and properties, Cell adhesion, host- tissue reactions. Tissue derived biomaterials: Structure and properties of collagen and collagen-rich tissues, Biotechnology of collagen, design of resorbable collagen-based medical implants soft. Bioactive glasses and hollow fiber membrane.

UNIT II **9 Hours**

BULK AND SURFACE CHARACTERIZATION

Bulk Characterization: XRD, FT-IR, SEM, energy dispersive X-ray (EDX), DSC, TGA, dielectric analysis (DEA); Surface analysis: XPS, SIMS, AES, surface enhances Raman spectroscopy (SERS), AFM/STM; Structural properties of tissues-bone, teeth and elastic tissues. Effects of sterilization on biomaterial properties. Cell-surface interaction by fluorescence and reflection confocal microscopy and protein- surface interactions. Non-co-operative cell-surface interactions. Phenotype changes due to cell adhesion.

UNIT III **9 Hours**

TESTING

Biocompatibility: blood and tissue compatibility; degradation of biomaterials in biological environment, toxicity tests, sensitization, carcinogenicity, mutagenicity and special tests; In vitro and In vivo testing, implant associated infections, biocompatibility enhancement using carona discharge and plasma processes, surface coatings; Ethical considerations. Good manufacturing practice, standards, Regulatory issue.

UNIT IV **9 Hours**

TISSUE REPLACEMENT IMPLANTS

Tissue replacements, wound dressings and sutures, surgical tapes, adhesives and sealants, percutaneous and skin implants, maxillofacial augmentation, blood interfacing implants, hard tissue replacement implants, internal fracture fixation devices, Joint replacements, implants for bone regeneration. Naturally occurring extracellular matrix-structure and function and use in dermal regeneration.

UNIT V **9 Hours**

ARTIFICIAL ORGANS

Artificial heart, prosthetic cardiac valves, limb prosthesis, externally powered limb prosthesis. Dental implants. Biomaterials in wound dressings, nephrology, neurology, ophthalmology, stem cell research, bio-artificial pancreas, repair of tendon and ligament injuries and resorbable osteosysnthesis materials in craniomaxilliofacieal surgery, and controlled drug delivery.

Total: 45 Hours

Reference(s)

1. D. Shi , Ed., Biomaterials and Tissue Engineering, Berlin, New York: Springer, 2004.
2. B. Joon Park, D.B. Joseph and Boca Ration, Biomaterials: principles and applications, CRC, press, 2003.
3. L. Hench and J. Jones, Biomaterials, Artificial Organs and Tissue Engineering, Woodhead Publishing in Materials, 2002.
4. Kay C. Dee, David A. Puleo and Rena Bizios, An Introduction to Tissue-Biomaterial Interactions, John wiley, 2002.
5. Ratner, B. D., et al, (eds.), Biomaterials Science: An Introduction to Materials in Medicine, Academic Press, 2004.
6. Saltzman W M,Tissue Engineering: Engineering Principles for the Design of Replacement Organs and Tissues, Oxford University Press, 2004.

22BT015 PROGRAMS FOR BIOINFORMATICS 3 0 0 3

Course Objectives

- To understand the history and basics of python.
- To gain knowledge about the different data types and control flow statements.
- To impart knowledge about the functions, files, list, set tuples and dictionaries.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the Limitations.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using bio resources

Course Outcomes (COs)

1. Apply profound knowledge in python for biology.
2. Analyze the protocols used in python for biology.
3. Analyze the relationship between various libraries in python.
4. Evaluate the recent advancements in biopython and its libraries.
5. Evaluate the emerging new libraries in python for biological applications.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	-	3	-	-	-	-	-	-	-	-	-	2	2
2	2	3	-	-	-	-	-	-	-	-	-	-	-	2	2
3	2	3	-	3	-	-	-	-	-	-	-	-	-	2	2
4	2	3	-	3	2	-	-	-	-	-	-	-	-	2	2
5	2	3	-	3	2	-	-	-	-	-	-	-	-	2	2

UNIT I 9 Hours

INTRODUCTORY CONCEPTS

Introduction to computational thinking; Python language- features, overview of syntax, data types, operators, I/O statements, control structures, arithmetic data structures, list, tuples, dictionaries and sets, looping constructs, list comprehension, functions and examples in computers and biology

UNIT II 9 Hours

STRING MANIPULATION AND FILES

Fundamentals of characters and string-string presentation, and formatting- searching strings-joining and splitting strings. Files- Introduction, file processing, working with text files working with csv files.

UNIT III **9 Hours**

OBJECT ORIENTED PROGRAMMING

Object oriented programming- Introduction, data abstraction and reusability, methods as class functions; implementing a time abstract data type with a class- special attributes using default arguments with constructors-deconstructors-class attributes. Operators overloading. Polymorphism. Implementation of point vector, currency class.

UNIT IV **9 hours**

EXPLORATORY DATA ANALYSIS

Overview - Common data cleaning techniques for bioinformatics - Handling missing data and outliers - Data transformation techniques - Univariate analysis - Bivariate analysis - Multivariate analysis.

UNIT V **9 hours**

APPLICATIONS

Database application programming interface - Python DB-API specification-creating MySQL database-database query example-quering the database-reading, inserting and updating a database. Python modules for scientific programming- plotting library (matplotlib), random library and numpy

Total: 45 Hours

Reference(s)

1. Bassi, S Python for Bioinformatics, Chapman and Hall CRC press, 2nd edition, 2018.
2. Guttag, J.V Introduction to computation and programming using python, MIT press, 2nd edition, 2016.

22BT016 **FUNDAMENTALS OF ALGORITHMS FOR BIOINFORMATICS** **3 0 0 3**

Course Objectives

- To identify various algorithm design techniques.
- To impart knowledge on runtime analysis of algorithms.
- To understand the theory and background of commonly available bioinformatics tools.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PSO1. Use the analytical instruments and techniques to isolate, purify and characterize biological compounds.

Course Outcomes (COs)

1. Apply the importance of algorithms for biological applications.
2. Apply the knowledge of bioinformatics in sequence analysis.
3. Analyze the structure of RNA for informatics analysis.
4. Analyze the concepts of clustering methods in biological applications.
5. Evaluate the tree algorithms for informatics-based applications.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	1	-	-	-	-	-	-	-	-	-	2	-	-
2	2	3	1	-	-	-	-	-	-	-	-	-	2	-	-
3	2	3	1	-	-	-	-	-	-	-	-	-	2	-	-
4	2	3	1	-	-	-	-	-	-	-	-	-	1	-	-
5	2	3	1	-	-	-	-	-	-	-	-	-	1	-	-

UNIT I **9 Hours**

STRINGS,GRAPHS AND SEQUENCE COMPARISON ALGORITHMS

Strings: Rabin Karp, finite automata, KMP algorithm, Boyer Moore algorithm and suffix tree. Interval graphs, Mapping-Restriction site mapping algorithms, Partial digest, Double Digest Problem (DDP)-Simulated annealing, circular maps, Fitting data to maps. Radiation hybrid mapping and optical mapping. Longest common substring and longest common subsequence.

UNIT II **9 Hours**

METHODS FOR AIDING ALIGNMENT

Sequence alignment algorithm, Global, local and semi global alignment; affine gaps, time warping. Similar matrices -PAM and BLOSSUM derivation, BLAST algorithm. MSA-scoring MSA methods (global and local)- CLUSTAL W, Muscle. Hidden Markov Model (HMM), Algorithm for HMM. Finding genes with HMM.

UNIT III **9 Hours**

PREDICTION OF SITES AND RNA SECONDARY STRUCTURE

Finding instances of known sites, finding instances of unknown sites - Greedy approach, Gibbs sampler, Maximum-subsequence problem; RNA secondary structure prediction- approaches to look at changes in the sequence: Minimum free energy and maximum base pair matching, MFOLD predictions, Pseudoknots.

UNIT IV **9 Hours**

CLUSTERING METHODS

Gene expression analysis - Hierarchical clustering, k-means, Clustering and functional analysis of coordinately regulated Genes, gene finding and annotation.

UNIT V **9 Hours**

TREE ALGORITHMS

Evolutionary Models Jukes-Cantor, Kimura, Distance-based tree reconstruction with problems - Reconstruction of trees from additive matrices-Evolutionary trees and hierarchical clustering, Character based tree reconstruction.

Total: 45 Hours

Reference(s)

1. Kelly, S.T and Didulo D. Computational Biology: A Hypertextbook. American society for microbiology, 2018.
2. Eidhammer, I, Jonassen, I and Taylor, W.R. An Algorithmic approach to sequence and structural analysis. John Wiley and Sons, 2004.
3. Sun, H. (2022). Construction of Computer Algorithms in Bioinformatics of the Fusion Genetic Algorithm. Mathematical Problems in Engineering.
4. Ramsden, J. (2023). Bioinformatics: an introduction. Springer Nature.
5. Saadeh, H., Al Fayez, R. Q., & Elshqeirat, B. (2020). Application of K-means clustering to identify similar gene expression patterns during erythroid development. Int J Mach Learn Comput, 10, 452-457.
6. Waterman, M. Introduction to Computational Biology: Maps, Sequences and Genomes. Chapman and Hall, 1 edition, 1995.
7. Zou, Q., Lin, G., Jiang, X., Liu, X. and Zeng, X., 2020. Sequence clustering in bioinformatics: an empirical study. *Briefings in bioinformatics*, *21*(1), pp.1-10.
8. https://onlinecourses.nptel.ac.in/noc21_bt06/preview.

22BT017 **MOLECULAR MODELLING** **3 0 0 3**

Course Objectives

- To interpret the basic concepts of computational / theoretical chemistry / biology for drug designing.
- To apply modelling tools and docking programme for predicting the three- dimensional structure of biomolecules.
- To analyse how drugs interact with macromolecules and strategies used in designing novel drugs and prodrugs.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.
PSO3. Conceive Plan and Deploy bio-resources for the benefit of society and environment.

Course Outcomes (COs)

1. Apply and develop theoretical and software skills to model biomolecules.
2. Apply the concept of molecular model.
3. Analyze new molecules with therapeutic values.
4. Evaluate the development of new biomolecules by modification.
5. Create new lead molecules in drug design.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	-	3	2	-	-	2	-	-	-	-	-	-	2	2
2	2	-	3	2	-	-	2	-	-	-	-	-	-	2	2
3	2	-	3	2	-	-	2	-	-	-	-	-	-	2	2
4	2	-	3	1	-	-	2	-	-	-	-	-	-	2	2
5	2	-	3	1	-	-	2	-	-	-	-	-	-	3	2

UNIT I **9 Hours**

QUANTUM MECHANICS

Introduction - coordinate systems - potential energy surfaces - introduction to quantum mechanics -postulates - Schrodinger wave equation - hydrogen molecule - Born-Oppenheimer approximation, introduction to computer hardware and software.

UNIT II **9 Hours**

MOLECULAR MECHANICS AND ENERGY MINIMIZATION

Empirical force field models - Bond stretching - angle bending - torsional term - nonbonding interactions- thermodynamics properties using a forcefield - derived and non-derived energy minimization method - simplex - sequential univariate method - steepest descent method - conjugate gradient method- Newton-Rapson method.

UNIT III **9 Hours**

MOLECULAR DYNAMICS

Basic principles of molecular dynamics and Monte Carlo Simulation for conformational analysis - Abinitio - Density- Functional Theory and semi empirical methods.

UNIT IV **9 Hours**

MACROMOLECULAR MODELING

Identification and mapping of active sites - Design of ligands for known macro molocular target sites. Drug-receptor interactions. Classical SAR/QSAR studies and their Implications to the 3-D modeler. 2-D and 3- D database searching - pharmocophore identification and novel drug design.

UNIT V **9 Hours**

STRUCTURE PREDICTION AND DRUG DESIGN

Structure Prediction - Introduction to Comparative Modeling. Sequence Alignment. Constructing and Evaluating a Comparative Model. Predicting Protein Structures by Threading, Molecular Docking, AUTODOCK and HEX. Structure based DeNovo Ligand design, Drug Discovery - Chemoinformatics - QSAR, Drug Design - Analog and Structure based drug design.

Total: 45 Hours

Reference(s)

1. Andrew Leach. Molecular modeling: principles and applications. 2nd edition. Pearson Education. 2001.
2. R.Leach - Molecular Modeling Principles and Application, 2nd edition, Longman Publications, 1996.
3. McCammon J A. and Harvey S C, Dynamics of Proteins and Nucleic Acids, Cambridge University Press, 1987.
4. Hans Pieter H and Folkens G, Molecular Modelling, VCH, 1999 Claude Cohen. N, Guide book on molecular modeling in drug design Synergix drug design, Israel,1999.
5. Fantini, J., Di Scala, C., Chahinian, H., & Yahi, N. (2020). Structural and molecular modelling studies reveal a new mechanism of action of chloroquine and hydroxychloroquine against SARS-CoV-2 infection. International journal of antimicrobial agents, 55(5), 105960.
6. https://nptel.ac.in/courses/103103036.

22BT018 COMPUTER AIDED DRUG DESIGN 3 0 0 3

Course Objectives

- To provide a broad overview of important approaches used in protein and ligand structure based drug design.
- To state the approaches that are currently applied in drug discovery efforts.
- To design and produce novel biomolecules.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the Limitations.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using bio resources.

Course Outcomes (COs)

1. Apply the basic terms in the field of drug designing and drug discovery.
2. Apply pharmacophore modelling methods for drug discovery.
3. Analyze new molecules with therapeutic values based on their structure activity relationship.
4. Evaluate the development of new biomolecules by analyzing their Pharmacology.
5. Create new lead molecules, antibiotics, antiviral and anticancer drugs.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	-	2	1	-	-	-	-	-	-	-	-	-	2	3
2	2	-	2	1	3	-	-	-	-	-	-	-	-	2	2
3	2	-	2	2	3	-	-	-	-	-	-	-	-	3	2
4	1	-	2	1	3	-	-	-	-	-	-	-	-	3	1
5	1	-	2	1	3	-	-	-	-	-	-	-	-	1	1

UNIT I 9 Hours

INTRODUCTION TO DRUG DESIGN AND DISCOVERY

Drug Discovery Therapeutic targets-identification and validation, Drug development process -An outline Discovery of drug candidates. Sources of hits, leads and candidate drugs. Basic principles in lead development and optimization, Membrane penetration-Lipinski Rule of five Stereochemistry in Drug Design and the importance.

UNIT II 9 Hours

DOCKING AND PHARMACOPHORE MODELLING

Role of X-ray crystallography in structure guided drug design, molecular docking and scoring methods, de novo ligand design, fragment-based drug design. Pharmacophore-based ligand design, pharmacophore concept, basic principles and step by step procedure, pharmacophore elements and their representations, receptor excluded and receptor essential volumes solvation effect. Benzodiazepine site of GABA receptors, 3D-Pharmacophore model.

UNIT III **9 Hours**

STRUCTURE ACTIVITY RELATIONSHIP-QSAR MODELS

Quantitative structure activity relationships and experimental design: Hamm equation, Free Wilson analysis, Hansch analysis hydrophobic correlations, multifactorial correlations physiochemical properties (electronic desorptors hydrophobic parameters, ST descriptors, biological relevance applications of Hansch equations (hydrophobic factors steric factors, electronic factors, ionization constant prediction from equations, blood-brain barrier penetration relations to molecular modeling: 3D-QSAR methodologies, Pharmacophore guided optimization of compounds.

UNIT IV **9 Hours**

RECEPTORS, ION CHANNELS AND ENZYMES- PHARMACOLOGY

Receptor structure and function: G-protein coupled receptors, ligand gated ion channel receptors, tyrosine kinase receptors, Nuclear receptors, Receptor pharmacology, lon channels: Structure and function of ion channels, classification of ion channels, ion channels and diseases. Inhibitors acting at the active site of an enzyme inhibitors acting at allosteric binding sites, uncompetitive and non-competitive inhibitors, transition state analogues, suicide.

UNIT V **9 Hours**

DESIGN OF ANTIVIRAL ANTICANCER AND ANTIBIOTICS

Anticancer Agents: Hallmarks of malignant cancer, currently used anticancer agents and their mode of actions. Antibiotics affecting bacterial cell wall formation, cytoplasmic membrane, nucleic acid synthesis, and protein synthesis. Antiviral Drugs and HIV compounds Nucleoside reverse transcriptase inhibitors; nucleotide reverse transcriptase inhibitors; non- nucleoside reverse transcriptase inhibitors, protease inhibitors. Viral entry inhibitors. and HBV compounds, Anti-herpes virus compounds, and influenza virus compounds.

Total: 45 Hours

Reference(s)

1. Han, Kamber, and Pel, J. Data Mining: Concepts and Techniques. Publishers. USA, 3 edition, 2012.
2. Voit E. A First Course in Systems Biology. Garland Science, 1/e. ISBN 0815344678, 2012.
3. Klipp E. Systems biology: a textbook. Wiley-VCH, 1/e. ISBN 9783527318742, 2009.
4. Newman MEJ. Networks: an introduction. Oxford Univ. Press. ISBN 9780199206650, 2011.
5. Bak, P. Brak 5. Bioinformatics: the machine leaming approach, MIT Press, 2 edition, 2001.
6. https:/www.coursera.org/learn/machine learning.
7. https://onlinecourses.nptel.ac.in/noc23_bt41/preview.

22BT019 METABOLOMICS AND GENOMICS – BIG DATA ANALYTICS 3 0 0 3

Course Objectives

- To understand and apply the basic scientific principles behind metabolic network in living system.
- To understand the uses and limitations of metabolomics.
- To introduce methods and strategies commonly used in metabolic engineering.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PSO2. Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Apply the principles and various techniques used to analyze the metabolism in living system.
2. Analyze collection, segregation and processing techniques for metabolomics.
3. Analyze various methods to control the material and energy balance in cellular metabolism.
4. Analyze the laws pertaining to the handling of metabolic flux.
5. Evaluate the process involved in the metabolic pathways and its application in disease treatment.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	1	1	1	-	-	-	-	-	-	-	-	-	2	2
2	2	1	3	1	-	-	-	2	-	-	-	-	-	2	2
3	1	-	2	2	3	-	2	-	-	-	-	-	-	2	2
4	-	1	3	1	-	2	-	-	-	-	-	-	-	2	2
5	-	-	-	3	2	-	-	2	-	-	-	-	-	3	2

UNIT I **9 Hours**

INTRODUCTION TO METABOLOMICS

Introduction to metabolomics - metabolites, and metabolism-Types of metabolism-primary and secondary, Structural diversity of metabolites-physical and chemical properties, metabolites in the biological system, metabolons, Metabolites isolation from the biological system - separation methods for metabolomics - Gas Chromatography (GC), HPLC, Capillaryelectrophoresis (CE); Detection methods GC-MS, Secondary ion mass spectrometry (SIMS), NMR-1D and 2D.

UNIT II **9 Hours**

CELLULAR METABOLISM

Review of cellular metabolism: Transport mechanisms and their models; Enzyme kinetics, Mechanisms and their dynamic representation, Regulation of enzyme activity versus regulation of enzyme concentration, Regulation of metabolic networks, Regulation of at the whole cell level, Examples of important pathways, Case studies and analytical-type problems.

UNIT III **9 Hours**

INTRODUCTION TO GENOMICS

Whole Genome Sequencing and Analysis: Concept, methods, assembly methods (de novo and reference-based) and algorithms, genome annotation (structural and functional), comparative genomics.

UNIT IV **9 Hours**

HIGH-THROUGHPUT TRANSCRIPTOME PROFILING

High-throughput Transcriptome Profiling: Concept, methods and applications; transcriptome construction (de novo and reference-based), differential gene expression.

UNIT V **9 Hours**

SINGLE NUCLEOTIDE POLYMORPHISM

Single nucleotide polymorphisms: Genome resequencing; data processing and SNP prediction; applications in agriculture /human health.

Total: 45 Hours

Reference(s)

1. Metabolomics- Ute Roessner, 2012. InTech Publishers.
2. Metabolomics, A Powerful Tool in Systems Biology. Jens Nielsen, Michael C Jewett, 2007. Springer.
3. Metabolic Engineering: Principles and Methodologies- George Stephanopoulos, Aristos A. Aristidou, Jens Nielsen, 1998.
4. Nielsen, Jens H. Biotechnology for the Future. Berlin: Springer, 2011.
5. Stephanopoulos, G, Aristos A. Aristidou, and Jens H. Nielsen. Metabolic Engineering: Principles and Methodologies. San Diego: Academic Press, 1998.
6. Sussulini, Alessandra. Metabolomics: from Fundamentals to Clinical Applications. , 2017.
7. Voet, Donald, and Judith G. Voet. Biochemistry. Hoboken, NJ: John Wiley and Sons, 2011.
8. Schork, N.J., Fallin, D. and Lanchbury, J.S., 2000. Single nucleotide polymorphisms and the future of genetic epidemiology. *Clinical genetics*, *58*(4), pp.250-264.

22BT020 **DATA MINING AND MACHINE LEARNING TECHNIQUES FOR INFORMATICS** **3 0 0 3**

Course Objectives

- To expose the students to data mining and machine learning techniques.
- To render knowledge of how to perform research in ANN, Bayes classifier biology and synthetic biology.
- To work in multi-disciplinary teams for big data analyze for biological applications.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PSO1. Use the analytical instruments and techniques to isolate, purify and characterize biological compounds

Course Outcomes (COs)

1. Apply the problems for machine learning and select the either supervised, unsupervised or reinforcement learning.
2. Apply cluster analysis methods for machine learning.
3. Analyze the theory of probability and statistics related to machine learning.
4. Analyze the concept learning, ANN, Bayes classifier, k nearest neighbor.
5. Evaluate big data analyze for biological applications.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	1	2	-	-	-	-	-	-	-	-	-	-	-
2	1	2	2	2	1	1	-	-	-	-	-	-	-	-	-
3	1	-	2	1	1	1	-	-	-	-	-	-	2	-	-
4	1	2	2	2	-	-	-	-	-	-	-	-	1	-	-
5	1	2	2	-	-	-	-	-	-	-	-	-	1	-	-

UNIT I **9 Hours**

INTRODUCTION TO DATA MINING

Types of attributes, basic statistical descriptions of data, measuring data similarity and dissimilarity, data pre-processing data cleaning: missing values; data integration and transformation, data reduction: dimensionality reduction (PCA), numerosity reduction (near regression).

UNIT II **9 Hours**

CLUSTER ANALYSIS

Introduction to cluster analysis; requirements for cluster analysis; clustering methods: partition-based methods- k-means algorithm, K-Medoids method, hierarchical methods- agglomerative and divisive clustering, evaluation of clustering

UNIT III **9 Hours**

CLASSIFICATION AND PREDICTION

Linear regression Decision tree induction - attribute selection measures-tree pruning- scalability and decision tree induction: Random Forests: Bayesian classification: Bayes theorem, Naive Bayesian classification, Neural network-back propagation algorithm, Support Vector Machine. Introduction accuracy and error measures: evaluating classifier accuracy, improving classification accuracy.

UNIT IV **9 Hours**

ASSOCIATION MINING

Basic concepts: Apriori algorithm, methods to improve efficiency of apriori method, FP growth method, patient evaluation methods, comparison of partum evaluation methods.

UNIT V **9 Hours**

BIG DATA ANALYTICS

Introduction to big data: Introduction to Big Data Platform – Challenges of Conventional Systems - Intelligent data analysis – Nature of Data - Analytic Processes and Tools - Analysis vs Reporting.

Total: 45 Hours

Reference(s)

1. Han, Kamber, and Pel, J. Data Mining: Concepts and Techniques. Publishers. USA, 3 edition, 2012.
2. Bak, P. Brak 5. Bioinformatics: the machine leaming approach, MIT Press, 2 edition, 2001.
3. https:/www.coursera.org/learn/machine learning.
4. Helma, C., Cramer, T., Kramer, S. and De Raedt, L., 2004. Data mining and machine learning techniques for the identification of mutagenicity inducing substructures and structure activity relationships of noncongeneric compounds. Journal of chemical information and computer sciences, 44(4), pp.1402-1411.

22BT021 SYSTEMS AND SYNTHETIC BIOLOGY 3 0 0 3

Course Objectives

- To expose the students to bottom-up and top-down design and analysis strategies for systems and synthetic biology.
- To render knowledge of how to perform research in interdisciplinary fields like systems biology and synthetic biology.
- To work in multi-disciplinary teams for both computational and wet-lab projects.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PSO1. Use the analytical instruments and techniques to isolate, purify and characterize biological compounds.

Course Outcomes (COs)

1. Apply the basic cellular and molecular biological concepts.
2. Apply the biological networks and alignments.
3. Analyze synthetic biological molecules and networks.
4. Analyze the modern tools in systems and synthetics biology.
5. Evaluate the ethical principles in systems biology.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	-	3	-	2	-	-	1	-	-	-	-	-	-	-
2	2	-	2	-	1	-	-	2	-	-	-	-	-	-	-
3	2	-	1	-	2	-	-	1	-	-	-	-	2	-	-
4	1	-	1	-	1	-	-	2	-	-	-	-	1	-	-
5	1	-	1	-	1	-	-	3	-	-	-	-	1	-	-

UNIT I 9 Hours
INTRODUCTION TO BASIC CELLULAR AND MOLECULAR BIOLOGY

Central dogma of biology, mechanisms of gene expression, Kinetics of Enzyme Action, Rate Processes, Raw laws, Stoichiometric, Introduction to cell metabolism, Metabolic pathways, Protein signalling, Enzymatic reaction kinetics.

UNIT II 9 Hours
BIOLOGICAL NETWORKS

Introduction to systems and synthetic biology, Biological networks: metabolic, signaling, regulatory, Network alignment and comparisons, network organization, Designing, simulating and building gene circuits, Genome design and synthesis.

UNIT III **9 Hours**

SYNTHETIC NETWORKS

Simple synthetic networks, Noise in gene expression, Structure of biological networks, Synthetic Networks, Design of promoters, Design of RNAs, Design of circuits, Characterization and optimization of devices, Examples and Applications of Synthetic Networks, Building synthetic networks, Monitoring outputs.

UNIT IV **9 Hours**

TOOLS IN SYSTEMS AND SYNTHETIC BIOLOGY

Flux analysis FBA, Computer aided design tools for metabolic engineering (lenera programs, retrosynthesis), Development of a flux theoretical model, correlation of the model with experimental data, Simulating synthetic networks, Manipulating DNA and measuring network responses.

UNIT V **9 Hours**

ETHICS IN SYSTEMS AND SYNTHETIC BIOLOGY

Biosafety introduction, Reengineering living organisms, ethical questions of synthetic biology, Current science-society situation and the place of synthetic biology, Controversies around key concepts: novelty, perfection, intentionality, complexity, life, Scientist's responsibility - Dual-use research and its implications from ethics to biosecurity.

Total: 45 Hours

Reference(s)

1. Pengcheng Fu, Sven Panke, "Systems Biology and Synthetic Biology", Wiley-Blackwell Publisher, 2009.
2. Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, Chapman & Hall, 2006.
3. James E. Bailey and David F. Ollis, Biochemical Engineering Fundamentals, McGraw-Hill, 1986.
4. Bartocci, E. and Lió, P., 2016. Computational modeling, formal analysis, and tools for systems biology. *PLoS computational biology*, *12*(1), p.e1004591.
5. Brückner, A., Polge, C., Lentze, N., Auerbach, D. and Schlattner, U., 2009. Yeast two-hybrid, a powerful tool for systems biology. *International journal of molecular sciences*, *10*(6), pp.2763-2788.

22BT022/22BTM22 **PLANT TISSUE CULTURE AND TRANSFORMATION TECHNIQUE** **3 0 0 3**

Course Objectives

- To gain ample knowledge on different plant culture types involved.
- To learn the techniques involved in plant tissue culturing.
- To have an exposure on the various real time applications of culturing techniques in GM crop production and sustainability.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO5. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12. Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
PSO2. Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for global welfare using bio-resources.

Course Outcomes (COs)

1. Apply the historical developments in plant cell culture and learn to handle the techniques in aseptic conditions.
2. Analyze the existing and recent developments with the knowledge of basic plant tissue culture techniques.
3. Analyze the recent methodologies of plant tissue and cell culture to develop a whole plant.
4. Evaluate the recent methodologies of plant tissue and cell culture to develop a whole plant.
5. Create the concepts of plant tissue culture in agricultural science for crop improvement.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	1	-	-	-	-	-	-	-	-	1	-	2	2
2	-	3	1	-	2	-	-	-	-	-	-	2	-	2	2
3	-	3	2	-	1	-	-	-	-	-	-	1	-	2	2
4	-	-	1	-	1	3	3	-	-	-		2	-	2	2
5	-	-	3	-	-	-	2	-	-	-	1	1	-	2	2

UNIT I **9 Hours**

INTRODUCTION TO PLANT TISSUE CULTURE

History of plant tissue culture, Laboratory requirements and organization; Types of media and its composition - inorganic nutrients, organic supplements, carbon source, vitamins, gelling agents, Explants and sterilization techniques- filter, heat, wet and chemical, Plant Growth hormones; Commonly used culture media.

UNIT II **9 Hours**

BASICS OF CULTURE TYPES AND TECHNIQUES

Suspension culture - Batch and continuous, Synchronisation of suspension culture, Micro propagation - Factors affecting morphogenesis and proliferation rate, technical problems in micropropagation; Protoplast isolation and fusion technology and its Viability test.

UNIT III **9 Hours**

CELL CULTURE AND TRANSFORMATION TECHNIQUES FOR REGENERATION OF CROPS

Organogenesis -formation of shoots and roots, production of virus free plants by Meristem and shoot-tip culture, Embryogenesis - Process of somatic embryogenesis, structure, stages of embryo development, factors affecting embryogenesis; production of artificial seeds; Cryopreservation; Transformation technique- Physical and chemical methods.

UNIT IV **9 Hours**

COMMERCIAL CROPS USING PLANT TISSUE CULTURE

Herbicide resistance; Pest resistance - BT Crops; Genetic engineering for male sterility- Barnase-Barstar; Delay of fruit ripening - Polygalacturonase, ACC synthase, ACC oxidase.

UNIT V **9 Hours**

APPLICATIONS OF TISSUE CULTURE

Application of plant tissue culture in mutant selection, Secondary metabolite production and clonal propagation. Plant products of industrial importance, Recent advances in plant tissue culture.

Total: 45 Hours

Reference(s)

1. M. K. Razdon, Introduction to Plant Tissue Culture, Oxford &IBH Publishing Company, 2006.
2. S. Narayanaswamy, Plant Cell & Tissue Culture, Tata Mc Graw-Hill, 2008.
3. A. Slater, N. Scott and M. Fowler, Plant Biotechnology: The genetic manipulation of plants, Oxford University Press, 2003.
4. https://onlinecourses.swayam2.ac.in/cec19_bt01/preview .

22BT023/22BTM23 TRANSGENIC TECHNOLOGY IN AGRICULTURE 3 0 0 3

Course Objectives

- To gain ample knowledge on different biotech techniques.
- To learn the techniques involved in Crop improvement.
- To have an exposure on the various real time applications for crop production and sustainability.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PSO3. Conceive, Plan and Deploy societal projects for global welfare using bio-resources

Course Outcomes (COs)

1. Apply the biology being crop culture techniques.
2. Apply the need of various physio chemical conditions in plant Tissue culture.
3. Analyze the recent methodologies of plant tissue and cell culture to develop a whole plant.
4. Analyze the commercial significance of plant tissue culture.
5. Evaluate the need of various interdisciplinary domains in Plant tissue culture procedures.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-
2	2	1	3	-	-	-	-	-	-	-	-	-	-	-	1
3	1	-	2	-	3	-	2	2	-	-	-	-	-	-	2
4	-	1	3	-	-	2	-	-	-	-	-	-	-	-	1
5	-	-	-	3	2	-	2	2	-	-	-	-	-	-	2

UNIT I **9 Hours**

PLANT ORGAN, TISSUE AND CELL CULTURE

Totipotency; micro-propagation and its uses; somaclonal variation and its use in crop improvement; embryo culture; anther culture; somatic embryo; artificial seeds; techniques of protoplast culture, regeneration and somatic cell hybridization, achievements and limitations, utility in improvement of crop plants; application in production of secondary metabolites and transformations.

UNIT II **9 Hours**

COMMERCIAL APPLICATIONS OF PLANT TISSUE CULTURE

Disease free seed production technology, Hybridization & mutant selection, Secondary metabolite production, GMO & transgenic Crops, organ culture for production of active ingredients in food and cosmetics, Regulations in PTC derived plantlets. Biosensors for agriculture. Post-transcriptional gene silencing (PTGS): VIGS and RNAi and their use in functional genomics and crop improvement. Bio fertilizers and bio insecticides:

UNIT III **9 Hours**

METHODS OF GENE TRANSFER IN PLANTS

Agrobacterium mediated gene transfer (dicots and monocots), direct DNA delivery methods (microinjection, particle gun method electroporation); gene targeting (including zinc finger nucleases). Transgenic plants in dicots and monocots: Utility of transgenics in basic studies and in crop improvement (resistance for biotic and abiotic stresses; barnase and barstar for hybrid seed production).

UNIT IV **9 Hours**

MOLECULAR PHARMING

Molecular farming for production of foreign proteins and edible vaccines; marker-assisted selection (MAS) in plant breeding. Molecular mapping and tagging of agronomic important traits. Statistical tools in marker analysis, Robotics; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, Gene pyramiding. Genomics and genoinformatics for crop improvement; Marker-assisted backcross breeding for rapid introgression.

UNIT V **9 Hours**

BIOSAFETY AND REGULATORY ISSUES

Biosafety issues including risks associated with transgenic crops; biosafety regulations (role of IBC, RCGM and GEAC or NBRA). International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights MOs and related issues (risk and regulations); Intellectual property rights.

Total: 45 Hours

References

1. Satbir Singh Gosal and Shabir Hussain Wani (2018) Biotechnologies of Crop Improvement, Volume 1, Springer.
2. Satbir Singh Gosal and Shabir Hussain Wani (2018) Biotechnologies of Crop Improvement, Volume 3, Springer.
3. S.M. Paul Khurana & Narendra Kumar (2022). Plant Biotehnology: A Text Book Scientific Publisher.
4. M. K. Razdon, (2006) Introduction to Plant Tissue Culture, Oxford &;IBH Publishing Company.

22BT024/22BTM24 BIOFERTILIZERS AND BIOPESTICIDES PRODUCTION 3 0 0 3

Course Objectives

- To understand the types and mechanisms of fertilizers.
- To formulate and production of bio fertilizers.
- To produce, formulate and study of regulation of bio pesticides.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources.

Course Outcomes (COs)

1. Apply the classifications of fertilizers and the contribution of microorganism to soil facility.
2. Apply the types of fertilizers and the contribution of microorganism to soil facility.
3. Analyze the commercial production of Bio fertilizers.
4. Analyze the concept of Bio pesticides, Bio fungicides, Bio insecticide.
5. Evaluate the regulation policies on Bio pesticides.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-
2	-	1	-	2	-	-	-	-	-	-	-	-	-	1	-
3	-	1	-	1	-	-	-	2	-	-	-	-	-	1	-
4	1	-	-	2	-	-	-	-	-	-	-	-	-	-	1
5	1	-	-	2	-	-	-	-	-	-	-	-	-	-	1

UNIT I **9 Hours**

INTRODUCTION TO BIOFERTILIZERS

Definition and Classification of fertilizers (synthetic fertilizers & natural fertilizers), Organic Fertilizers, Advantages of biofertilizers over synthetic fertilizers, Microbial inoculants in Agriculture - contributions of microorganisms to soil fertility, Rhizosphere concept.

UNIT II **9 Hours**

TYPES OF BIOFERTILIZERS

Different groups of biofertilizers - bacterial, fungal and algal biofertilizers; Phosphorus Biofertilizers - Rock phosphate solubilisation; Phosphorus mobilization – mycorrhiza -types– endo, ectomycorrhiza and orchidaceous mycorrhiza, Problems and prospects of biofertilizers. BSI standards of biofertilizers, Economics of biofertilizers.

UNIT III **9 Hours**

COMMERCIAL PRODUCTION OF BIOFERTILIZERS

Principles of Mass production - growth characteristics - Fermentation- Principles and techniques - inoculum preparation. Large-scale production of bacterial biofertilizers, Azolla- Blue green algae, VAM fungi and Ectomycorrhiza; Field performance of biofertilizers - method of application; Carrier materials - Types and quality, characteristics of an ideal carrier.

UNIT IV **9 Hours**

BIO PESTICIDES

Bio pesticides - present status and future prospects; bio fungicides - commercial development of bio fungicides, microbial action for disease control, bioinsectides - neem and related natural products, commercialization of neem products; Bt: natural and recombinant bio insecticide products, Bt transgenic plants.

UNIT V **9 Hours**

BIO PESTICIDES PRODUCTION - REGISTRATION AND MANAGEMENT PROTOCOLS

Pesticide policy influences on bio pesticides technologies; environmental and regulatory aspects: industry view and approach; formulations of bio pesticides; delivery systems and protocols for bio pesticides; analysis, monitoring and some regulatory implications; principles of dose acquisition for bio insecticides; strategies for resistance management.

Total: 45 Hours

Reference(s)

1. S.Kannaiyan , Biotechnology of Biofertilizer, Narosa Publishing House, 2002.
2. R.H.Franklin and J.M.Julius, Biopesticides - Use and Delivery. Humana Press Inc., 1999.
3. S.S.Purohit, Agricultural Biotechnology, Agrobios India, 2003.
4. P.S.Nutman, Symbiotic nitrogen fixation in plants, Cambridge Univ. Press, London, 1976.
5. N.S.SubbaRao, Advances in Agricultural Microbiology, Oxford and IBH, Publn. Co., New Delhi, 1982.
6. Shukla, R. and Shukla, A., 2012. Market potential for biopesticides: a green product for agricultural applications. *International Journal of Management Research and Reviews*, *2*(1), p.91.
7. http://acl.digimat.in/nptel/courses/video/102105058/L51.html.

22BT025/22BTM25 MUSHROOM CULTIVATION AND VERMICOMPOSTING 3 0 0 3

Course Objectives

- To understand the basic concepts, principles, potentials and limitations of mushroom cultivation and vermiculture techniques.
- To Apply the active compounds of mushroom for developing a solution for health care problems.
- To develop mushroom cultivation and vermiculture skills for entrepreneurial activity.

Programme Outcomes (POs)

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PSO2. Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Apply the active compounds of mushroom in food and pharmaceutical industry.
2. Apply the cultivation techniques for mushroom production.
3. Apply post-harvest technology to preserve the quality of the product.
4. Analyze the significance of earthworms in increasing the soil fertility.
5. Execute the techniques of vermicomposting for large scale production and marketing.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-
2	-	-	3	-	2	-	3	-	-	-	-	-	-	-	1
3	-	-	2	-	3	-	3	-	-	-	-	-	-	-	1
4	-	3	2	-	-	-	2	-	-	-	-	-	-	1	1
5	-	-	2	-	2	-	3	-	-	-	-	-	-	2	-

UNIT I **9 Hours**

INTRODUCTION

Introduction and Importance of mushrooms; History of mushroom cultivation; Present status of mushroom industry in India; Cultivable edible mushroom; Biology of mushroom; Food value of edible mushrooms; Uses of mushrooms, Poisonous mushrooms, and Medicinal mushrooms.

UNIT II **9 Hours**

MUSHROOM CULTIVATION AND BIOLOGICAL IMPORTANCE

Mushrooms farm structure; design and layout; Spawn principles, techniques of spawn production; Principle and techniquesof compost and compositing; Cultivation techniques of White button mushroom, oyster mushroom.

UNIT III **9 Hours**

DISEASE AND POST-HARVEST TECHNOLOGY

Conventional dosage forms – Solid – Tablet, Capsule and Powder; Semi-Solid – Ointments, Creams, Lotions and Gels; Liquid – Solution, Suspension, Syrup and Emulsion; Gaseous – Aerosols and Sprays; Novel Drug Delivery Systems - Liposomes, Dendrimers, Microspheres, Nanoparticles and Micelles.

UNIT IV **9 Hours**

VERIMICULTURE TECHNOLOGY

Permaculture Technology; organic farming, soil fertility; Distribution and Ecology of Earthworms Earthworm taxonomy - Morphological and Anatomical characteristics of Earthworm -Food habits, excretion and life cycle. Types of Earthworms - Exotic and native species.

UNIT V **9 Hours**

METHODS OF VERMICOMPOSTING

Collection and preservation of earthworms for vermicomposting and culturing techniques of earthworms. Preparation of vermicomposting requirement, different methods of Vermicompositing (Heap method, Pot method, and Tray method). Changes during vermin compositing, Nutrient value of Vermicompositing; Problems in vermicomposting preparation; Earthworm as bioreactors. Influence of chemical inputs on earthworms activities. Large scale manufacture of Vermicomposting, packaging; financial supporting (Government and NGOs for vermi culture work).

Total: 45 Hours

Reference(s)

1. NPCS Board of Consultants & Engineers, The Complete Technology Book on Vermiculture and Vermicomposting, 2004
2. Keshav Singh, Textbook of Vermicompost: Vermiwash and Biopesticides, 2014
3. Robin Gogoi Yella Rathaiah T R Borah, Mushroom Cultivation Technology, Scientific Publishers, 2006
4. S.C. Tiwari & Pankaj Kapoor, Mushroom Cultivation, 2018
5. Purnawanto, A. M., Ahadiyat, Y. R., & Iqbal, A. (2020). The Utilization of Mushroom Waste Substrate in Producing Vermicompost: The Decomposer Capacity of, and. Acta Technologica Agriculturae, 23(2), 99-104.

22BT026/22BTM26 FUNGAL AND ALGAL TECHNOLOGY 3 0 0 3

Course Objectives

- To develop skills of the students in the research areas of Mycology and Algae
- To execute the bioprocess techniques in Mycology and algae
- To acquire prerequisite knowledge for all Bioprocess Technology processes

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of and need for sustainable development.

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PSO1. Use the analytical instruments and techniques to isolate, purify and characterize biological compounds

PSO3. Conceive, Plan and Deploy societal projects for global welfare using bioresources.

Course Outcomes (COs)

1. Apply the general characteristic features of Fungi.
2. Analyze the fungal forms and its associations.
3. Analyze the economic importance of fungi.
4. Analyze the algal classification, lifecycle and reproduction.
5. Determine economic importance of Algae.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	-	2	-	-	-	2	-	1	-	-	-	1	-	-
2	2	-	2	-	-	-	3	-	2	-	-	-	1	-	-
3	1	-	3	-	-	-	1	-	2	-	-	-	-	-	-
4	2	-	3	-	-	-	2	-	2	-	-	-	-	-	-
5	2	-	2	-	-	-	1	-	2	-	-	-	-	-	2

UNIT I 9 Hours

GENERAL CHARACTERS OF FUNGI

Introduction to the Fungi, Diversity of fungi and fungus-like organisms, History of mycology the fungal body and cells, and growth, fungal physiology, nutrition, and growth. Mushrooms, Mushroom poisoning, Rust and smut fungi, Range of structure and organization of vegetative and reproductive bodies. Ontogeny of conidia, Saccardo's classification system, conidial fungi, sterile technique; isolation and growing fungi.

UNIT II 9 Hours

FUNGAL FORMS AND ASSOCIATIONS

Structure and reproduction with reference to the following fungal forms (no developmental stage) Rhizopus, Aspergillus, Saccharomyces, Neurospora, Types, structure, reproduction. Mycorrhizae Clinical mycology: Structure, reproduction, diagnoses and control measures of the following: Dermatophytes: (Trichophyton); Systemic mycoses (Candida), Fungal toxins.

UNIT III **9 Hours**

ECONOMIC IMPORTANCE OF FUNGI

Economic importance. Lichens: Habitat, Structure and organization of lichens. Method of reproduction. Physiological relationship of mycobiont and phycobiont. Economic importance of lichens, Mycorrhizae: Habitat, Structure and organization of Mycorrhizae. Types of Mycorrhizae and its economic importance.

UNIT IV **9 Hours**

ALGAE - INTRODUCTION

A general account and classification of Algae – distribution - range of thallus organization – pigmentation-flagellation- reserve food – Reproduction(vegetative-asexual-sexual); Lifecycle patterns salient features of algal divisions, phylogeny - Fossil algae, Algae -Structure and reproduction with reference to the following algal forms – Anabaena, Chlorella, Volvox,

UNIT V **9 Hours**

ALGAE - APPLICATIONS

Algal biotechnology: single cell proteins (SCP): Spirulina as single cell protein-production and harvesting of algal biomass – factors affecting biomass production. Cyanobacterial inoculants (BGA): Isolation, preparation of starter culture, mass cultivation, field applications and crop response. Economic importance of algae: Algae as food and fodder, use of algae in agriculture and space research, commercial products of algae: Agar-Agar, Alginates, Carrageenin, diatomite, mucilage, minerals and elements - Algae in medicine and biofuels.

Total: 45 Hours

References:

1. Srivastava, H.N. 1999. Algae. Pradeep publications, Meerut.
2. Sharma, O.P. 2004. A Textbook of Algae. Tata McGraw- Hill publishing Company Limited, New Delhi.
3. Bilgrami, K.S. and Saha, L.C. 2012. A Textbook of Algae. CBS Publishers & Distributors Pvt. Ltd., New Delhi.
4. Vashista, B.R. 2000. Fungi, Chand & Co. New Delhi
5. Harold C. Bold, 1982. Morphology of plants. Weiley- Eastern Ltd.
6. Sathyanarayana, U. 2010. Biotechnology; Books and allied (P) Ltd. Kolkatta
7. Solomon, L., Tomii, V.P. and Dick, A.A.A., 2019. Importance of fungi in the petroleum, agro-allied, agriculture and pharmaceutical industries. *NY Sci. J*, *12*, pp.8-15.
8. https://archive.nptel.ac.in/courses/102/103/102103015/

22BT027/22BTM27 **PHYTOTHERAPEUTICS** **3 0 0 3**

Course Objectives

- To understand and apply the basic scientific and sustainability principles behind phytotherapeutics.
- To analyze the fundamental principles of existing and emerging technologies for the treatment of diseases.
- To appreciate the increasing importance of bioavailability of phytocompounds.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6 The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using bioresources.

Course Outcomes (COs)

1. Apply the scope and importance of medicinal plants.
2. Analyze the classification of herbal drugs.
3. Analyze the importance of ethanobotany.
4. Analyze the Phototherapeutic compounds.
5. Evaluate the bio availability and pharmacokinetic aspects for herbal drugs.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-
2	2	1	3	-	-	-	-	-	-	-	-	-	-	-	1
3	1	-	2	-	3	-	2	2	-	-	-	-	-	-	2
4	-	1	3	-	-	2	-	-	-	-	-	-	-	-	1
5	-	-	-	3	2	-	2	2	-	-	-	-	-	-	2

UNIT I **9 Hours**
INTRODUCTION

Key Historical events, Scope and importance of medicinal plants. Traditional medicinal systems: Siddha, Ayurveda, Homeopathy, Chinese medicine, Unani, Naturopathy and Aromatherapy. Status of Indian medicinal plant trade, medicinal plants prohibited from export, leading companies in India in trade of medicinal plants.

UNIT II **9 Hours**

CLASSIFICATION OF HERBAL DRUGS

Classification of herbal drugs based on the Alphabetical, Morphological, Taxonomical, Chemical and pharmacological. Collection and processing of herbal raw materials for drugs preparation-Post Harvesting care, Drying, Dressing, Packing and Storage. Conservation and mass propagation of important medicinal plants through In vitro propagation methods. Role of NMPB, CDRI and CIMAP on medicinal plants conservation and research development. WHO regulation and Guidelines for quality control and trade of herbal medicine.

UNIT III **9 Hours**

ETHNOBOTANY

Ethno botany - concept, scope and objectives; Ethnobotany as an interdisciplinary science. The relevance of ethnobotany in the present context; Role of ethnobotany in modern Medicine Medico-Ethnobotanical sources – Eg. Contribution of Kani Tribes. Ethnobotany and plant genetic resources conservation of medicinal plants with special reference to India. Major tribes of South India and their ethno botanical knowledge.

UNIT IV **9 Hours**

PHYTOTHERAPEUTIC COMPOUNDS OF MEDICINAL PLANTS

Phytotherapeutic compounds of medicinal plants - Alkaloids, Glycosides, Terpenoids, Tannins, Flavonoids and Phenols. Patent guidelines for Phytotherapeutic compounds. Identification and utilization of the medicinal herbs in curing various ailments – *Catharanthus roseus* (Anti-cancer), *Aegle marmelos* (Cardiotonic), *Withania somnifera* (Drugs acting on nervous system), *Cardiospermum halicacabum* (Anti-rheumatic) and *Centella asiatica* (Memory booster), *Phyllanthus emblica (*Rejuvenating) and (Hepato-protective).

UNIT V **9 Hours**

BIOAVABILITY & PHARMACOKINETIC ASPECTS FOR HERBAL DRUGS

Preparation of liquid orals, tablets, capsules, ointments, creams and cosmetics, Methods involved in monoherbal and polyherbal formulation with their merits and demerits. Excipients used in herbal formulation, Compatibility studies, Stability studies, Bioavailability & Pharmacokinetic aspects for herbal drugs with examples of well-known documented, clinically used herbal drugs. Quality Control of finished herbal medicinal products.

Total: 45 Hours

Reference(s)

1. Iqbal Ramzan, (2020) Phytotherapies: Efficacy, Safety, and Regulation, 015 John Wiley & Sons, Inc.
2. Michael Heinrich, Joanne Barnes, Jose Prieto-Garcia , Simon Gibbons Elizabeth and M. Williamson, (2018) Fundamentals of Pharmacognosy and Phototherapy, 3rd Edition, Elsevier.
3. Williamson, E. M.; Okpako, D. T. ; Evans, F. J. (1996)Pharmacological methods in phytotherapy research: volume 1: Selection, preparation and pharmacological evaluation of plant material. John Wiley & Sons Ltd.
4. http://shawnacohen.tripod.com/thetribaltraditions/id51.html

22BT028/22BTH28 ANIMAL PHYSIOLOGY AND METABOLISM 3 0 0 3

Course Objectives

- To learn about the physiology of blood, mammalian digestive system, urinary system and neuronal system.
- To understand the role of hormones in mammalian physiology.
- To study the metabolic pathways and energy generation in biological systems.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO6 The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.

Course Outcomes (COs)

1. Apply the physiological principles related to mammalian digestive and urinary system.
2. Analyze the physiology of blood and neuronal system.
3. Analyze the role and interactions of hormones.
4. Evaluate the concepts of coenzymes, and energy generation in biological systems.
5. Evaluate the interrelationship of metabolic pathways in relation to overall physiological states.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	-	2	-	-	2	-	3	-	-	-	-	-	2	-
2	2	-	3	-	-	2	-	2	-	-	-	-	-	-	-
3	3	-	2	-	-	3	-	3	-	-	-	-	-	1	-
4	2	-	3	-	-	2	-	2	-	-	-	-	-	1	-
5	2	-	2	-	-	3	-	3	-	-	-	-	-	2	-

UNIT I 9 Hours

PHYSIOLOGY OF DIGESTION AND EXCRETION

Hydrolysis and resorption of food components; Digestive processes: formation of HCl, Zymogen activation, fat digestion; Bile salts - composition and functions, Biotransformation, Cytochrome P450 system, Liver function and diagnostic tests, Formation and acidification of urine, acid-base balance and maintenance.

UNIT II 9 Hours

PHYSIOLOGY OF BLOOD, AND NEURONAL SYSTEM

Blood composition, plasma proteins, lipoproteins, Buffer systems of plasma, Blood clotting and fibrinolysis; Gas transport, Cerebrospinal fluid; Neurons- types and functions, blood-brain barrier, resting and action potentials, neurotransmitters.

UNIT III **9 Hours**

BIOCHEMISTRY AND FUNCTIONS OF HORMONES

Organization and regulation of secretions and function of: Anterior and Posterior pituitary, Thyroid, Adrenal cortex and medulla, Parathyroid, Pancreas, sex hormones, Clinical orientation.

UNIT IV **9 Hours**

BIOENERGETICS AND BIOLOGICAL OXIDATION

Role of High energy phosphates in Bioenergetics and energy capture, Role and mechanism of action of $NAD^+/NADP^+$, FAD, lipoic acid, thiamine pyrophosphate, tetrahydrofolate, biotin, pyridoxal phosphate, B12 coenzymes and metal ions, Respiratory chain and its role in energy capture.

UNIT V **9 Hours**

REGULATION OF INTERMEDIARY METABOLISM

Major and unique features of metabolism of the principal organs (liver, brain, muscle, kidney) in various metabolic states - fed and starved states, Coordinated Regulation of glycolysis and glycogenesis, Regulation of gluconeogenesis, Regulation of fatty acid synthesis and degradation, Ketogenesis.

Total: 45 Hours

Reference(s)

1. Nelson, D. L. and Cox, M. M., Lehninger's Principles of Biochemistry, 5th Ed, Worth Publishers. 2008.
2. Murray, R. K., Granner, D. K., Mayes, P. A., Rodwell., Harper's Illustrated Biochemistry by, V.W., 26th Ed, The McGraw-Hill Companies, Inc. 2006.
3. Guyton., Textbook of Medical Physiology, 11th Ed, A. C., H. Sanders Philadelphia. 2005.
4. Frayn, Keith N.., Evans, Rhys. Human Metabolism: A Regulatory Perspective. United Kingdom: Wiley, 2019.
5. Silverthorn, Dee Unglaub., Johnson, Bruce R.. Human Physiology: An Integrated Approach. United Kingdom: Pearson/Benjamin Cummings, 2010.

22BT029/22BTH29 **ANIMAL HEALTH AND NUTRITION** **3 0 0 3**

Course Objectives

- To learn about the animal health, nutrition, pathology, toxicology and epidemiology.
- To understand the concepts of animal pathology and animal toxicology.
- To study the epidemiological methods in livestock disease management and disease forecasting.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.

Course Outcomes (COs)

1. Apply the ruminant and non-ruminants nutritional requirement.
2. Apply the microbial basics in pathogenesis of livestock diseases.
3. Apply the biotechnological techniques in enhancing animal health and its production.
4. Analyze the utilization of livestock for developing commercially important novel products.
5. Evaluate the concepts of toxicity caused by heavy metals, plants and agrochemicals affecting livestock health.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	-	2	-	-	2	-	3	-	-	-	-	-	2	-
2	2	-	3	-	-	2	-	2	-	-	-	-	-	-	-
3	3	-	2	-	-	3	-	3	-	-	-	-	-	1	-
4	2	-	3	-	-	2	3	2	-	-	-	-	-	1	-
5	3	-	2	-	-	3	-	3	-	-	-	-	-	2	-

UNIT I **9 Hours**

NUTRIENT REQUIREMENTS OF ANIMAL

Basic concept of food and nutrition; Biochemistry of carbohydrate, proteins, lipids, minerals and vitamins; Feeding standards for maintenance and growth: Nutrient requirements for maintenance and growth, Nutritional control of growth; Feeding standards for reproduction: Nutrition requirements for reproduction; Lactation: Nutrient requirements of the lactating dairy. Voluntary intake of food: Feeding behavior.
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UNIT II **9 Hours**

ANIMAL PATHOLOGY

Food and Water borne infections: Bacterial, Viral and Parasitic infections - its causative agent, sources of infection, symptoms and prevention. Biosecurity - Disease transmission and management.

UNIT III **9 Hours**

SUSTAINABLE ANIMAL PRODUCTION AND HEALTH

Genetically modified organisms - Nuclear Transplantation, Retroviral Method, DNA microinjection ; Transgenic Animals- Production of Pharmaceuticals, production of donor organs, Expressing cloned genes in mammalian cells. Conservation Biology - Cryopreservation: In vitro fertilization and embryo transfer in farm animals, Artificial insemination; Gene Therapy.

UNIT IV **9 Hours**

ANIMAL VACCINES & THERAPEUTICS

Introduction to the concept of vaccines; Conventional methods of vaccine production; Recombinant approaches to vaccine production; Recombinant cytokines and monoclonal antibodies: their use in the treatment of animal infections; Therapeutic cloning.

UNIT V **9 Hours**

ANIMAL TOXICOLOGY

Toxicity caused by metals and non-metals; Poisonous plants; plants causing thiamine deficiency. plants causing photosensitization and lathyrism. Toxicity caused by Agrochemicals; Common adulterants and feed additives of concentrates and fodders and its uses.

Total: 45 Hours

Reference(s)

1. Wu G. Principles of animal nutrition. CRC Press; 2017 Nov 22.
2. McDonald, P., Edwards, R.A., Greenhalgh, J.F.D., Morgan, C.A., Sinclair, L.A. and Wilkinson, R.G., 2010. Animal nutrition 7th edition.
3. D'Mello, J.F. ed., 2000. Farm animal metabolism and nutrition. Cabi.

22BT030/22BTH30 ANIMAL CELL CULTURE TECHNIQUES 3 0 0 3

Course Objectives

- To impart the knowledge on basic tissue culture techniques
- To train students on theoretical and practical aspects of animal cell culture
- To demonstrate knowledge of cell lines used in mammalian tissue culture, their origins and applications

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO6 The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.

Course Outcomes (COs)

1. Apply the fundamental knowledge of cell culture techniques and their competence in laboratory techniques.
2. Apply the knowledge of cell isolation, maintenance and characterization in organ culture.
3. Analyze the proficiency in establishing and maintaining of cell lines.
4. Analyze cell cytotoxicity in regard to cell proliferation and viability.
5. Evaluate the potential benefits of cell culture techniques in disease management.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	-	2	-	-	2	-	3	-	-	-	-	-	2	-
2	2	-	3	-	-	2	-	2	-	-	-	-	-	-	-
3	3	-	2	-	-	3	-	3	-	-	-	-	-	1	-
4	2	-	3	-	-	2	-	2	-	-	-	-	-	1	-
5	2	-	2	-	-	3	-	3	-	-	-	-	-	2	-

UNIT I: INTRODUCTION TO CELL CULTURE 9 Hours

Introduction of cell culture development, Equipment for cell culture, Regulatory frameworks for GMP (Good Manufacturing Practice) in cell culture, Biosafety and bioethics in cell culture research, Safety protocols.

UNIT II: CELL CULTURE MEDIA AND REAGENTS 9 Hours

Different type of cell culture media, Cellular metabolism, Serum free media, Advanced media optimization for metabolic and proteomic studies: Advantages, disadvantages and their applications.

UNIT III: CELL CULTURE TECHNIQUES **9 Hours**

Different cell culture techniques: primary and secondary culture, Intracellular signaling in cultured cells: pathways and regulatory mechanisms, Role of biomechanical forces in cell culture, Cell lines, nomenclature, cell line designations. 3D and Organoid Cultures.

UNIT IV: DEVELOPMENT AND MAINTENANCE OF CELL LINES **9 Hours**

Development of synthetic cell lines, Characterization and maintenance of cell lines Microfluidic Cell Culture Systems, Artificial Intelligence in Cell Culture: Predictive modeling for media optimization and cell behavior.

UNIT V: APPLICATIONS OF CELL CULTURE **9 Hours**

Bioprocessing of cells for therapeutic protein production, Single-cell sequencing and applications, Tissue and Organ Bioprinting, Cellular aging and senescence, Ethical considerations in regenerative medicine, **Advanced** Drug Development**:** Patient-derived xenograft (PDX) models.

Total: 45 Hours

Reference(s)

1. Freshney, Culture of Animal Cells, 5th Edition, Wiley-Liss, 2005.
2. Ed. John R.W. Masters, Animal Cell Culture - Practical Approach, 3rd Edition, Oxford University Press, 2000.
3. Ed. Martin Clynes, Animal Cell Culture Techniques. Springer, 1998.
4. Shalini Mani, Manisha Singh, Anil Kumar - Animal Cell Culture: Principles and Practice, https://doi.org/10.1007/978-3-031-19485-6, Springer Cham, 2023.
5. Cell Culture Technologies (102104059) - https://archive.nptel.ac.in/courses/102/104/102104059/ https://drive.google.com/file/d/1qEG9TFDvVhPu8W9YgncAeyWCH_67y2oi/view
6. Merten, O.W., 2006. Introduction to animal cell culture technology—past, present and future. *Cytotechnology*, *50*(1), pp.1-7.

22BT031/22BTH31 BIO-TECHNIQUES IN ANIMAL BREEDING 3 0 0 3

Course Objectives

- To educate the students about the basic tools requirement for cell culture and Micromanipulation.
- To provide depth knowledge about micromanipulation and application.
- To teach the importance of stem cell mediated production and guidelines.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6 The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using bioresources.

Course Outcomes (COs)

1. Apply the concept of basic tools requirement for cell culture and micromanipulation.
2. Apply the knowledge on micromanipulation and its application.
3. Analyze the concept of stem cells and ES cell of transgenic animals.
4. Analyze the research importance in transgenic animals.
5. Evaluate knowledge on ethical CPCSEA guidelines.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	3	1	-	-	-	-	-	-	-	-	-	2	2
2	3	2	3	2	-	-	-	-	-	-	-	-	-	2	2
3	2	1	3	-	-	-	-	-	-	-	-	-	-	2	2
4	-	-	-	-	3	-	-	-	-	-	-	-	-	2	2
5	3	3	3	1	-	1	-	-	-	-	-	-	-	2	2

UNIT I **9 Hours**

BASIC TOOLS REQUIREMENTS FOR CELL CULTURE AND MICROMANIPULATION

Biosafety levels, safety equipment, personal protective equipment, safe laboratory practices. Cell culture equipment: basic equipment - centrifuge, Inverted microscope, confocal microscope, flow cytometer, Hemocytometer, cell culture vessels, bioreactors. Cell culture laboratory: Aseptic work area, Cell culture hood, Incubator, cryostorage, cell counter, aseptic technique, Maintenance of nutrients, prevention of cross contamination. Micromanipulation tools: micromanipulator, pipette puller, pipette grinder, holding pipette.

UNIT II **9 Hours**

MICROMANIPULATION AND ITS APPLICATION

Enrichment of x and y bearing sperms from semen samples of animals; artificial insemination and germ cell manipulations; in vitro fertilization and embryo transfer; micromanipulation technology and breeding of farm animals.

UNIT III **9 Hours**

STEM CELLS AND TRANSGENIC ANIMALS

Stem cells – sources, types, uses, ES cells, pluripotent stem cells, adult stem cell, epithelial stem cell, bone marrow and hematopoietic, neural stem cell, transgenic techniques, Stem cell mediated transgenic animals.

UNIT IV **9 Hours**

TRANSGENIC ANIMALS IN RESEARCH

Ethics of transgenic technology, Dolly (transgenic sheep), Transgenic mice, rat, sheep, goat, rabbit, pig, fish, cow- case studies.

UNIT V **9 Hours**

ETHICAL GUIDELINES ON ANIMAL BREEDING

Major and unique features of metabolism of the principal organs (liver, brain, muscle, kidney) in various metabolic states - fed and starved states, Coordinated Regulation of glycolysis and glycogenesis, Regulation of gluconeogenesis, Regulation of fatty acid synthesis and degradation, Ketogenesis.

Total: 45 Hours

Reference(s)

1. Watson, J.D., Gilman, M., Witowski J. and Zoller, M. Recombinant DNA, 3rd ed., Scientific American Books, 2007.
2. Glick, B.R. and Pasternack, J.J. Molecular Biotechnology, 3rd ed., ASM Press, 2003.
3. Lewin, B. Genes VIII, Pearson Prentice Hall, 2004.

22BT032/22BTH32 FUNDAMENTALS OF ANIMAL TRANSGENICS 3 0 0 3

Course Objectives

- To provide the fundamentals of animal cell culture, details of the diseases and therapy.
- To analye the cellular and molecular level of animal cells.
- To offer the knowledge about the micromanipulation and transgenic animals.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6 The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for global welfare using bio-resource.

Course Outcomes (COs)

1. Apply the evolution of life and animal diversity.
2. Analyze the level of animal diversity and evolution.
3. Analyze the cellular and molecular levels of animal cells.
4. Analyze in vitro fertilization and embryo transfer techniques.
5. Evaluate the concepts of micromanipulation technology and transgenic animal technology.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	3	1	-	-	-	-	-	-	-	-	-	2	2
2	3	2	3	2	-	-	-	-	-	-	-	-	-	2	2
3	2	1	3	-	-	-	-	-	-	-	-	-	-	2	2
4	-	-	-	-	3	-	-	-	-	-	-	-	-	2	3
5	3	3	3	1	-	1	-	-	-	-	-	-	-	3	3

UNIT I **9 Hours**

ORIGIN AND EVOLUTION OF LIFE

Theories of the origin of life, early earth, modern self-assembly theories, Oparin Haldane theory of chemical evolution, The Miller Urey experiment, Organic evolution, Development of evolution theory, Darwin’s theory, Origin and evolution of human being.

UNIT II **9 Hours**

PHYSIOLOGY OF BLOOD, AND NEURONAL SYSTEM

Basis of classification, levels of organization (Symmetry, diploblastic and triploblastic organization), Coelom, segmentation, Notochord. The nature of natural selection, Examples of natural selection, levels of selection, selection of organisms and groups, species selection.

UNIT III **9 Hours**

STRUCTURAL ORGANIZATION AND CELL CULTURE TECHNIQUES

Animals Tissues: Epithelial Tissue, connective Tissue, Muscle Tissue, Neural Tissue. Culturing of cells, primary and secondary cell lines, Cell Culture-Scaling up of animal cell culture- monolayer culture, suspension culture.

UNIT IV **9 Hours**

MICROMANIPULATION OF EMBRYOS

Micromanipulation technology; equipment used in micromanipulation; enrichment of x and y bearing sperms from semen samples of animals; artificial insemination and germ cell manipulations; in vitro fertilization and embryo transfer; micromanipulation technology and breeding of farm animals.

UNIT V **9 Hours**

TRANSGENIC ANIMALS

Concepts of transgenic animal technology; strategies for the production of transgenic animals and their importance in biotechnology; stem cell cultures in the production of transgenic animals.

Total: 45 Hours

Reference(s)

1. Sue Dallas, Emily Jewell. Animal Biology and Care Wiley-Blackwell; 3rd edition.
2. Franklin Shull A, George R. Larue, Alexander G. Ruthven. Principles of animal biology. Mc GrawHill agricultural and Biological publications.
3. Ranga M.M. Animal Biotechnology. Agrobios India Limited, 2002
4. Ramadass P, Meera Rani S. Text Book of Animal Biotechnology. Akshara Printers, 1997
5. Miao, X., 2013. Recent advances in the development of new transgenic animal technology. *Cellular and Molecular Life Sciences*, *70*, pp.815-828.

22BT033/22BTH33 **STEM CELL TECHNOLOGY** **3 0 0 3**

Course Objectives

- To gain knowledge on the basics of stem cells and their origin.
- To learn the methods of stem cell identification and various sources.
- To give way to the therapeutic treatment using stem cells.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6 The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources.

Course Outcomes (COs)

1. To analyze different stem cell types, their niches, potency, and self-renewal.
2. To examine differentiation processes and their role in tissue development.
3. To evaluate methods for generating and testing embryonic and adult stem cells.
4. To investigate gene editing techniques like electroporation and viral-mediated delivery.
5. To assess stem cell applications in tissue engineering, gene therapy, and regenerative medicine.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	3	1	-	-	-	-	-	-	-	-	-	2	2
2	3	2	3	2	-	-	-	-	-	-	-	-	-	2	2
3	2	1	3	-	-	-	-	-	-	-	-	-	-	2	2
4	-	-	-	-	3	-	-	-	-	-	-	-	-	2	2
5	3	3	3	1	-	1	-	-	-	-	-	-	-	3	2

UNIT I **9 Hours**

INTRODUCTION AND SCOPE OF STEM CELL TECHNOLOLGY

Introduction to stem cells; Stem cell niche - embroyonic stem cells, hematepoitic stem cells, bone marrow stem cells, germline stem cells, cancer stem cells, neural stem cells, adult stem cells, muscle and cardiac stem cell; Properties potency and self-renewal Epigenetics.

UNIT II **9 Hours**

DIFFERENTIATION OF STEM CELLS

Differentiation status of cells - Primordial germ cell, Skin cell, Gastrointestinal cells; Embryonic stem cell differentiation as a model to study haematopoetic cell development. Endothelial cell development.

UNIT III **9 Hours**

GENERATION OF STEM CELLS

Testing and generation of embryonic stem cells; testing for adult stem cells and differentiation. Animal models of regeneration.

UNIT IV **9 Hours**

MANIPULATION OF EMBRYONIC STEM CELLS

Integration of transgenes into a defined locus in human embryonic stem cells; Genetic manipulation of embryonic stem cells; Genetic manipulation through DNA delivery by electroporation, , chemical-based reagents and viruses Nucleofection.

UNIT V **9 Hours**

APPLICATIONS OF STEM CELLS

Uses of Stem cells; Human stem cells; Renewal of stem cells; Stem cells and Tissue engineering; Embryonic stem cells and Gene therapy; Therapeutic Cloning.

Total: 45 Hours

Reference(s)

1. MD. Steward Sell, Stem cells, Human Press Inc., 2004.
2. Ariff Bongso and Eng Hin Lee, Stem cells, World Scientific Publication Co. Pvt. Ltd., 2005.
3. Robert Paul Lanza, Essentials of stem cell biology, Academic Press, 2006.
4. Harvey F. Lodish, Arnold Berk and Chris A. Kaiser, Molecular cell Biology, W. H. Freeman and Co., 2008.

22BT034/22BTH34 TISSUE ENGINEERING 3 0 0 3

Course Objectives

- To develop the skill of the student in the emerging field of Regenerative medicine.
- To familiarize students with the various techniques used in Tissue engineering.
- To make the students think about higher studies and careers in the field of Tissue engineering.

Programme Outcomes (POs)

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources.

Course Outcomes (COs)

1. Apply the different biomaterials and generate ideas for their use in tissue engineering.
2. Apply the concepts of biomechanical connections underlying cell and tissue biology at the molecular level.
3. Apply the knowledge of mechanobiology in designing bioreactors.
4. Analyze the existing ethical concerns in regard to tissue regeneration.
5. Evaluate the efficacy, limitations and applications of stem cells technology.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	3	3	1	-	-	-	-	-	-	-	-	-	2	2
2	-	2	3	2	-	-	-	-	-	-	-	-	-	2	2
3	-	1	3	-	-	-	-	-	-	-	-	-	-	2	2
4	-	-	-	-	3	-	-	-	-	-	-	-	-	2	2
5	-	3	3	1		1	-	-	-	-	-	-	-	3	2

UNIT I 9 Hours

INTRODUCTION AND SCOPE OF TISSUE ENGINEERING AND REGENERATIVE MEDICINE

The History of Tissue Engineering and current perspectives of Regenerative Medicine, Cell culture; primary cultures & cell lines; cell quantification; cells as therapeutic agents with examples; Growth factors and signals for tissue engineering; extracellular matrix (ECM) (structure, function and applications); typical tissue-engineered device Ethical Issues in Tissue Engineering.

UNIT II **9 Hours**

BIOMATERIALS IN TISSUE ENGINEERING

Biomaterials: Definition, Classification: Polymers, ceramics (biosorbable and bioactive), hydrogels and metallic implants. Surface, Scaffold fabrication and tailoring Biomaterials; physical and chemical properties of materials - mechanical properties of implants. Bulk analysis- FTIR, SEM; Surface analysis - AES. Sterilization techniques: ETO, gamma radiation, autoclaving. Effects of sterilization on material properties.

UNIT III **9 Hours**

BIOREACTORS IN TISSUE ENGINEERING

Establishment of spatially uniform cell distributions on 3D scaffolds; Maintenance of desired nutrient and gas concentrations in the medium; Expose the developing tissue to physical stimuli; Types of bioreactors for tissue engineering applications (Spinner flask bioreactor, Rotating wall bioreactor, Direct perfusion bioreactors, Hollow fiber bioreactor, Hydrostatic pressure bioreactors, Biomimetic bioreactors); bioreactors for various tissues, e.g. cartilage, muscle, tendon, bone and blood vessels.

UNIT IV **9 Hours**

GROWTH FACTOR DELIVERY, STEM CELLS AND GENE TRANSFER IN REGENERATIVE MEDICINE

Growth factor delivery systems; Introduction to stem cells- different types of stem cells, the plasticity of stem cells; cell separation methods and treating cells individually; mesenchymal stem cells, hematopoietic stem cells & tissue-derived stem cells in tissue engineering applications. Gene transfer and its applications in tissue engineering

UNIT V **9 Hours**

TISSUE ENGINEERING APPLICATIONS IN CLINICS

Current clinical applications & research in (with its limitations) - Artificial blood vessels, artificial pancreas, liver, skin, corneal and bone tissue engineering.

Total: 45 Hours

Reference(s)

1. Atala & R. P. Lanza, Methods of Tissue Engineering, Academic Press, 2002.
2. J. P. Fisher, A.G. Mikos and J.D. Bronzino, Tissue Engineering, CRC Press, 2007.
3. Ratner, Hoffman, Schoen and Lemons, Biomaterials Science - An Introduction to Materials in Medicine, Academic Press, 1996.
4. V. Yannas, Tissue and Organ Regeneration in Adult, Springer, 2001.
5. R. P. Lanza, R. Langer, and W. L. Chick, Principles of Tissue engineering, Academic Press, 1997.
6. W. M. Saltzman, Drug Delivery: Engineering Principles for Drug Therapy, Oxford University Press, 2001.
7. Ikada, Y., 2006. Challenges in tissue engineering. *Journal of the Royal Society Interface*, *3*(10), pp.589-601.
8. https://onlinecourses.nptel.ac.in/noc23_bt46/preview.

22BT035 BASIC PRODUCTION ON MEDICAL BIOTECHNOLOGY 3 0 0 3

Course Objectives

- To understand the principles and fundamental concepts of medical biotechnology production.
- To apply the knowledge of the regulatory requirements and ethical consideration associated with the production of medical biotechnology products.
- To analyze the various biotechnological components and techniques employed in medical sciences.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PSO1. Use the analytical instruments and techniques to isolate, purify and characterize biological compounds.
PSO3. Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Apply the regulatory requirements and ethical considerations in medical biotechnology production.
2. Apply critical thinking skills to troubleshoot technical issues and optimize molecular diagnostic assays.
3. Analyze the scientific rationale and evidence supporting the use of specific modern therapeutics for different diseases.
4. Evaluate the scientific literature, clinical trial data, and epidemiological studies related to vaccines and vaccine technologies.
5. Evaluate and interpret scientific literature, guidelines, and regulatory requirements in the field of clinical trials.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-
2	2	1	3	-	-	-	-	-	-	-	-	-	1	-	-
3	1	-	2	-	3	-	2	2	-	-	-	-	2	-	-
4	-	1	3	-	-	2	-	-	-	-	-	-	-	-	1
5	-	-	-	3	2	-	2	2	-	-	-	-	-	-	2

UNIT I **9 Hours**

DRUG DISCOVERY AND DEVELOPMENT

Introduction, worldwide market in medical biotechnology, revolution in diagnosis, changing approaches of therapy, FDA – Organization chart and regulatory measures for drug discovery: Investigational new drug. Drug discovery: Overview, rational drug design, combinatorial chemistry in drug development, computer assisted drug design, role of bioinformatics in genome – based therapy, antisense DNA technology for drug designing.

UNIT II **9 Hours**

MOLECULAR DIAGNOSIS

Biochemical disorders; Immune, Genetic and Neurological disorders; Molecular techniques for analysis of these disorders; Assays for the Diagnosis of inherited diseases; Bioinformatics tools for molecular diagnosis, Antibody based diagnosis; Monoclonal antibodies as diagnostic reagents; Production of monoclonal antibodies with potential for diagnosis; Diagnosis of bacterial, viral and parasitic diseases by using; ELISA and Western blot.

UNIT III **9 Hours**

MODERN THERAPEUTICS

Stem cells in therapy, Gene Therapy: basic approaches to gene therapy, vectors used in gene therapy, applications of gene therapy in cancer, genetic disorders and AIDS. Therapeutic proteins, interleukins, interferon – principle, production and applications. Biotechnological approaches to obtain blood products: Tissue plasminogen activator and erythropoietin. Nutraceuticals- Food derived bioactive peptides. Production of single cell protein. Chiral technology - Principle and applications.

UNIT IV **9 Hours**

VACCINES AND VACCINE TECHNOLOGIES

History of vaccines, Conventional vaccines: Bacterial and Viral vaccine. Vaccine based on routes of administration. Minicells as vaccines, impact of genetic engineering on vaccine production. New Vaccine Technologies - Rationally designed vaccines, DNA vaccination, Mucosal vaccination, New approaches for vaccine delivery, Engineering virus vectors for vaccination, Vaccines for targeted delivery systems. Disease specific vaccines: Tuberculosis vaccine, Malaria vaccine, HIV/AIDS vaccine. New Emerging diseases and vaccine needs –Ebola, Zika.

UNIT V **9 Hours**

CLINICAL TRAILS AND LICENSING

Clinical trials: Phase I, Phase II, Phase III and Phase IV trail norms, ICMR guidelines for design and conducting clinical trials, licensing procedure in India, intellectual Property Rights and patents in biotechnology.

Total: 45 Hours

Reference(s)

1. Pongracz J, Keen M. Medical Biotechnology. First Edition, Churchill Livingstone, Elsevier Publication, UK, 2009.
2. Trivedi PC. Medical Biotechnology, First Edition, Aavishkar Publisher Distrib. Jaipur, India, 2008.
3. Albert Sasson. Medical Biotechnology: Achievements, Prospects and Perceptions. United Nations University Press, 2005.
4. Kun LY. Microbial Biotechnology – Principles and applications. World Science publications, 2004
5. Glick BR & Patten CL. Molecular Biotechnology: Principles and applications of Recombinant DNA, Fifth Edition, ASM press, 2017.

22BT036 MOLECULAR THERAPEUTICS AND DIAGNOSTICS 3 0 0 3

Course Objectives

- To introduce students to a new and developing science which involves recombinant DNA technology, protein production and purification, molecular biology and biotechnology.
- To explore possible careers in the science of therapeutics and translational science, whether in academia or industry.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PSO1. Use the analytical instruments and techniques to isolate, purify and characterize biological compounds.

PSO3. Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Apply the physiological principles related to mammalian digestive and urinary system.
2. Analyze the physiology of blood and neuronal system.
3. Analyze the role and interactions of hormones.
4. Evaluate the concepts of coenzymes, and energy generation in biological systems.
5. Evaluate the interrelationship of metabolic pathways in relation to overall physiological states.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	-	2	-	2	2	-	3	-	-	-	-	-	-	2
2	2	-	3	2	2	2	-	2	-	-	-	-	2	-	-
3	3	-	2	2	2	3	-	3	-	-	-	-	2	-	1
4	2	-	3	1	3	2	-	2	-	-	-	-	-	-	1
5	2	-	2	-	2	3	-	3	-	-	-	-	-	-	2

UNIT I 9 Hours

PHYSIOLOGY OF DIGESTION AND EXCRETION

Hydrolysis and resorption of food components; Digestive processes: formation of HCl, Zymogen activation, fat digestion; Bile salts - composition and functions, Biotransformation, Cytochrome P450 system, Liver function and diagnostic tests, Formation and acidification of urine, acid-base balance and maintenance.

UNIT II **9 Hours**

PHYSIOLOGY OF BLOOD, AND NEURONAL SYSTEM

Blood composition, plasma proteins, lipoproteins, Buffer systems of plasma, Blood clotting and fibrinolysis; Gas transport, Cerebrospinal fluid; Neurons- types and functions, blood-brain barrier, resting and action potentials, neurotransmitters.

UNIT III **9 Hours**

BIOCHEMISTRY AND FUNCTIONS OF HORMONES

Organization and regulation of secretions and function of: Anterior and Posterior pituitary, Thyroid, Adrenal cortex and medulla, Parathyroid, Pancreas, sex hormones, Clinical orientation.

UNIT IV **9 Hours**

BIOENERGETICS AND BIOLOGICAL OXIDATION

Role of High energy phosphates in Bioenergetics and energy capture, Role and mechanism of action of NAD^+/$NADP^+$, FAD, lipoic acid, thiamine pyrophosphate, tetrahydrofolate, biotin, pyridoxal phosphate, B12 coenzymes and metal ions, Respiratory chain and its role in energy capture.

UNIT V **9 Hours**

REGULATION OF INTERMEDIARY METABOLISM

Major and unique features of metabolism of the principal organs (liver, brain, muscle, kidney) in various metabolic states - fed and starved states, Coordinated Regulation of glycolysis and glycogenesis, Regulation of gluconeogenesis, Regulation of fatty acid synthesis and degradation, Ketogenesis.

Total: 45 Hours

Reference(s)

1. Nelson, D. L. and Cox, M. M., Lehninger's Principles of Biochemistry, 5th Ed, Worth Publishers. 2008.
2. Murray, R. K., Granner, D. K., Mayes, P. A., Rodwell., Harper's Illustrated Biochemistry by, V.W., 26th Ed, The McGraw-Hill Companies, Inc. 2006.
3. Guyton., Textbook of Medical Physiology, 11th Ed, A. C., H. Sanders Philadelphia. 2005.
4. Frayn, Keith N.., Evans, Rhys. Human Metabolism: A Regulatory Perspective. United Kingdom: Wiley, 2019.
5. Silverthorn, Dee Unglaub., Johnson, Bruce R.. Human Physiology: An Integrated Approach. United Kingdom: Pearson/Benjamin Cummings, 2010.

22BT037 **BIONANOTECHNIQUES** **3 0 0 3**

Course Objectives

- To develop the skills of the student in the area of nano biotechnology and its application.
- To familiarize student with different techniques for synthesizing and characterizing of various nanoparticles.
- To motivate and facilitate student to undertake the project and research work in nano biotechnology.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PSO1. Use the analytical instruments and techniques to separate, purify and characterize biological compounds.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sector.

Course Outcomes (COs)

1. Apply the profound knowledge in Nanoparticle synthesis and characterization process.
2. Apply the suitable methods in the preparation of DNA and peptide nanostructures.
3. Analyze the usage of analytical tools in nanobiotechnology.
4. Analyze the applications of nanoparticles in drug delivery.
5. Evaluate the strategies in the preparation of biomaterials in nanomedicine.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
2	2	1	3	-	-	-	-	-	-	-	-	-	-	2	-
3	-	1	2	2	3	-	-	-	-	-	-	-	3	-	-
4	2	-	2	1	-	2	-	1	-	-	-	-	2	-	-
5	2	1	3	-	-	2	-	1	-	-	-	-	-	2	-

UNIT I **9 Hours**

INTRODUCTION TO NANOBIOTECHNOLOGY

Synthesis and Characteristics of nanoparticles; Characterization of Nanoscale materials, Strategies for Nano architecture- bottom up, top down and functional approaches; Quantum dots, Carbon nanotubes- properties, synthesis and application.

UNIT II **9 Hours**

DNA AND PROTEIN BASED NANOSTRUCTURES

DNA-gold particle conjugates; DNA nanostructrures for mechanics and computing; Polymer nanocontainers; Peptide nanotubes and their applications electronics, antibacterial agents, DNA microarrays; Nanobiosensors.

UNIT III **9 Hours**

NANOANALYTICS AND NANO-STRUCTURED MATERIALS

UV-visible spectrophotometer; Particle size analyzer; Zeta sizer; X-Ray Diffractometer, Transmission electron microscopy, Scanning electron microscopy; Energy-dispersive X-ray spectroscopy; Atomic force microscopy; Mass spectroscopy; Fourier transform infrared spectroscopy; X-ray photoelectron spectroscopy, Thermogravimetric analysis.

UNIT IV **9 Hours**

NANOPARTICLES IN DRUG DELIVERY

Applications and Hazards of Nanobiotechnology in drug delivery; Polymeric nanoparticles for drug and gene delivery; Liposomes; Micelles for drug delivery; Nanotoxicology-Cyto-toxicity, Geno-toxicity In vivo tests/assays etc.

UNIT V **9 Hours**

NANOMATERIALS AND NANOMEDICINE

Cardiovascular implants, Biomaterials for ophthalmology, Structure, property of Biological Materials: tissues, bones and teeth, collagen rich, tissues, elastic tissues, nanostructured collagen mimics in tissue Engineering. Biopolymers: Preparation of Nano biomaterials Polymeric scaffolds collagen, Elastins: Mucopolysaccharides, proteoglycans, cellulose and derivatives; Dextran; Alginates; Pectin; Chitin, Nano surgery.

Total: 45 Hours

Reference(s)

1. C. M. Niemeyer and C. A. Mirkin, Nanobiotechnology: Concepts, Applications and Perspectives, Weiheim: Wiley-VCH Verlag GmbH and Co. KGaA, 2004.
2. T. Pradeep, Nano: The Essentials Understanding Nanoscience and Nanotechnology, New Delhi: Tata McGraw- Hill, 2008.
3. H. S. Nalwa, Encyclopedia of Nanoscience & Nanotechnology, California: American Scientific Publishers, 2004.
4. Bhusan, Handbook of Nanotechnology, Berlin, Heidelberg, Germany: Springer-Verlag, 2004.
5. P. M. Ajayan, L. S. Schadler, and P. V. Braun, Nanocomposite Science and Technology, Weiheim: Wiley-VCH Verlag, GmbH & Co. KGaA, 2003.
6. M. Kohler and W. Fritzsche, Nanotechnology: An Introduction to Nanostructuring Techniques. Weiheim: Wiley-VCH Verlag GmbH & Co. KgaA, 2004.

22BT038 **CANCER AND NEUROBIOLOGY** **3 0 0 3**

Course Objectives

- To develop in depth knowledge in molecular biology of cancer and brain to Identify different cancer causing agents in our day to day life and potential of neurons.
- To compute about the diagnosis and prevention of cancer and to Assess the recent techniques in cancer treatment and functional of Neural system.
- To develop new approaches in the emerging field of computational neurology by implementing the concepts of AI/ML and develop new techniques in identification and mitigation of cancer based on high throughput screening.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for development.
PSO3. Conceive, Plan and Deploy societal projects for global welfare using bio-resources.

Course Outcomes (COs)

1. Apply the basics of brain, the cell cycle checkpoints for identification of cancer.
2. Apply the significance of brain biology in neuroanatomy in detection of role of signaling pathways to cause cancer.
3. Analyze the role of various biomolecules in Neuroscience to enumerate the relationship of genes and cancer.
4. Evaluate the role of neurology in cognitive science and the recent advancements in cancer diagnosis.
5. Evaluate the emerging computational interventions in Neuroscience and the emerging new strategies for the treatment of cancer.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	1	-	2	-	-	-	-	-	-	-	-	-	-	1
2	1	-	3	2	-	1	-	-	-	-	-	-	-	-	-
3	-	2	1	-	2	-	1	-	-	-	-	-	-	-	-
4	1	-	-	2	-	1	-	-	-	-	-	-	-	-	2
5	-	-	2	-	3	-	1	-	-	-	-	-	-	-	2

UNIT I **9 Hours**

BIOLOGY OF BRAIN AND CANCER

Brain anatomy and physiology, The neuron: Neurotransmitters and Secondary messengers, Brain Development: Birth of neurons and Brain wiring, Sensation and perception, State of sleep and stress, Neuron Aging Mitosis, Regulation of cell cycle - Check points, Cell proliferation and Apoptosis, Theory and mechanism of carcinogenesis-Chemical, physical & radiation carcinogenesis, Causes of cancer.

UNIT II **9 Hours**

NEUROANATOMY AND BIOLOGY OF CANCER

Structure and function of neurons, Synapses, Glial cells, Myelination, Neuronal differentiation and characterization. Resting and Action potential, Voltage dependent channels, Nodes of Ranvier, Effects on receptor, signal switches, signal targets and cancer, activation of kinases; Oncogenes, identification of oncogenes, mechanism of oncogenes activation, retroviruses and oncogenes, detection of oncogenes; tumor suppressor genes - Rb, p53, APC, BRCA paradigms.

UNIT III **9 Hours**

MOLECULAR NEUROBIOLOGY AND PRINCIPLES OF CANCER METASTASIS

Neuronal Junction: Tight and Gap, Neuropathology: Gap junction perspective, G-protein coupled receptors, Ligand gated Ion channels: nACh Receptors & GABAA Receptors, Voltage-gated Channels: KcsA Channel & Voltage-Sensitive Chloride Channels, Chemoreceptors, Photoreceptors and mechanoreceptors. Mechanism of spread; Clinical significances of invasion, heterogeneity of metastatic phenotype, basement membrane disruption, three step theory of invasion, proteinases and tumour cell invasion; Angiogenesis.

UNIT IV **9 Hours**

COGNITIVE NEUROLOGY AND DETECTION OF CANCER

Cognition, Neurochemistry of cognition, Cognitive disorders and dysfunctions, Memory disorders, Dementia: Epidemiology and neuropathology & Alzheimer’s Disease, Neurosurgery for cognitive disorders. Cancer detection: Detection using biochemical assays and molecular; Different types of tumour markers, tumour imaging and molecular imaging, Gene expression profiling. Diagnostics- Imaging (MRI, PET) & Biopsy.

UNIT V **9 Hours**

COMPUTATIONAL NEUROSCIENCE AND CANCER THERAPY

Dynamical systems and its types, Basic notation and techniques, Molecular dynamics & Brownian dynamics, Single neuron modelling, Artificial Intelligence and Machine learning in Computational Neurology. Therapy forms surgery, chemotherapy &radiation, Hyperthermia and magnetic hyperthermia; New approaches of cancer therapy: Monoclonal antibodies, vaccines, gene therapy, Stem cell therapy.

Total: 45 Hours

Reference(s)

1. Eric R. Kandel. Principles of Neural Science. (2000).
2. Smith, Christopher U. M. Elements of molecular neurobiology. (J. Wiley, 2002).
3. Husain, M. & Schott, J. M. Textbook of Cognitive Neurology and Dementia. (2016).
4. Abbott, L. Theoretical Neuroscience. (2000).
5. Purves, D. Neuroscience, 3rd Edition. (2004).
6. Jian Feng. Computational Neuroscience a Comprehensive Approach. (2004).
7. Baars, B. J. & Nicole Gage. Cognition, Brain, And Consciousness Second Edition. (2010).
8. Robin A. Murphy & Robert C. Honey. Handbook on the Cognitive Neuroscience of Learning. (2016).
9. Mark D’ Esposito. Neurological Foundations of Cognitive Neuroscience. (2003).

22BT039 HUMAN GENETICS 3 0 0 3

Course Objectives

- To impart the principle and pattern of segregation of genes and its characters.
- To gain knowledge about the mechanism of crossing over, linkage of genes and identification of genetic material.
- To learn about genetic material and genetic transfer.
- To gain an insight on mutations and inheritance of various genetic conditions.
- To enlighten the students about evolutionary genetics.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PSO3. Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Apply the principles of Mendel's experiment, pattern of segregation of genes and its characters.
2. Analyze the mechanism of sex determination, linkages and crossing over.
3. Analyze and understand the variation in chromosomal patterns occurring at evolution and speciation.
4. Analyze and apply the chromosomal Inheritance in life forms.
5. Evaluate the genetic basis of normal and abnormal functioning of human body.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	3	2	3	-	-	-	-	-	-	-	-	-	-	-
2	3	1	-	3	-	-	-	-	-	-	-	-	-	-	-
3	3	2	-	3	-	-	-	-	-	-	-	-	-	-	1
4	3	2	-	3	2	-	-	-	-	-	-	-	-	-	2
5	3	3	-	3	-	-	-	-	-	-	-	-	-	-	2

UNIT I 9 Hours

MENDELIAN GENETICS AND BASICS OF HUMAN GENETICS

Mendel's study of heredity – Monohybrid crosses and Dihybrid crosses; The Punnett square methods; The Chi-square test; Mendelian segregation in human families; Allelic variation and Gene function; Law of segregation Law of independent assortment; History of Human Genetics; Pedigrees- gathering family history, pedigree symbols, construction of pedigrees; Monogenic traits - Autosomal inheritance-dominant and recessive.

UNIT II **9 Hours**

CHROMOSOMAL BASIS OF INHERITANCE

Sex Chromosomes and determination in Drosophila and human, X linked genes, Pedigree analysis; linkage and crossing over; Cytogenetics – Techniques, polyploidy and aneuploidy. Non-Mendelian inheritance; Genetic and Physical mapping; heredity and environment (twin studies).

UNIT III **9 Hours**

MOLECULAR GENETICS

Human gene therapy; DNA fingerprints in forensic applications; Human genome project; Reverse Genetics: Antisense RNA; Transposable elements in humans; RNA interference; Activation and inactivation of whole chromosomes.

UNIT IV **9 Hours**

CLINICAL GENETICS

Muscle genetic disorders, mitochondrial syndromes, Genetic disorders of eye.

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UNIT V **9 Hours**

MOLECULAR GENETICS

Genetic basis of male and female infertility, Diagnostic Molecular Genetics. Neurogenetic disorders.

Total: 45 Hours

Reference(s)

1. M.J. Simmons and. D.P. Snustad, Principles of Genetics, John Wiley, 2012.
2. EJ Mongia and AP Mongia, Basic Human Genetics, Sinauer Associates Inc.,U.S. 1993.
3. E.J. Gardner, M.J. Simmons and. D.P. Snustad, Principles of Genetics, John Wiley, 2006
4. H.T. Robert, Principles of Genetics, Tata McGraw Hill, 2002.
5. L. Daniel, Hartl and W. Elizabeth, Essential Genetics, Jones and Bartlett publishers, Massachusetts, 2002.

22BT040 **VACCINE TECHNOLOGY** **3 0 0 3**

Course Objectives

- To study the various forms of vaccines.
- To learn the techniques of vaccine production and their delivery methods.
- To give an exposure on the regulatory and biosafety measures of vaccine.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PSO2. Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Apply the principle of vaccination for immunization processes.
2. Apply the types of vaccines and their applications.
3. Analyze the vaccine purification, preservation and formulation techniques.
4. Analyze the advanced methods of vaccine delivery.
5. Evaluate the quality measures and regulatory issues concerned with vaccine production.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	1	-	-	-	-	-	-	-	-	-	-	-	-
2	-	1	2	3	-	-	-	-	-	-	-	-	-	2	-
3	-	-	-	3	2	-	-	-	-	-	-	-	-	1	-
4	-	-	-	2	3	-	-	-	-	-	-	-	-	-	1
5	-	-	2	-	-	3	-	-	-	-	-	-	-	-	1

UNIT I **9 Hours**

INTRODUCTION

Vaccines - definition, History of vaccine development, requirements for immunity, Basics of immunization-Epitopes, linear and conformational epitopes, characterization and location of APC, MHC and immunogenicity; immunization programs and role of WHO in immunization programs.

UNIT II **9 Hours**

TYPES AND METHODS OF APPLICATION

Active and passive immunization; Viral/bacterial/parasite vaccine differences, methods of vaccine preparation - Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, edible vaccines, reverse vaccinology, combination vaccines, therapeutic vaccines; Peptide vaccines, conjugate vaccines; Cell based vaccines. Uses of nanoparticles in vaccine application. Reverse Vaccinology.

UNIT III **9 Hours**

TECHNIQUES IN VACCINE PRODUCTION

Purification, preservation and formulation techniques. Commercial production of DPT, TT, polio, rabies and hepatitis vaccines.

UNIT IV **9 Hours**

DELIVERY METHODS

Needle free Vaccine delivery, ISCOMS, Adjuvant delivery systems, Intranasal and inhaled vaccine delivery, liquid jet and solid dose injectors, development of gene-based vectors.

UNIT V **9 Hours**

REGULATORY AND BIOSAFETY MEASURES

Quality assurance in vaccine production. Regulatory issues - Environmental concerns with the use of recombinant vaccines - Disease security and biosecurity principles and OIE guidelines.

Total: 45 Hours

Reference(s)

1. P. Ramadass, Animal Biotechnology - Recent concepts and Developments, MJP Publications, 2008.
2. T. J. Kindt, R. A. Goldsby, B. A. Osborne and J. Kuby, Kuby Immunology, W.H. Freeman & company, 2007.
3. S. A. Plotkin, W. A. Orenstein and P. A. Offit, Vaccines, W B Saunders Company, 2012.
4. Cheryl Barton, Advances in Vaccine Technology and Delivery, Espicom Business Intelligence, 2009.
5. Ronald W. Ellis, New Vaccine Technologies, Landes Bioscience, 2001
6. Pardi, N., Hogan, M.J. and Weissman, D., 2020. Recent advances in mRNA vaccine technology. *Current opinion in immunology*, *65*, pp.14-20.

22BT041 BIOPHARMACEUTICS AND ITS BIOSIMILARS 3 0 0 3

Course Objectives

- Introduction to Pharmacokinetics and Pharmacodynamics.
- Expose students to the importance of biosimilar and generic drugs.
- Build a deeper understanding of the application of biotechnology tools in the world of medicine.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for development.
PSO2. Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors.

Course Outcomes (COs)

1. Apply the basic concepts of drugs & biosimilar and to differentiate generic from branded drugs and biosimilars.
2. Apply the need for biosimilar in Indian and Global scenarios and also regarding the drug patents.
3. Apply the knowledge of pharmacokinetic models and parameters to describe the process of drug absorption and distribution.
4. Apply the knowledge of pharmacokinetic models and parameters to describe the process of drug metabolism and elimination.
5. Analyze the dosage regimens of the drugs using pharmacodynamics parameters and evaluate the drug performance based on bioavailability and bioequivalence.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	1	-	-	2	1	-	-	-	-	-	-	2	-
2	1	2	3	-	-	1	1	-	-	-	-	-	-	2	-
3	3	1	2	-	-	1	1	-	-	-	-	-	-	3	-
4	2	1	3	-	-	1	1	-	-	-	-	-	-	2	-
5	2	1	2	-	-	1	1	-	-	-	-	-	-	2	-

UNIT I 9 Hours

INTRODUCTION TO BIOGENERICS

Definition: Drug, Generics and its advantages, Biogenerics and Biosimilar, Generic vs Branded, Biosimilar vs Generic, Protein-based biopharmaceuticals, Manufacturing processes, Industries dealing with biogenerics and its market value, Indian Market and Global Market.

UNIT II **9 Hours**

INTRODUCTION TO BIOSIMILARS

Introduction to biologics and biosimilar, Applicable Regulations and Guidelines, Principles for Development of Similar Biologics, Data Requirements for Preclinical Studies, Clinical Trial Studies and for Post Market Surveillance, Pharmacovigilance, GMP.

UNIT III **9 Hours**

FUNDAMENTAL ON DRUG ABSORPTION AND DISTRIBUTION

Introduction to Pharmacokinetics, Drug Absorption - Mechanisms of drug absorption through GIT, factors influencing drug absorption though GIT, Drug Distribution -Tissue permeability of drugs, binding of drugs, volume of drug distribution, plasma and tissue protein binding of drugs, factors affecting protein-drug binding.

UNIT IV **9 Hours**

FUNDAMENTAL ON DRUG METABOLISM AND ELIMINATION

Drug Metabolism - Biotransformation of drugs, Phase I and Phase II reactions - pathways and enzymes of drug metabolism, factors affecting the metabolism of drugs. Drug Excretion - Basic understanding of excretory pathways – renal and non-renal routes, factors affecting renal excretion of drugs.

UNIT V **9 Hours**

DRUG PRODUCT PERFORMANCE AND PHARMACODYNAMICS

Bioavailability and Bioequivalence: Definition and Objectives of bioavailability, absolute and relative bioavailability, measurement of bioavailability, bioequivalence studies, methods to enhance the dissolution rates and bioavailability of poorly soluble. Pharmacodynamics - Definitions – agonist/antagonist, antagonism as a mechanism of drug action, classification of antagonists, drug-receptor interactions, factors affecting drug-target interactions, quantifying drug-target interactions: dose-response relationships - graded dose and quantal dose-responses.

Total: 45 Hours

Reference(s)

1. Biopharmaceutics and Clinical Pharmacokinetics by Milo Gibaldi, 4th edition, Philadelphia, Lea and Febiger, 1991.
2. Biopharmaceutics and Pharmacokinetics, A. Treatise, D .M. Brahmankar and Sunil B. Jaiswal., Vallab Prakashan, Pitampura, Delhi.
3. Gary Walsh, Biopharmaceuticals: Biochemistry and Biotechnology, John Wiley & Sons, Inc., 2nd Edition, 2003.
4. Rodney J. Y. Ho, Biotechnology and Biopharmaceuticals: Transforming Proteins and Genes into Drugs, John Wiley & Sons, Inc., 2nd Edition.
5. Textbook of Biopharmaceutics and Pharmacokinetics, Dr. Shobha Rani R. Hiremath, Prism Book.
6. Oliver Kayser and Heribert Warzecha, Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications, John Wiley & Sons, Inc., 2nd Edition, 2012.

22BT042 CLINICAL TRIALS AND HEALTHCARE POLICIES IN BIOTECHNOLOGY 3 0 0 3

Course Objectives

- To learn the basics of clinical trials and regulatory.
- To understand the biotechnology national policies.
- To analyze the national and international policies in biotech practices.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PSO3. Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Apply the clinical trials and its organization.
2. Analyze the clinical research and its regulatory.
3. Analyze the biotechnology national policies.
4. Analyze maintain the biotechnology global practice.
5. Evaluate the international policies for biotechnology.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-
2	2	-	3	-	-	-	-	-	-	-	-	-	-	-	1
3	1	-	2	-	3	-	-	-	-	-	-	-	-	-	2
4	-	-	3	-	-	-	-	-	-	-	-	-	-	-	1
5	-	-	-	3	2	-	-	-	-	-	-	-	-	-	2

UNIT I 9 Hours

CLINICAL TRIALS - OVERVIEW AND ORGANIZATIONS

Clinical Trial - Definitions and usage of ethical practice; Phases of clinical trials and practice; Organizations for ensuring ethical clinical practice in India; Central Drugs Standard Control Organization - role and importance in clinical trials; Drugs Controller General of India - Overview and responsibility; Indian Council of Medical Research - roles and responsibilities; Research funds regulation for clinical trials.

UNIT II 9 Hours

CLINICAL TRIALS - REGULATORY REQUIREMENTS

Acts related to Biotechnology and Pharmaceutical sector: Drugs and Cosmetics act (1940) - Rules (1945) - Ethical Guidelines of ICMR (2006) - Good Clinical Practice Guideline (2001) - Regulatory changes in Indian landscape - 2005 - 2016); Regulatory requirements for case studies.

UNIT III **9 Hours**

BIOTECHNOLOGY NATIONAL POLICIES

Clinical trial in India - Definitions - conduct - research - approval - registration - reports -Building Capacities – A Skilled Workforce And Strengthened State Of The Art Infrastructure; Unati Biotech Missions – Aligned With National And Global Priorities -Building A Self-Reliant India (Atmanirbhar Bharat) Through Biotech Interventions – Affordable And Accessible Products And Technologies A. Moving Technology From Lab To Market B. Scaling The Innovation Ecosystem.

UNIT IV **9 Hours**

BIOTECHNOLOGY GLOBAL PRACTICE

Leveraging The Strength Of Strategic Partnerships – National And International; Preparing For The Future – Building The Knowledge Base; Taking Science To Society – Empowering The Rural Sector; Effective Outreach And Communication– Building The Public Trust; Global Benchmarking And Performance Measurement – A Measurement Matrix To Build Quality; Policy Enablers.

UNIT V **9 Hours**

INTERNATIONAL POLICIES FOR BIOTECHNOLOGY PRACTICE

U.S. Food & Drug Administration: Agency responsible for enforcing laws and policies on food, drugs, medical devices in the U.S.; US Centers for Medicare & Medicaid Services -Information on Medicare and Medicaid enrollment, coverage, reimbursement policies, etc.

Total: 45 Hours

Reference(s)

1. Friedman, L. M., Furberg, C., & DeMets, D. L. (2010). Fundamentals of Clinical Trials. Springer.
2. Glickman, S. W., et al. (2009). "The Role of Clinical Trials in the Development of New Therapies." The New England Journal of Medicine, 360(24), 2545-2554.
3. Frost, J., & Sullivan, A. (2017). Biotechnology and Healthcare Policy: A Guide to Current Issues. Oxford University Press.
4. Eisenberg, R. S. (2008). "The Role of Government in Biotechnology Regulation." Nature Biotechnology, 26(8), 953-958.
5. Noble, K. J., & Hutton, J. (2015). Clinical Trials: A Practical Guide to Design, Analysis, and Reporting. Wiley-Blackwell.

22BT043 BIOTECH PRODUCTS AND ITS VALIDATION 3 0 0 3

Course Objectives

- To understand significance of biological resources and its role in product formulation.
- To understand about validation and how it can be applied industry and thus to improve the products.
- To describe the complete information about validation, types, methodology and application.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.

PSO3. Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources.

Course Outcomes (COs)

1. Apply the importance of bio resources in product formation.
2. Apply the different aspect of validation.
3. Analyze the knowledge of validation to instruments and equipment.
4. Analyze the validation of manufacturing processes.
5. Evaluate the manufacturing facilities.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1	3	-	-	-	-	-	-	-	-	-	-	-	1	-
3	1	-	-	3	-	-	-	-	-	-	-	-	-	1	-
4	-	-	-	-	3	-	-	2	-	-	-	-	-	-	1
5	-	-	-	-	3	-	-	2	-	-	-	-	-	-	1

UNIT I 9 Hours

INTRODUCTION

Definition of Qualification and Validation, Advantage of Validation, Streamlining of Qualification & Validation process and Validation Master Plan.

UNIT II 9 Hours

QUALIFICATION

User Requirement Specification, Design Qualification, Factory Acceptance Test (FAT)/ Site Acceptance Test (SAT), Installation Qualification, Operational Qualification, Performance Qualification, Re – Qualification (Maintaining status-Calibration Preventive Maintenance, Change management),Qualification of Manufacturing Equipment, Qualification of Analytical Instruments and Laboratory equipment.

UNIT III **9 Hours**

QUALIFICATION OF ANALYTICAL INSTRUMENTS

Electronic balance, pH meter, UV-Visible spectrophotometer, FTIR, GC, HPLC, HPTLC Qualification of Glassware: Volumetric flask, pipette, Measuring cylinder, beakers and burette.

UNIT IV **9 Hours**

VALIDATION OF UTILITY SYSTEMS

Pharmaceutical Water System &pure steam, HVAC system, Compressed air and nitrogen. Cleaning Validation: Cleaning Validation – Cleaning Method development, Validation and validation of analytical method used in cleaning. Cleaning of Equipment, Cleaning of Facilities. Cleaning in place (CIP).

UNIT V **9 Hours**

ANALYTICAL METHOD VALIDATION

General principles, Validation of analytical method as per ICH guidelines and USP.

Total: 45 Hours

Reference(s)

1. Validation Master plan by Terveeks or Deeks, Davis Harwood International publishing.
2. Validation Standard Operating Procedures: A Step by Step Guide for Achieving Compliance in the Pharmaceutical, Medical Device, and Biotech Industries, Syed Imtiaz Haider.
3. Analytical Method validation and Instrument Performance Verification by Churg Chan Heiman Lam Y.C. Lee, Yue. Zhang, Wiley Inter Science.

22BT044 QA AND QC IN BIOTECHNOLOGY 3 0 0 3

Course Objectives

- To understand the quality management system followed in biotech industries.
- To demonstrate the knowledge of quality assurance and regulatory.
- To analyze the quality control systems and FDA regulations in biotechnology.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations
PSO3. Conceive, Plan and Deploy societal projects for global welfare using Bio-resources.

Course Outcomes (COs)

1. Apply the GMP and GLP concepts in biotechnology industry.
2. Apply the quality management system in biotechnology industries.
3. Analyze the test and evaluate the quality of materials or finished products.
4. Evaluate and calibrate laboratory or technical equipment.
5. Create documentation related to legal or regulatory matters.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-
2	2	2	3	-	-	-	-	-	-	-	-	-	-	-	1
3	1	2	2	-	3	-	-	-	-	-	-	-	-	-	2
4	-	2	3	-	-	-	-	-	-	-	-	-	-	-	1
5	-	-	-	3	2	-	-	-	-	-	-	-	-	-	2

UNIT I 9 Hours

INTRODUCTION

Introduction to bio products and quality; Concept and evolution and scopes of Quality Control and Quality Assurance for drugs and biologics, Good Laboratory Practice, GMP, Definitions, Overview of ICH Guidelines, CPCSEA guidelines.

UNIT II 9 Hours

QUALITY MANAGEMENT SYSTEM IN BIOTECH INDUSTRIES

Definitions-QMS in biotech industries; Essential components of QMS-Document management, Reporting management, Inspection management, Audit management, Learning management, Product life cycle management; Practice of QMS in biotech industries; Validation services; Quality Management software tools-applications in biotech and biopharma industries.

UNIT III **9 Hours**

QUALITY ASSURANCE IN BIOTECH

QA – Definition, fundamentals, importance of QA in biotech industries; QA's responsibilities; QA checklists, Methods- Failure testing, Statistical process control (SPC), Total quality management-concepts, principles, tools & techniques; QA standards, career opportunities of quality assurance in biotechnology industries.

UNIT IV **9 Hours**

QUALITY CONTROL IN BIOTECH

QC-Definitions, terminologies in QC, fundamentals, importance of QC in biotech industries, QC's responsibilities; QC procedures-Batch inspection, Sampling, Validation, Laboratory testing-analytical method, compendial and Non-compendial methods; FDA regulations and ICH regulations; career opportunities of quality control in biotechnology industries.

UNIT V **9 Hours**

REGULATIONS OF BIOLOGICS

Regulatory affairs-Introduction, history, terminologies, Biologics product categories; FDA Regulations-role, guidelines ; Biologics product approvals & clearance-submitting application, purple book, BPCI Act; Approval pathways- characterization, biologics quality activities.

Total: 45 Hours

Reference(s)

1. Walsh, G. (2010). *Biopharmaceuticals: Biochemistry and Biotechnology*. John Wiley & Sons.
2. Sharma, S. K. (2016). *Quality Control in Biotechnology: An Overview*. In *Biotechnology: A Modern Approach*. Springer.
3. Bhatia, S. (2018). *Good Manufacturing Practices for Pharmaceuticals*. CRC Press.
4. Regalado, J. (2017). "Quality Assurance in Biotechnology: Ensuring Compliance and Standards." *Journal of Biotechnology*, 261, 1-8.
5. Griffin, J. R., & Kessler, C. (2019). *The Quality Assurance and Quality Control Handbook for Biotech Products*. Elsevier.

22BT045 PATENT DESIGN, IPR IN BIOTECHNOLOGY AND BIOENTREPRENEURSHIP 3 0 0 3

Course Objectives

- To inculcate the entrepreneurship skill among the student community by converting their research ideas into commercial product.
- To demonstrate the knowledge of entrepreneurship skill in biotechnology.
- To study the patent design and technology transfer.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PSO1. Use the analytical instruments and techniques to separate, purify and characterize biological compounds.
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using Bioresources .

Course Outcomes (COs)

1. Apply entrepreneurship skills to convert their research ideas into commercial products.
2. Analyze the history of pioneer biotech companies and start effective biotech venture.
3. Analyze the functions of business models to transfer technology from laboratory into market.
4. Evaluate the effectiveness of business plan through feasible business strategies.
5. Evaluate the importance of Intellectual property rights to protect the biotechnology inventions.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	-	2	-	-	-	-	-	-	1	-	-	-	-	-
2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
3	1	2	2	-	-	-	-	-	-	2	-	-	1	-	2
4	2	1	-	2	-	-	-	-	-	2	-	-	-	-	1
5	2	2	1	-	-	-	-	-	-	2	-	-	-	-	2

UNIT I 9 Hours

FORMS OF PATENT

Introduction to Patents; Types of patent applications: Ordinary, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees Invention in context of Prior art; Patent databases; Searching International Databases; Country-wise patent searches.

UNIT II **9 Hours**

PATENTING PROCEDURES

National and Patent Cooperation Treaty filing procedure; Time frame and cost; Status of the Patent applications filed; Precautions while patenting - disclosure/non-disclosure; Financial assistance for patenting, Existing schemes, Patent licensing and agreement Patent infringement meaning, scope, litigation, case studies.

UNIT III **9 Hours**

INTELLECTUAL PROPERTY RIGHTS

Types of Intellectual property: Patents, Trademarks, Copyright and Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs, IP as a factor in R&D; IPs of relevance to Biotechnology Agreements and Treaties. History of GATT and TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty Indian Patent Act 1970 and recent amendments Case Studies.

UNIT IV **9 Hours**

INTRODUCTION AND COMPONENTS OF A BIOTECH COMPANY

Entrepreneurship, Definition; Factors necessary for Entrepreneurship, Attributes in an Entrepreneur, Bio entrepreneurship; Indicators of Bio entrepreneurship. Paths for starting new Biotech ventures, History of establishment of pioneer biotechnology companies, Key for success, Mission and Strategy, product selection for new Biotech venture.

UNIT V **9 Hours**

BUSINESS PLAN, BUSINESS STRATEGIES AND TECHNOLOGY TRANSFER

General considerations, Business plan – Do's and don'ts, How to write Business proposal, Checklist for Business proposal writing, Intellectual property in biotech - Licensing, Accessing University technology, Licensing of Biotechnological invention.

Total: 45 Hours

Reference(s)

1. S. N. Jogdand, Entrepreneurship and Business of Biotechnology, Himalaya Publishing Home, 2007.
2. R Oliver, The coming biotech age: The business of biomaterials. New York: McGraw Hill, 2000.
3. S. Shaleesha. Bioethics, Wisdom educational service, Chennai, 2008.

22BT046 BIOSAFETY AND HAZARD MANAGEMENT 3 0 0 3

Course Objectives

- To identify potential hazardous biological materials and the risks associated with them.
- To select appropriate means to minimize risk and to protect against or prevent exposure.
- To recognize applicable legal requirements and prepare the necessary documents to obtain authorizations.
- To understand how to run a bio risk management program

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PSO1. Use the analytical instruments and techniques to separate, purify and characterize biological compounds.

PSO3. Conceive, Plan and Deploy societal projects for environmental protection using Bioresources.

Course Outcomes (COs)

1. Apply the insights into Biosafety guidelines.
2. Analyze and Manage the Risks involved with GMOs.
3. Analyze the International Agreements and Regulations with respect to Biosafety.
4. Analyze and gain Knowledge of working principles in a laboratory taking all safety measures.
5. Evaluate and handle the live cultures, disposal of infectious waste, care of the equipment requiring safety audit.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	-	2	-	-	-	-	-	-	1	-	-	-	-	-
2	2	2	2	-	-	-	-	-	-		-	-	-	-	-
3	1	2	2	-	-	-	-	-	-	2	-	-	1	-	2
4	2	1	-	2	-	-	-	-	-	2	-	-	-	-	1
5	1	-	2	-	-	-	-	-	-	1	-	-	-	-	-

UNIT I 9 Hours

NEED FOR BIOSAFETY

Introduction; the history and incidence of laboratory-acquired infections (LAI), incidents of secondary transmission from the laboratory, Outline the types of laboratory accidents leading to LAIs, Explain the role of aerosols in LAIs, Illustrate the importance of biosafety and biocontainment in minimizing the risk of LAIs.

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UNIT II **9 Hours**

RISK ANALYSIS

Overall risk analysis–emergency planning-on site &off site emergency planning, risk management ISO 14000, EMS models case studies. Quantitative risk assessment – rapid and comprehensive risk analysis; Risk due to Radiation, explosion due to over pressure, jet firefire ball.

UNIT III **9 Hours**

QUALITY CHECKS & BIOSAFETY GUIDELINES

Implementation of safety procedures – periodic inspection and replacement; Accidents -identification and prevention; promotion of industrial safety; Biosafety guidelines – Government of India; Definition of GMOs and LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMO.

UNIT IV **9 Hours**

HAZARDOUS OPERATIONS AND SAFETY AUDITS

Hazop-guide words, parameters, derivation-causes-consequences-recommendation-coarse Hazop study-case studies- pumping system-reactor-mass transfer system. Hazard identification safety audits, checklist, what if analysis, vulnerability models event tree analysis fault tree analysis, Hazan past accident analysis Fixborough-Mexico-Madras- Vizag Bopal analysis.

UNIT V **9 Hours**

BIOCONTAINMENT AND CERTIFICATION

Overview of biocontainment principles; types of biocontainment facilities; risk assessment and management; certification processes for biosafety; regulations and guidelines for safe handling of biological materials; case studies on biocontainment practices.

Total: 45 Hours

Reference(s)

1. Fawatt, H.H. and Wood, W.S., Safety and Accident Prevention in Chemical Operation, Wiley Interscience, 1965.
2. Biosafety in Microbiological and Biomedical Laboratories, 5th ed. 2009.
3. Biological Safety, Principles and Practices, 4th ed. (Fleming and Hunt) ASM Press 2006.
4. Collins, C.H., and Kennedy, D.A. Laboratory-acquired infections. In: Laboratory acquired infections: history, incidence, causes and preventions. Oxford, UK: Butterworth-Heinemann, 1999;1-37.
5. 5 .Hyatt, N., Guidelines for process hazards analysis, hazards identification and risk analysis, Dyadem Press, 2004.
6. Handley, W., Industrial Safety Hand Book, 2nd Edn., McGraw-Hill Book Company,1969.
7. Heinrich, H.W. Dan Peterson, P.E. and Rood, N., Industrial Accident Prevention, McGraw-Hill Book Co., 1980.
8. Chemical Process Safety: Fundamentals with Applications, Daniel A. Crowl, J.F. Louvar, Prentice Hall, NJ, 1990.
9. Taylor, J.R., Risk analysis for process plant, pipelines and transport, Chapman and Hall, London, 1994.

22BT047 GOOD MANUFACTURING PRACTICES 3 0 0 3

Course Objectives

- To develop in depth knowledge in concepts of Good Manufacturing Practice.
- To describe quality assurance, design of quality systems, risk analysis and risk assessment.
- To describe new standards in production under GMP and preparation of monographs, standard operating procedure, SOP, batch protocols quality control.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PSO2. Design and synthesis of the novel bio-molecule for the agriculture and healthcare sectors.
PSO3. Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources.

Course Outcomes (COs)

1. Apply profound knowledge in basic concepts of Good Manufacturing Practice.
2. Analyze the role of microbiological quality control in aseptic production.
3. Analyze the relationship between risk analysis and hazard.
4. Evaluate the recent advancements in design of quality systems.
5. Evaluate the emerging new strategies for the aseptic production and analysis of protocols.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1	3	-	-	-	-	-	-	-	-	-	-	-	1	-
3	1	-	-	3	-	-	-	-	-	-	-	-	-	1	-
4	-	-	-	-	3	-	-	2	-	-	-	-	-	-	1
5	-	-	-	-	3	-	-	2	-	-	-	-	-	-	1

UNIT I **9 Hours**

FUNDAMENTALS

Good Manufacturing Practice (GMP) & Good Laboratory Practice (GLP), Historic Events and Milestones in the Development of GMP, Components & Principles of cGMP.

UNIT II **9 Hours**

QUALITY CONTROL

Quality control introduction. In process quality control, Sampling procedures of product and equipment in biopharmaceuticals industries, Microbiological test and air quality control in Aseptic production localities, Personal hygiene, clothing & gowning, clean room entry exit procedures. Cleaning and sanitation, Housekeeping

UNIT III **9 Hours**

QUALITY ASSURANCE

Quality assurance introduction, Principles for documentation in GMP, Risk analysis and Risk assessment. Near miss, Deviation investigation& report - Corrective and Preventive Actions. SOP framing. Regulatory compliance - FDA regulations, EU directives Certification systems - ISO 22000:2009.

UNIT IV **9 Hours**

DESIGN OF QUALITY SYSTEMS

Introduction to Cleanroom - types, Basic clean room design requirements and considerations, equipment, and personnel flow in cleanrooms. AHU, HVAC systems in cleanrooms. Classification of cleanrooms in terms of air quality.

UNIT V **9 Hours**

PROCESS VALIDATION& MAINTANENCE

Qualification Procedures (IQ, OQ & PQ), Process validation introduction - concept, Cleaning in place, Sterilization in place, Fumigation. - Equipment cleaning validation. Preventive maintenance, Equipment Maintenance & Calibration tracking.

Total: 45 Hours

Reference(s)

1. Graham P. Bunn, Good Manufacturing Practices for Pharmaceuticals, 2019.
2. Ramkumar Dubey, Manohar A Potdar, CGMP Current Good Manufacturing Practices for Pharmaceuticals, 2019.
3. B. N. Cooper, Good Manufacturing Practices for Pharmaceuticals, 2017.
4. W. Whyte, Clean room Technology: Fundamentals of Design, Testing and Operation, 2001.
5. Gail Sofer, Anurag Rathore, Process Validation in Manufacturing of Biopharmaceuticals: Guidelines, Current Practices, and Industrial Case Studies, 2000.

ONE CREDIT COURSES

22BT0XA	DRUG DESIGN AND COMPUTATIONAL METHODS	L	T	P	C
		1	0	0	1

Course Objectives

- Familiarize with the working drug design, tools and techniques of analytical methods
- Design experiment and understand instrumentation
- Understand the strengths, limitations and creative use of computational method

Program Outcomes (POs)

PO4 **Conduct investigations of complex problems:** Use research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PSO3 Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources

Course Outcomes (COs)

The students will be able to

1. Apply technique to analyze the techniques used in various industries.
2. Analyze the right methods for purification and analysis of pharmaceuticals
3. Analyze the principle of Docking and ADMET properties
4. Analyze the objectives of QSAR,CoMFA and CoMSIA and smiles
5. Evaluate the concepts of imunoinformatics

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	2	2	-	-	-	-	-	-	-	-	-	2
2	-	-	-		2	-	-	-	-	-	-	-	-	-	2
3	-	-	-	2	2	-	-	-	-	-	-	-	-	-	1
4	-	-	-		2	-	-	-	-	-	-	-	-	-	2
5	-	-	-	2	2	-	-	-	-	-	-	-	-	-	2

Computational methods for drug designing — **15 Hours**

Fundamentals of computing, Operating Systems, Information Technology , Introduction to statistical thinking in drug research; types of data; sample and population; data summarization; hypothesis testing; regression methods Introduction & Applications of Computer-Aided Drug Design/ Bio-informatics/ Chemo-informatics . Molecular indices in QSAR; 2D and 3D QSAR methods – significance; Feature selection data reduction approaches; Interpolation and extrapolation; Retro-QSAR – status and scope , Protein sequence and structural databases; Modeling; Docking , Introduction to Solid form informatics; computational approaches in crystalline form selection and solid form development; polymorph screening of drugs , Hands-on training/tutorials and/or project assignments

Total — **15 Hours**

References

1. Molecular Modeling for Beginners by Allan Hinchkliffe
2. Combinatorial Library Methods and Protocols edited by Lisa B. English
3. Molecular Modeling : Basic Principles and applications by Gerd Folkers,Wolfgang sippl, Didier Rognan, Hans Dieter(EDT) Holtje- Science-2003
4. Gupta S.P. Quantum Biology, New Age, 1996.5.Essentials of Drug Designing by V. Kothekar, Dhruv Publications.

22BT0XB	BIO ANALYTICAL TECHNIQUES FOR PHARMACEUTICAL PRODUCTS	L	T	P	C
		1	0	0	1

Course Objectives

- Familiarize with the working principles, tools and techniques of analytical methods
- Design experiment and understand instrumentation.
- Understand the strengths, limitations and creative use of bio analytical techniques for problem solving

Program Outcomes (POs)

PO4 Conduct investigations of complex problems: Use research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PSO1 Use the analytical instruments and techniques to separate, purify and characterize biological compounds

Course Outcomes (COs)

The students will be able to

1. Apply spectroscopic technique to investigate biomolecules and monitor biochemical reactions of pharmaceuticals.
2. Analyze the precise chromatographic/hybrid methods for purification and analysis of pharmaceuticals.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO 3
1	-	-	-	2	2	-	-	-	-	-	-	-	1	-	-
2	-	-	-	-	2	-	-	-	-	-	-	-	3	-	-

Analysis of pharmaceutical products	**15 Hours**

Principles, instrumentation, sampling and applications of UV-VIS, FT-IR, Fluorescence, Raman, CD and NMR spectroscopic techniques-case studies with simple biomolecules, drugs and proteins. Principles of Gas, liquid, Column, reverse phase, normal phase, ion exchange, size exclusion, hydrophobic interaction, bioaffinity, pseudo affinity, thin layer and paper chromatographic techniques. Protein Removal; Phospholipid Removal; Protein Precipitation; Liquid-Liquid Extraction; Solid Phase Extraction. FTIR, HPLC: Instrumentation, detectors, columns, pumps, solvent programming and applications with examples. Gas Chromatography- Instrumentation, Hyphenated techniques in chromatography, GC-MS and LC-MS.

Total	**15 Hours**

References

1. Williams, D. and Fleming, I. Spectroscopic Methods in Organic Chemistry, 6th edition, McGraw-Hill Higher Education, Maidenhead, UK, 2008.
2. James M. Miller, Chromatography : Concepts and contrasts , Wiley, 2019
3. Skoog, D.A., Crouch, S.R., and Holler, F.J. Principles of Instrumental Analysis, 6th edition, Brooks/Cole, USA, 200 .

22BT0XC	MACHINE LEARNING FOR BIOLOGICAL DATA ANALYSIS	L	T	P	C
		1	0	0	1

Course Objectives

- To apply the machine learning techniques for biological data analysis.
- To analyse the information derived out a biological database using ML approaches.

Program Outcomes (POs)

PO4 **Conduct investigations of complex problems:** Use research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PSO3 Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources

Course Outcomes (COs)

The students will be able to

1. Analyze the appropriate model for specific biological data analysis
2. Analyze the relevant information derived out of the biological data analysis.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO 3
1	-	-	-	2	2	-	-	-	-	-	-	-	-	-	2
2	-	-	-	-	2	-	-	-	-	-	-	-	-	-	2

Machine learning for biological data analysis — **15 Hours**

Basics of machine learning, Supervised and unsupervised learning, Machine Learning (ML) models, Training, validation and testing a model, ML models for biological data classification (case study), ML for Regression analysis in biological data (case study), ML for biological data clustering (case study), Dimensional reduction in Genomic data analysis (case study), Artificial Neural Networks in sequence analysis (case study), Antibody Engineering using Support Vector Machines (case study).

Total **15 Hours**

References

1. Mohammad Sufian Badar, A Guide to Applied Machine Learning for Biologists (2023), Springer, No. of pages: 262.
2. Faheem Masoodi, Mohammad Quasim, Syed Bukhari, Sarvottam Dixit, Shadab Alam, Applications of Machine Learning and Deep Learning on Biological Data (2023), CRC Press, No. of pages: 210.
3. Xu, C., Jackson, S.A. Machine learning and complex biological data. Genome Biol, 20, 76 (2019).
4. Joe G. Greener, Shaun M. Kandathil, Lewis Moffat and David T. Jones, A guide to machine learning for biologists. Nature Reviews (2021).

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22BT0XD	BIOSTIMULANTS FOR ENHANCED CROP PRODUCTION	L	T	P	C
		1	0	0	1

Course Objectives

To provide basic and applied training in the subject for development of skills for a successful career in entrepreneurship, generate technically trained human resource for Biofertilizer industries

Program Outcomes (POs)

PO6 The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO9 Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PSO3 Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources

Course Outcomes (COs)

The students will be able to

1. Apply the techniques to focus on commercial applications of biostimulants such as crop improvement
2. Analyze the growth and other parameters like sustainability and beneficial effects for the agricultural crops

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO 3
1	-	-	-	-	-	1	2	-	2	-	-	-	-	-	1
2	-	-	-	-	-	1	2	-	2	-	-	-	-	-	3

Biostimulants for enhanced crop production	**15 Hours**

Categories- Humic and fulvic acids, Protein hydrolysates and other N-containing compounds, Seaweed extracts and botanicals, Chitosan and other biopolymers, Inorganic compounds, Beneficial fungi, Beneficial bacteria. Regulation of biostimulants; opportunities and challenges. Beneficial Bacteria for Agriculture - Isolation of Bacillus sp. from agricultural soil; Phosphate solubilizing bacteria as plant biostiumulants; Beneficial Fungi for Agriculture - Isolation of Arbuscule-forming mycorrhiza; In-vivo method of production of Arbuscular Mycorrhizal Fungi.

Total	**15 Hours**

References

1. Rouphael Y., Jardin P (2020) Biostimulants for sustainable crop production, 1st Edition, Kindle Edition.
2. Calvo., Pamela., Nelson L, and Kloepper J W(2014) Agricultural uses of plant Biostimulants, Plant and soil, 383.
3. Jardin D, Patrick (2015) Plant biostimulants: Definition, concept, main categories and regulation, Scientia horticulturae 196.
4. https://www.biostimulant.com/scientific-research/

22BT0XE	MICROPROPAGATION FOR VIRAL FREE PLANT PRODUCTION	L	T	P	C
		1	0	0	1

Course Objectives

- To provide basic and applied training in the subject for development of skills for a successful career in entrepreneurship, generate technically trained human resource for tissue culture industries

Program Outcomes (POs)

PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

PO12 Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO3 Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources

Course Outcomes (COs)

The students will be able to

1. Apply the techniques to focus on commercial applications of plant tissue culture such as crop improvement
2. Analyze the secondary metabolite production, and various strategies for inducing genetic interference

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO 3
1	-	-	-	-	-	-	2	-	-	-	-	2	-	-	1
2	-	-	-	-	-	-	-	2	-	-	-	3	-	-	3

Micropropagation for viral free plant production — **15 Hours**

Micropropagation - Factors affecting morphogenesis and proliferation rate; technical problems in micropropagation. Organogenesis - formation of shoots and roots, production of virus free plants by meristem and shoot-tip culture. Omatic embryogenesis - Process of somatic embryogenesis, structure, stages of embryo development, factors affecting embryogenesis; production of artificial seeds; Cryopreservation; Preparation of mother plants for collection of explants - Demonstration of meristematic explants in different plants - Establishment of cultures for the induction of embryogenic callus.

Total **15 Hours**

References

1. Cervelli R and Senaratna T (1995) Economic aspects of Somatic embryogenesis. In: J. AitkenChristie et al. (Eds.) Automation and environment control in plant tissue culture. Kluwer, Dordrest
2. Smith R.H (2000) Plant Tissue Culture: techniques and Experiments, Second edition, Academic Press, USA
3. Anderson S.B, Christiansen I and Faresveit B (1990) Carrot (Daucus carota L.): In vitro production of haploids and field trials. In: Y.P.S. Bajaj (Ed.) Biotechnology in Agriculture and Forestry, Vol. 12. Haploids in crop improvement I. Springer, Berlin.
4. Taşkın, H., Baktemur, G., Kurul, M. and Büyükalaca, S., 2013. Use of Tissue Culture Techniques for Producing Virus-Free Plant in Garlic and Their Identification through Real-Time PCR. The Scientific

22BT0XF	CLINICAL RESEARCH AND DATA MANAGEMENT	L	T	P	C
		1	0	0	1

Course Objectives

- To provide overview in different type of clinical research, drug development process and clinical trial management.

Program Outcomes (POs)

PO7 **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

PO12 **Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO3 Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources

Course Outcomes (COs)

The students will be able to

1. Apply the techniques to focus on clinical research and drug development.
2. Analyze the guidelines in the clinical research and clinical data management.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO 3
1	-	-	-	-	-	-	2	-	-	-	-	2	-	-	1
2	-	-	-	-	-	-	-	2	-	-	-	3	-	-	3

Introduction to clinical research (theory) **15 Hours**

Clinical Research: An Overview, Different types of Clinical Research, Terminologies and definition in Clinical Research, Drug Development Process: Preclinical trail, Human Pharmacology (Phase-I), Therapeutic Exploratory trail (Phase-II), Therapeutic Confirmatory Trail (Phase-III) and Post marketing surveillance (Phase-IV). Guidelines and Regulations in Clinical Research: International Conference on Harmonization (ICH), Guidelines for Good Clinical Practice, ICMR guidelines for Biomedical Research on Human Subjects, Regulation in Clinical Research: Drug and cosmetic act, FDA, Schedule-Y- Ethics Committee and their responsibilities. Clinical Trial Management (Theory cum Practical): Contract Research Organization (CRO), Site Management Organization (SMO), Central Lab, Clinical Research Operation, Monitoring and Clinical Evaluation: Project management, Protocol in Clinical Research, Informed Consent, Case Report Form, Investigator's Brochure (IB), Selection of an Investigator and Site, Patient screening, Inclusion and exclusion criteria, Randomization, Blinding, Recruitment Techniques (materials and methods),Retention and complaisance of study subjects, Ethics and Regulatory submission, Monitoring Visits, Investigator Meeting, Essential Document preparation (IB, ICF, PIS, TMF, ISF, CDA.CTA etc), CDM Systems: Clinical data management systems, Electronic data capture systems,.

Total **15 Hours**

References

1. Practical Guide to Clinical Data Management, PROKSCHA, CRC Press; Third edition (1 January 2016).
2. Textbook of Clinical Research, Vikas Dhikav, AITBS Publishers & Distributors; First Edition (1 January 2016).

22BT0XG	ADVANCED PHARMACEUTICAL FORMULATION: NANOTECHNOLOGY AND PERSONALIZED MEDICINE	L	T	P	C
		1	0	0	1

Course Objectives

- To understand the advanced pharmaceutical formulation strategies, focusing on the integration of nanotechnology and personalized medicine.
- To apply the principles, applications, and challenges of utilizing nanocarriers for drug delivery and understand the concept of tailoring treatments for individual patient needs.

Program Outcomes (POs)

PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PSO3 Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources

Course Outcomes (COs)

The students will be able to

1. Apply the advanced pharmaceutical formulation strategies, focusing on the integration of nanotechnology and personalized medicine.
2. Apply the advanced drug delivery routes and nano medicine in cancer therapy
3. Analyze the emerging trends in nanotechnology and personalized medicine

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO 3
1	1	2	2	-	-	-	3	-	-	-	-	-	-	-	1
2	2	2	-	-	-	-	1	-	-	-	-	-	-	-	3
3	1	-	-	-	-	-	3	-	-	-	-	-	-	-	2

Introduction to Advanced pharmaceutical formulation — **15 Hours**

Overview of traditional pharmaceutical formulations, Rationale for advancing to nanotechnology and personalized medicine approaches, Fundamentals of nanotechnology and its applications in pharmaceuticals, Nanoparticle design, synthesis, and characterization, Exploration of lipid-based formulations for enhanced drug delivery, Liposomes, micelles, and lipid nanoparticles in pharmaceutical technology, Introduction to personalized medicine and its relevance in drug development, Pharmacogenomics and individualized treatment regimens, Nanoparticles for targeted drug delivery in cancer treatment, Overcoming challenges and optimizing efficacy in oncology,

Innovations in drug administration routes beyond oral and injectable, Regulatory guidelines for nanomedicine products, Quality control measures in the manufacturing of nanopharmaceuticals, Case studies illustrating successful applications in pharmaceutical formulations

Total	**15 Hours**
References	

1. Tovey, G. D. (Ed.). (2018). *Pharmaceutical Formulation: The Science and Technology of Dosage Forms*. Royal Society of Chemistry.
2. Vizirianakis, I. S. (Ed.). (2014). *Handbook of personalized medicine: advances in nanotechnology, drug delivery, and therapy*. CRC Press.
3. Cannon, C.P., Brindis, R.G., Chaitman, B.R., Cohen, D.J., Cross Jr, J.T., Drozda Jr, J.P., Fesmire, F.M., Fintel, D.J., Fonarow, G.C., Fox, K.A. and Gray, D.T., 2013. 2013 ACCF/AHA key data elements and definitions for measuring the clinical management and outcomes of patients with acute coronary syndromes and coronary artery disease: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Clinical Data Standards (Writing Committee to Develop Acute Coronary Syndromes and Coronary Artery Disease Clinical Data Standards). Circulation, 127(9), pp.1052-1089.

22BT0XH	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN DRUG DISCOVERY	L	T	P	C
		1	0	0	1

Course Objectives

- To understand the integration of artificial intelligence (AI) and machine learning (ML) techniques in drug discovery.
- To analyze the application of these technologies for target identification, compound screening, in the pharmaceutical industry.

Program Outcomes (POs)

PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PSO3 Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources

Course Outcomes (COs)

The students will be able to

1. Apply the artificial intelligence and machine learning techniques in drug discovery.
2. Apply the advanced drug delivery routes and nano medicine in cancer therapy
3. Analyze the emerging trends in nanotechnology and personalized medicine

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO 3
1	1	-	2	-	-	-	3	-	-	-	-	-	-	-	1
2	2	-	-	-	-	-	1	-	-	-	-	-	-	-	3
3	1	-	-	-	-	-	3	-	-	-	-	-	-	-	2

Artificial Intelligence and Machine Learning in Drug Discovery — **15 Hours**

Overview of the drug discovery process, Introduction to artificial intelligence and machine learning, Applications of AI/ML in pharmaceutical research, Applications of AI/ML in pharmaceutical research, Supervised, unsupervised, and reinforcement learning, Feature engineering and data preprocessing for biological data, Evaluation metrics in drug discovery, Basics of molecular biology relevant to drug discovery, Introduction to cheminformatics and chemical informatics databases Integration of molecular and chemical data in AI/ML models, QSAR (Quantitative Structure- Activity Relationship) models, Predicting drug-likeness and ADMET properties, Structure-based drug design using ML techniques, Analyzing genomic data for target identification, Integrating genomics and proteomics data in drug discovery pipelines, Introduction to deep learning

architectures, Applications of deep learning in drug discovery, Case studies on successful

applications of AI/ML in drug discovery, Challenges, limitations, and future directions in the field, Ethical considerations in AI/ML applications in drug discovery**.**	
Total	**15 Hours**
References	

1. Clyde, A. R. (2022). Artificial Intelligence and High-Performance Computing for Accelerating Structure-Based Drug Discovery (Doctoral dissertation, The University of Chicago).
2. Paul, D., Sanap, G., Shenoy, S., Kalyane, D., Kalia, K., & Tekade, R. K. (2021). Artificial intelligence in drug discovery and development. Drug discovery today, 26(1), 80.

22BT0XI	CULTURED MEAT AND ALTERNATIVE PROTEIN PRODUCTION	L	T	P	C
		1	0	0	1

Course Objectives

- To understand the cell biology and tissue engineering for production of cultured meat
- To analyze and optimize the cell culture, scaffold and bioreactor design for production of cultured meat.

Program Outcomes (POs)

PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PSO3 Conceive, Plan and Deploy societal projects for environmental protection using Bio-resources

Course Outcomes (COs)

The students will be able to

1. Apply the principle of cellular biology and tissue engineering to cultured meat
2. Apply the knowledge and optimize the medium formulation for efficient cell growth for cultured meat.
3. Analyze and compare the different scaffold material and impact on tissue development.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO 3
1	1	-	2	-	-	-	2	-	-	-	-	-	-	-	2
2	2	-	-	-	-	-	1	-	-	-	-	-	-	-	3
3	1	-	-	-	-	-	2	-	-	-	-	-	-	-	2

Cultured Meat and Alternative Proteins — **15 Hours**

Overview of the current state of the meat industry and its environmental impact, Introduction to cultured meat, plant-based proteins, and other alternative protein sources, Cell biology fundamentals: cell types, structures, and function ,Tissue engineering basics: scaffolds, bioreactors, and tissue culture techniques, Cellular agriculture and the science behind cultured meat production, Cell isolation, proliferation, and differentiation Medium formulation and optimization for cell growth, Challenges and advancements in large-scale cell culture for meat production, Scaffold materials and their impact on tissue development, Scaling up cultured meat production: challenges and solutions Global regulatory landscape for cultured meat and alternative proteins, Ethical considerations in the production and consumption of alternative proteins, Extraction and processing of plant-based proteins, Other alternative protein sources (e.g., fungal proteins, insect proteins), Business models and strategies for cultured meat companies

Total **15 Hours**

References	

1. Shapiro, P. (2018). Clean meat: how growing meat without animals will revolutionize dinner and the world. Simon and Schuster.
2. Djisalov, M., Knežić, T., Podunavac, I., Živojević, K., Radonic, V., Knežević, N. Ž., & Gadjanski, I. (2021). Cultivating multidisciplinarity: Manufacturing and sensing challenges in cultured meat production. Biology, 10(3), 204.

22BT0XJ	PHYTOTHERAPEUTICS IN MODERN MEDICINE	L	T	P	C
		1	0	0	1

Course Objectives

- To identify bioactive compounds in medicinal plants and their pharmacological properties.
- To evaluate the safety and efficacy of phytotherapeutics through evidence-based research.
- To analyze the mechanisms of action of plant-derived compounds in the treatment of various medical conditions and explore the integration of phytotherapeutics into modern medical practice.

Programme Outcomes (POs)

PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO1 Use the analytical instruments and techniques to isolate, purify and characterize biological compounds

PSO2 Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors

Course Outcomes (COs)

The students will be able to

1. Assess the scientific evidence supporting the use of specific medicinal plants and their derivatives in the management and treatment of various health conditions.
2. Analyze research studies, clinical trials, and meta-analyses to determine the efficacy and safety profile of phytotherapeutic interventions.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	2	1	-	2	1	2	2	-	-	-	2	2	1	-
2	2	2	1	-	2	-	1	2	-	-	-	2	2	2	-

PHYTOTHERAPEUTICS IN MODERN MEDICINE	**15 Hours**
Introduction to Phytotherapeutics, Current trends in phytotherapeutics research, Phytochemistry and Pharmacognosy, Pharmacological Principles of Phytotherapeutics, Evidence-Based Medicine and Herbal Research, Common Phytotherapeutic Agents, Herbal Medicine in Clinical Practice, Regulatory and Legal Aspects of Herbal Medicine and Future Directions in Phytotherapeutics.	
Total	**15 Hours**

References

1. Heinrich, M., Barnes, J., Gibbons, S., & Williamson, E. (Eds.). (2012). Fundamentals of Pharmacognosy and Phytotherapy. Churchill Livingstone.
2. Mills, S., & Bone, K. (2000). Principles and Practice of Phytotherapy: Modern Herbal Medicine. Churchill Livingstone.

22BT0XK	GENOME EDITING TECHNOLOGIES	L	T	P	C
		1	0	0	1

Course Objectives

- To understand the fundamental principles of genome editing technologies.
- To compare and evaluate different genome editing tools and methodologies.
- To explore applications of genome editing in biomedicine, agriculture, and environmental science.

Programme Outcomes (POs)

PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9 Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO1 Use the analytical instruments and techniques to isolate, purify and characterize biological compounds

PSO2 Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors

Course Outcomes (COs)

The students will be able to

1. Design and execute genome editing experiments in various biological systems, including cell lines, model organisms, and primary cells.
2. Optimize genome editing protocols to enhance efficiency, specificity, and scalability, considering factors such as delivery methods, target site selection, and repair mechanisms.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	-	2	-	2	-	-	3	2	-	-	3	1	2	-
2	1	-	1	-	2	-	-	3	1	-	-	2	-	2	-

GENOME EDITING TOOLS AND APPLICATIONS	7 Hours

Introduction to Genome Editing, CRISPR-Cas Systems, TALENs and ZFNs, Prime Editing and Other Advanced Techniques, Applications in Biomedicine, Applications in Agriculture and Environmental Science, Current Challenges and Future Directions.

HANDS ON	8 Hours

Hands-on training on Genome editing tools CRISPR-Cas, TALENs AND ZFNs.

Total	15 Hours

References	

1. Enzyme Kinetics: Behavior and analysis of rapid equilibrium and steady state enzyme systems. Irwin H SEGEL. ISBN: 978-0-471-30309-1.
2. Biochemistry. 5th edition, Berg JM, Tymoczko JL, Stryer L. publisher: W H Freeman

22BT0XL	3D BIOPRINTING	L	T	P	C
		1	0	0	1

Course Objectives

- To fabricate living tissues and organs that can be used for transplantation, regenerative medicine, and drug testing.
- To enable personalized implants and prosthetics tailored to individual patient anatomy.
- To facilitate advanced drug testing, disease modeling, and biomedical research through accurate tissue replication.

Program Outcomes (POs)

PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO1 Use the analytical instruments and techniques to isolate, purify and characterize biological compounds

PSO2 Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors

Course Outcomes (COs)

The students will be able to

1. Analyze the proficiency in utilizing bioprinting technologies to engineer complex tissue and organ constructs.
2. Apply principles of biomaterials science and tissue engineering to address healthcare challenges.
3. Competence in conducting research, analyzing data, and innovating in the field of regenerative medicine and biomedical engineering.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	2	1	-	2	1	2	2	-	-	-	2	2	1	-
2	2	2	1	-	2	-	1	2	-	-	-	2	2	2	-
3	1	1	-	-	1	-	1	-	-	-	-	1	1	-	-

3D Bioprinting **8 Hours**

Introduction to 3D bioprinting, Process of 3D bioprinting, Bioprinting approach: Biomimicry, Autonomous self-assembly and Mini tissue, Classification of Bioprinters, Bio fabrication of Complex tissue, Drug testing and Disease modelling, Applications.

Hands On **7 Hours**

Hands on Training on 3D bioprinting

Total **15 Hours**

References

1. Heinrich, M., Barnes, J., Gibbons, S., & Williamson, E. (Eds.). (2012). Fundamentals of Pharmacognosy and Phytotherapy. Churchill Livingstone.
2. Mills, S., & Bone, K. (2000). Principles and Practice of Phytotherapy: Modern Herbal Medicine. Churchill Livingstone.

22BT0XM	ANALYSIS OF GENOMIC AND PROTEIN CLONES	L	T	P	C
		1	0	0	1

Course Objectives

- To analyze the conceptual design of Genomic and protein clones
- To understand and analyze the various types of Gene manipulation and protein debugging
- To understand the various screening processes involved in selection of hosts
- To apply the appropriate methods to improve gene expressions

Programme Outcomes (POs)

PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO1 Use the analytical instruments and techniques to isolate, purify and characterize biological compounds

PSO2 Design and synthesis of the novel biomolecule for the agriculture and healthcare sectors

Course Outcomes (COs)

The students will be able to

1. Evaluate and design the various types of clones
2. Analyze the various screening processes involved in selection of hosts

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	2	1	-	2	1	2	2	-	-	-	2	2	1	-
2	2	2	1	-	2	-	1	2	-	-	-	2	2	2	-

MANIPULATION OF GENE EXPRESSION	**15 Hours**
Genomic Clones: Introduction - DNA sequencing - Shotgun sequencing - Sequence Comparison with Databank-Blast Method. **Protein Clones:** Location of Promoters-Reporter Gene Method. Protein-DNA Interaction-Yeast one Hybrid Method. Protein-Protein Interaction-Two Hybrid Method-Phage Display Library. Translational Analysis-Western Blotting- 2 Dimensional Electrophoresis.	
Total	**15 Hours**
References	

1. Heinrich, M., Barnes, J., Gibbons, S., & Williamson, E. (Eds.). (2012). Fundamentals of Pharmacognosy and Phytotherapy. Churchill Livingstone.
2. Mills, S., & Bone, K. (2000). Principles and Practice of Phytotherapy: Modern Herbal Medicine. Churchill Livingstone.

OPEN ELECTIVES (OFFERED TO BIOTECH STUDENTS)

22OCE01 ENERGY CONSERVATION AND MANAGEMENT

3 0 0 3

Course Objectives

- To develop an understanding and analyze the energy data of industries
- To carry out energy accounting and balancing
- To conduct energy audit and suggest methodologies for energy savings
- To utilize the available resources in optimal ways

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

Course Outcomes (COs)

1. Classify and characterize the energy resources.
2. Illustrate the concept of green building.
3. Outline the sustainable construction practices.
4. Understand the hydropower production and conservation of water.
5. Emphasis the significance of energy and resource recovery from waste materials.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-
2	1	2	-	-	-	-	2	-	-	-	1	-	-	-	-
3	1	2	-	-	-	-	2	-	-	-	1	-	-	-	-
4	1	2	-	-	-	-	2	-	-	-	1	-	-	-	-
5	1	2	-	-	-	-	2	-	-	-	1	-	-	-	-

UNIT I **9 Hours**

INTRODUCTION TO ENERGY SOURCE

Introduction to energy systems and resources; Introduction to Energy, sustainability & the environment. Energy - Past & Present scenario of World; Renewable and Nonrenewable energy resources.

UNIT II **9 Hours**

ENERGY CONSERVATION IN BUILDINGS

Principles of Planning of buildings: orientation, energy efficiency, utility. Components of building-classification of buildings. Green building - LEED building assessment standard – LEED certification process - Building rating system - Building energy issues – Building energy design strategies – Energy Auditing.

UNIT III **9 Hours**

SUSTAINABLE CONSTRUCTIONS

Equipment use in excavations, foundation, concreting. Advanced Techniques in tunneling, under water construction, piling techniques, Innovations & efficiency in Highways, Railways & Harbours - linkages between economic and environmental outcomes

UNIT IV **9 Hours**

WATER CONSERVATION & SUSTAINABILITY

Types of reservoirs and its functions – Hydropower production – Types of Turbines & selections of turbines & Energy calculations. Water losses from reservoirs and channels – Canal lining & its economic aspects. Water supply systems & Irrigation methods - Rain Water Harvesting methods & benefits.

UNIT V **9 Hours**

ENERGY RECOVERY FROM WASTE

Classification and sources of wastes- Factors affecting MSW generation – Waste management hierarchy - Energy recovery from wastes: Thermochemical methods for energy production - Details of incineration, gasification and pyrolysis & biochemical conversions - Landfill gas recovery system - Principles of fermentation - Concept of MFC - Trans-esterification process - Biofuel processing - Biomass gasification - Organic waste for hydrogen production.

Total: 45 Hours

Reference(s)

1. Boyle, Godfrey, Bob Everett, and Janet Ramage (Eds.) (2004), Energy Systems and Sustainability: Power for a Sustainable Future. Oxford University Press
2. Charles. J. Kibert, Sustainable Construction: Green Building Design and Delivery, John Wiley & Sons, Inc., New Jersey, 2008.
3. H. M. Raghunath, Irrigation Engieering, Wiley India (P) Ltd, 2011
4. E H Thorndike (1976), Energy & Environment: A Primer for Scientists and Engineers, Addison-Wesley Publishing Company
5. M. Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, ISBN-10: 8173191409,1997.
6. Lal, P.M. Sarma, Priyangshu M, Wealth from Waste: Trends and Technologies, 3rd Edition, The Energy and Resources Institute, New Delhi, ISBN: 9788179934241, 2011.
7. W. McDonough, M. Braungart, Cradle to Cradle: Remaking the Way We Make Things, United States: North Point Press, ISBN-10: 0865475873, 2002.

3 0 0 3

22OCS01 **OBJECT ORIENTED PROGRAMMING**

Course Objectives

- Understand the concepts of Object Oriented Programming
- Study the concepts of objects and classes.
- Familiarize in the types of constructors.

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

Course Outcomes (COs)

1. Identify the characteristics and data types of C++ language.
2. Develop programs using objects and classes for real world applications
3. Construct programs to implement operator overloading and inheritance techniques
4. Apply Polymorphism and File streams concepts to develop C++ program
5. Design applications using templates and apply exception handling mechanisms

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	-	-	3	-	-	-	-	-	-	-	-	-	-
2	1	2	3	-	3	-	-	-	-	-	-	-	-	-	-
3	1	2	2	-	3	-	-	-	-	-	-	-	-	-	-
4	1	2	3	-	3	-	-	-	-	-	-	-	-	-	-
5	1	2	3	-	3	-	-	-	-	-	-	-	-	-	-

UNIT I **8 Hours**

INTRODUCTION

Need for object oriented programming - Procedural Languages vs. Object oriented approach - Characteristics Object oriented programming - C++ Programming Basics: Basic Program Construction - Output Using cout - Input with cin - Data types- Variables and Constants - Operators - Control Statements-Manipulators - Type conversion. Function Prototyping- call by reference, return by reference- Inline function- Default arguments - Function overloading.(sona)

UNIT II **8 Hours**

OBJECTS AND CLASSES

Objects and Classes Simple Class - C++ Objects as Physical Objects - C++ Object as Data types- CONSTRUCTORS: Parameterized Constructors - Multiple Constructors in a Class - Constructors with Default Arguments - Dynamic Initialization of Objects - Copy and Dynamic Constructors - Destructors(PSG) - Structures and Classes - Arrays and Strings

UNIT III **9 Hours**

OPERATOR OVERLOADING AND INHERITANCE

Operator Overloading and Inheritance Need of operator overloading- Overloading Unary Operators- Overloading binary Operators - Overloading Special Operators - Data Conversion Inheritance: Derived Class and Base Class - Derived Class Constructors-Overriding Member Functions-Class Hierarchies- Public and Private Inheritance-Levels of Inheritance-Multiple Inheritance.

UNIT IV

POLYMORPHISM AND FILE STREAMS **10 Hours**

Polymorphism and File Streams Virtual Function - Friend Function - Static Function-Assignment and Copy Initialization- Memory Management: new and delete Pointers to Objects, this Pointer- Streams - String I/O - Character I/O - Object I/O - I/O with Multiple Objects - File Pointers - Disk I/O with Member Functions- Error Handling in File I/O.

UNIT V **10 Hours**

TEMPLATES AND EXCEPTION HANDLING

Templates: Introduction - Function Templates - Overloading Function Templates-, user defined template arguments(sona) - Class Templates - Exception Handling - Syntax, multiple exceptions, exceptions with arguments.

Total: 45 Hours

Reference(s)

1. Deitel & Deitel, C++ How to program, Prentice Hall,2005
2. Robert Lafore, Object Oriented Programming in-C++, Galgotia Publication.
3. D.S.Malik, C++ Programming, Thomson, 2007.
4. K.R. Venugopal, Rajkumar and T.Ravishankar, Mastering C++, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2006.
5. E.Balagurusamy, Object Oriented Programming with C++, Tata McGraw Hill Publishing.

22OCS02 JAVA FUNDAMENTALS 3 0 0 3

Course Objectives

- Implement applications based on core Java Concepts with examples
- Construct application using inheritance, packages and exception handling for real time problems.
- Integrate the Java I/O concepts to handle input and output operations.
- Develop programs to perform string manipulation in java.
- Design GUI with Java for event handling and database applications.

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

Course Outcomes (COs)

1. Demonstrate applications based on core Java Concepts with examples
2. Construct application using inheritance, packages and exception handling for real time problem
3. Explain the Java I/O concepts to handle input and output operations.
4. Develop programs to perform string manipulation in Java.
5. Design GUI with Java for event handling and database applications.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	3	2	-	2	-	-	-	-	-	-	-	-	-	-
2	2	3	2	-	2	-	-	-	-	-	-	-	-	-	-
3	3	3	3	-	3	-	-	-	-	-	-	-	-	-	-
4	2	2	2	-	2	-	-	-	-	-	-	-	-	-	-
5	2	2	2	-	2	-	-	-	-	-	-	-	-	-	-

UNIT I **9 Hours**

BASICS OF JAVA

The Genesis of Java - Overview of Java - Data Types, Variables, and Arrays - Operators – Control Statements - Introducing Classes - Methods and Classes.

UNIT II **9 Hours**

INHERITANCE, PACKAGES AND EXCEPTIONS

Inheritance: Basics - Using Super - Creating a Multilevel Hierarchy - Method overriding - Using Abstract Classes - Packages and Interfaces: Packages - Access Protection - Importing Packages- Interfaces Definitions and Implementations - Exception Handling: Types - Try and Catch - Throw.

UNIT III **9 Hours**

EXPLORING JAVA I/O

I/O Basics - Reading Console Input -Writing Console output - Native Methods - I/ O Classes and Interfaces - File - The Byte Streams - The Character Streams - Using Stream I/ O - Serialization.

UNIT IV **9 Hours**

JAVA STRINGS

String Handling: Special String operations and Methods - String Buffer - Exploring java.lang: Simple type Wrappers - System - Math - Collections Framework: Collections Interfaces and Classes – Utility Classes: String Tokenizer - Date and Time.

UNIT V **9 Hours**

GUI WITH JAVA

Applet Basics - Applet Architecture - Applet Display Methods - Parameter Passing - Event Handling Mechanisms - Event Classes - Event Listener - Working with Windows, Graphics, Colors and Fonts - AWT Controls - Layout Managers and Menus – JDBC

Total: 45 Hours

Reference(s)

1. Herbert Schildt, Java 2-Complete Reference, Tata Mc Graw Hill, 2015.
2. Deitel & Deitel, Java How to Program, Prentice Hall of India, 2010.
3. Gary Cornell and Cay S.Horstmann, Core Java Vol.1 and Vol.2, Sun Microsystems Press, 2008.

22OCS03 KNOWLEDGE DISCOVERY IN DATABASES 3 0 0 3

Course Objectives

- Introduce the basic concepts of data warehousing.
- Impart knowledge about the data mining functionalities.
- Assess the strengths and weaknesses of association mining and cluster analysis.

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

Course Outcomes (COs)

1. Explain the concepts of Data Warehousing architecture and business analysis process.
2. Illustrate the process of Data Mining and preprocessing techniques for data cleansing.
3. Apply the association rules for mining the various kinds of data
4. Analyze Classification and Clustering algorithms for various problems with high dimensional data.
5. Illustrate the various data mining techniques on complex data objects

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2	3	2	-	-	-	-	-	-	-	-	-	-	-	-
3	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
4	3	2	2	2	-	-	-	-	-	-	-	-	-	-	-
5	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-

UNIT I 9 Hours

DATA WAREHOUSING AND BUSINESS ANALYSIS

Data warehousing Components -Building a Data warehouse -Data Warehouse and DBMS- Metadata-Multidimensional data model - Data Extraction, Cleanup and Transformation Tools -Reporting, Query tools and Applications - OLAP vs OLTP - OLAP operations - Data Warehouse Schemas: Stars, Snowflakes and Fact constellations.

UNIT II **8 Hours**

INTRODUCTION TO DATA MINING

Introduction - Steps in knowledge discovery from databases process - Architecture of a Typical Data Mining Systems - Data Mining Functionalities - Classification of Data Mining Systems - Data mining on different kinds of data - Different kinds of pattern - Task Primitives - Integration of a Data Mining System with a Data Warehouse - Major issues in Data mining.

UNIT III **9 Hours**

ASSOCIATION RULE MINING

Market Basket Analysis- Frequent Item Set Mining methods: Apriori algorithm - Generating Association Rules - A Pattern Growth Approach- Pattern mining in multilevel and multidimensional space - Mining Various Kinds Of Association Rules - Association Analysis to Correlation Analysis - Constraint Based Association Mining.

UNIT IV **9 Hours**

CLASSIFICATION AND CLUSTERING

Decision Tree Induction - Bayesian Classification - Rule Based Classification - Classification by Back propagation - Support Vector Machines - Clustering: Types of data - Partitioning methods: k-means, k- medoid - Hierarchical Methods: distance based agglomerative and divisible clustering, BIRCH – Density Based Method: DBSCAN - Grid Based Method: STING.

UNIT V **10 Hours**

DATA MINING APPLICATIONS

Mining complex data objects - Text Mining - Graph mining - Web mining - Spatial Data mining - Application and trends in data mining - Social impacts of Data mining.

Total: 45 Hours

Reference(s)

1 Jiawei Han, Micheline Kamber and Jian Pai , Data Mining: Concepts and Techniques, Morgan Kauffman, 3rd Edition, 2013.

2 Alex Berson and Stephen J Smith, Data Warehousing, Data Mining, and OLAP, Tata Mcgraw- Hill, 1997.

3 David Hand, Heikki Manila, Padhraic Symth, Principles of Data Mining, MIT Press, 2001.

4 Margaret H.Dunham, Data Mining: Introductory and Advanced Topics, Pearson Education 2003.

22OCS04 **E-LEARNING TECHNIQUES** **3 0 0 3**

Course Objectives

- Understand the technologies involved in e-learning.
- Gain the fundamentals of e-learning techniques
- Determine the characteristics of Teaching-Learning Process

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

Course Outcomes (COs)

1. Acquire knowledge about the basic concepts of e-learning.
2. Explain the technology mediated communication in e-learning
3. Exemplify of e-learning and content the process management.
4. Analyze the teaching and learning processes in e-learning environment.
5. Assess the various applications of e-learning.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2	2	3	-	-	-	-	-	-	-	-	-	-	-	-
3	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-
4	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
5	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I **9 Hours**
INTRODUCTION
Evolution of Education - Generations of Distance Educational Technology - Role of E-Learning - Components of e-learning: CBT, WBT, Virtual Classroom - Barriers to e-Learning Roles and Responsibilities: Subject Matter Expert - Instructional Designer - Graphic Designer - Multimedia Author - Programmer - System Administrator - Web Master

UNIT II **9 Hours**
TECHNOLOGIES
Satellite Broadcasting - Interactive Television - Call Centers - Whiteboard Environment - Teleconferencing: Audio Conferencing - Video Conferencing -Computer Conferencing. Internet: E-mail, Instant Messaging, Chat, Discussion Forums, Bulletin Boards, Voice Mail, File Sharing, Streaming Audio and Video.

UNIT III **9 Hours**
MANAGEMENT
Content: E-Content, Dynamic Content, Trends - Technology: Authoring, Delivery, Collaboration - Services: Expert Service, Information Search Service, Knowledge Creation Service - Learning Objects and E-Learning Standards. Process of E-Learning: Knowledge acquisition and creation, Sharing of knowledge, Utilization of knowledge - Knowledge Management in E-Learning.

UNIT IV **9 Hours**
TEACHING-LEARNING PROCESS
Interactions: Teacher-Student - Student-Student - Student-Content - Teacher- Content - Teacher-Teacher - Content-Content Role of Teachers in E-Learning - Blended Learning -Cooperative Learning - Collaborative Learning - Multi Channel learning -Virtual University - Virtual Library.

UNIT V **9 Hours**
APPLICATIONS
Customer service training - Sales training - Customer training - Safety training - IT training – Product training - Healthcare training.

Total: 45 Hours

Reference(s)

1. E-Learning: An Expression of the Knowledge Economy, Gaurav Chadha, S.M. Nafay Kumail, Tata McGraw-Hill Publication, 2002.
2. E-Learning: New Trends and Innovations, P.P. Singh, Sandhir Sharma, Deep & Deep Publications, 2005. 4. 4. Michael Allen's Guide to E-Learning, Michael W. Allen, Michael Allen, Wiley Publication, 2002
3. E-Learning: Concepts, Trends and Applications, Epignosis LLC, LLC publications, 2014.
4. Michael Allen's Guide to E-Learning, Michael W. Allen, Michael Allen, Wiley Publication, 2002.

22OCS05 SOCIAL TEXT AND MEDIA ANALYTICS 3 0 0 3

Course Objectives

- Understand the basic ideas of Text mining.
- Analyze the methods and approaches used in analytics.
- Gain knowledge on various types of analytics like web, social network, and social media

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

Course Outcomes (COs)

1. Demonstrate the concepts and applications of text mining
2. Explain Content analysis and Sentiment analysis
3. Illustrate web analytics with a suitable model
4. Illustrate social network analytics with suitable example.
5. Illustrate social media analytics with suitable example.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	3	-	2	3	-	-	-	-	-	-	-	-	-	-
2	2	3	-	2	2	-	-	-	-	-	-	-	-	-	-
3	2	3	-	3	3	-	-	-	-	-	-	-	-	-	-
4	2	2	2	3	2	-	-	-	-	-	-	-	-	-	-
5	2	3	-	2	3	-	-	-	-	-	-	-	-	-	-

UNIT I **7 Hours**

TEXT MINING

Introduction, Core text mining operations, Preprocessing techniques, Categorization, Clustering, Information extraction, Probabilistic models for information extraction, Text mining applications.

UNIT II **9 Hours**
METHODS
Content Analysis-Natural Language Processing-Clustering & Topic Detection-Simple Predictive Modeling-Sentiment Analysis; Sentiment Prediction.

UNIT III **9 Hours**
WEB ANALYTICS
Web analytics tools-Clickstream analysis-A/B testing, online surveys-Web search and retrieval-Search engine optimization-Web crawling and Indexing-Ranking algorithms-Web traffic models.

UNIT IV **10 Hours**
SOCIAL NETWORK ANALYTICS
Social contexts: Affiliation and identity - Social network analysis - Social network and web data and methods. Graphs and Matrices - Basic measures for individuals and networks

UNIT V **10 Hours**
SOCIAL MEDIA ANALYTICS
Information visualization - Making connections: Link analysis - Random graphs and network evolution.

Total: 45 Hours

Reference(s)

1. Ronen Feldman and James Sanger, The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data, Cambridge University Press, 2006.
2. Hansen, Derek, Ben Sheiderman, Marc Smith. Analyzing Social Media Networks with NodeXL: Insights from a Connected World, Morgan Kaufmann, 2011.
3. Avinash Kaushik. Web Analytics 2.0: The Art of Online Accountability, 2009.
4. Hanneman, Robert and Mark Riddle. Introduction to Social Network Method, 2005.
5. Wasserman, S. & Faust, K. Social network analysis: Methods and applications. New York: Cambridge University Press, 1994.
6. Monge, P. R. & Contractor, N. S. Theories of communication networks. New York: Oxford University, 2003

22OEC01 BASICS OF ANALOG AND DIGITAL ELECTRONICS **3 0 0 3**

Course Objectives

- Understand the working of diodes and transistors in electronic circuits.
- Understand the analog operational amplifier and its applications.
- Understand the implementation of combinational and sequential circuits in digital systems.

Programme Outcomes (POs)

Course Outcomes (COs)

1. Apply the diodes and transistors in regulators and amplifiers and analyze their characteristics.
2. Illustrate the working of analog IC with different configurations and its applications.
3. Simplification of Boolean expressions using K-map and implementation of combinational circuits.
4. Analyze the Flip flops and memory configurations in digital circuits.
5. Classify and analyze A/D and D/A converters with its parameters.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	1										2	
2		3	1										2	
3			2		1								2	
4			2		3								2	
5			3		2								2	

UNIT I **9 Hours**

SEMICONDUCTORS DEVICES

Conductor, Semiconductors & Insulators, Semiconductors: intrinsic & extrinsic, energy band diagram - Mobility - Electrons and holes - The P-N junction diode - Zener diode - Avalanche effect- Rectifier Circuits Half wave, Full wave circuits, Efficiency, PIV, Ripple factor and AC and DC current and voltage in rectifier. PNP and NPN Bipolar junction Transistors - H parameters equivalent circuit - Common emitter amplifier - DC behavior: the load slope and the Q point - AC behavior - Emitter follower amplifier - Field effect transistors: JFET and MOSFET.

UNIT II **9 Hours**

OPERATIONAL AMPLIFIERS: DC PERFORMANCE

The operational amplifier - Input resistance, Output resistance, Open loop gain - Bias currents - Offset currents - Offset voltage - Differential mode gain - Common mode gain - Common mode rejection ratio - Negative feedback - Open loop gain and closed loop gain - Inverter amplifier - Non-inverter amplifier - The voltage follower - Transimpedance amplifier (Current to voltage converter) - Differential amplifier. Adders, Subtractors, Comparator, Integrator and Differentiator.

UNIT III **9 Hours**

DIGITAL TECHNIQUES : COMBINATIONAL CIRCUITS

Numbering systems - Binary, octal and hexadecimal numbers - Boole algebra - Conversion and operations - AND gate- OR gate - Inverter - NAND gate - NOR gate - Exclusive OR gate. Morgans laws. Combinational Circuits: Truth tables, logic expressions, Logic simplification using K- map, , half and full adder/subtractor, multiplexers, demultiplexers, Logic families :TTL and CMOS.

UNIT IV **9 Hours**

DIGITAL TECHNIQUES: SEQUENCIAL CIRCUITS

Gated Latches & Flip Flops- Level triggered and Edge triggered Flip-Flops, Flop (FF) types: RS type. JK FF. JK FF Master slave. D FF. T FF. Flip Flop Conversion. Shift registers, Counters. Memories Structure: address and data bus. ROM, PROM, EPROM and flash RAM. Volatiles Memories: RAM, SRAM, DRAM. Addressing modes.

UNIT V **9 Hours**

DIGITAL TO ANALOG CONVERTERS AND ANALOG TO DIGITAL CONVERTERS

DIGITAL TO ANALOG CONVERTERS : Input latch. Binary Weighted Resistor Network. R-2R Ladder Resistor Network.Pulse Width Modulation . Resolution. Accuracy. Linearity. Zero Offset. Settling Time.Glitches. ANALOG TO DIGITAL CONVERTERS: Sampling. Real time sampling and equivalent time sampling. Sampling frequency. Sampling theorem (Nyquist). Anti-aliasing filtering. Sampling and holding. Conversion.

Total: 45 Hours

Reference(s)

1. L Robert Boylestead, Louis Nashelsky, Electronic Devices and Circuit Theory, Pearson Education,2012.
2. J Millman, C. Halkias & Satyabrata Jit, Electronic Devices and Circuits, Tata McGraw-Hill,2010.
3. Ramakant A.Gayakwad, OP-AMP and Linear IC"s , Prentice Hall of India, 2002.
4. D.RoyChoudhry, Shail Jain, Linear Integrated Circuits, New Age International Pvt. Ltd., 2000.
5. Thomas L.Floyd, Digital Fundamentals, Prentice Hall, 11th Edition, 2015.
6. M.Morris Mano, Michael D Ciletti Digital Design 4th edition Pearson, 2011.

22OEC02 MICROCONTROLLER PROGRAMMING 3 0 0 3

Course Objectives

- Understand Series of Microcontrollers in terms of architecture, Programming and Interfacing.
- Learn Programming of PIC series of microcontrollers and learn building of hardware circuits using PIC 16F series of Microcontrollers
- Learn the emerging trends in the design of advanced Microncontrollers.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

e. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

m. Able to design new concepts in the domains of Microelectronics and Communication Engineering.

Course Outcomes (COs)

1. Interpret the components and functionalities of 8051 Microcontrollers.
2. Develop microprocessor applications using Assembly Language Program
3. Illustrate the working nature of PIC microcontroller on various versions
4. Illustrate the interfacing of different peripherals using PIC Microcontroller
5. Analyze the architecture and instruction set of ARM Microcontroller

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	1										2	
2		3	1										2	
3			2		1								2	
4			2		3								2	
5			3		2								2	

UNIT I **9 Hours**

8-BIT MICROCONTROLLER

Introduction-Intel 8051 architecture-Counters and Timers-Serial Interface- Interrupts- Interfacing to external memory and 8255- Instruction set- Address modes.

UNIT II **9 Hours**

8051 ALP AND APPLICATIONS

Assembly language program- Timers and Counters programming- DAC- ADC- Sensor- Keyboard and LCD.

UNIT III **9 Hours**

PIC MICROCONTROLLER

PIC Microcontroller features- PIC Architecture, Program Memory, Addressing Modes, Instruction Set, Instruction Format- Byte-oriented Instructions- Bit-oriented Instructions- Literal Instructions- Control Instructions (CALL & GOTO)- Destination Designator. MPLAB overview: Using MPLAB, Toolbars, Select Development Mode and Device type, Project, Text Editor, Assembler, MPLAB operations.

UNIT IV **9 Hours**

PIC HARDWARE

Reset, Clock, Control registers, Register banks, Program Memory Paging, Ports, Interrupts, Timer and Counter, Watchdog Timer, Power up timer, Sleep mode, I2C bus- A/D converter.

UNIT V **9 Hours**

HIGH PERFORMANCE RISC ARCHITECTURE

ARM: The ARM architecture- ARM organization and implementation- The ARM instruction set- The THUMB instruction set- Basic ARM Assembly Language Program- ARM CPU Cores.

FOR FURTHER READING

Introduction- Architecture- Registers- Memory- Instruction set- Addressing Modes- I/O Pins- Timers- Counters- Interrupts.

Total: 45 Hours

Text Book(s)

1. Ayala, Kenneth, "The 8051 Microcontroller", Thomson, 3rd Edition, 2004.

Reference(s)

1. Muhammad Ali Mazidi, Janice Gillispie Mazidi, " The 8051 Microcontroller and Embedded Systems", Person Education, 2nd Edition, 2004.
2. John B.Peatman, "Design with Microcontrollers", Person Education", 1st Edition, 2004.
3. Steave Furber, "ARM system-on-chip architecture" Addison Wesley, 2nd Edition, 2000.
4. A.V.Deshmukh, "Microcontrollers: Theory and Applications", Tata Mc Graw Hill, 12th reprint, 2005.

22OEC03 PRINCIPLES OF COMMUNICATION SYSTEMS

3 0 0 3

Course Objectives

- To study the various analog and digital modulation techniques
- To study the various digital communication techniques
- To enumerate the idea of spread spectrum modulation
- To study the design concepts of satellite and optical communication

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

m. Able to design new concepts in the domains of Microelectronics and Communication Engineering.

Course Outcomes (COs)

1. Illustrate the process involved in Amplitude, Frequency and phase modulation systems.
2. Analyze the performance of different digital modulation /demodulation techniques.
3. Analyze Pulse Code Modulation scheme for the transmission of analog data in digital format.
4. Apply the concepts of spread spectrum modulation techniques to eradicate interference in wireless communication.
5. Analyze the system design of satellite and optical communication.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	2										2		
2	3	2											2		
3	3	2											2		
4	2	2	2										2		
5	3	2											2		

UNIT I **9 Hours**

FUNDAMENTALS OF ANALOG COMMUNICATION

Principles of amplitude modulation, AM envelope, frequency spectrum and bandwidth, modulation index and percent modulation, AM Voltage distribution, AM power distribution, Angle modulation. FM andPM waveforms, phase deviation and modulation index, frequency deviation and percent modulation,Frequency analysis of angle modulated waves. Bandwidth requirements for Angle modulated waves

UNIT II **9 Hours**

DIGITAL COMMUNICATION

Introduction, Shannon limit for information capacity, Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK) Minimum Shift Keying (MSK),Phase Shift Keying (PSK), BPSK, QPSK, 8 PSK Quadrature Amplitude Modulation (QAM), Bandwidth Efficiency,Comparison of various Digital Communication System (ASK - FSK - PSK - QAM).

UNIT III **9 Hours**

DIGITAL TRANSMISSION

Introduction, Pulse modulation, PCM , PCM sampling, sampling rate, signal to quantization noise rate,companding, delta modulation, adaptive delta modulation, differential pulse code modulation, pulse transmission, Intersymbol interference, eye patterns.

UNIT IV **9 Hours**

SPREAD SPECTRUM AND MULTIPLE ACCESS TECHNIQUES

Introduction, Pseudo-noise sequence, DS spread spectrum with coherent binary PSK, processing gain, FH spread spectrum, multiple access techniques, wireless communication, TDMA and CDMA in wireless communication systems, source coding of speech for wireless communications.

UNIT V **9 Hours**

SATELLITE AND OPTICALCOMMUNICATION

Satellite Communication Systems-Keplers Law,LEO and GEO Orbits, footprint, Link model-OpticalCommunication Systems-Elements of Optical Fiber Transmission link, Types, Losses, Sources and Detectors.

FOR FURTHER READING

RADAR Communication: Basic Radar, The simple form of the Radar Equation, Radar Block Diagram, Radar Frequencies, Applications of Radar.

Total: 45 Hours

Reference(s)

1. Wayne Tomasi, Advanced Electronic Communication Systems, 6/e, Pearson Education, 2007.
2. Simon Haykin, Communication Systems, 4th Edition, John Wiley & Sons., 2001.
3. H.Taub,D L Schilling,G Saha ,Principles of Communication,3/e,2007.
4. B.P.Lathi,Modern Analog And Digital Communication systems, 3/e, Oxford University Press, 2007
5. Dennis Roddy, "Satellite Communications", Third Edition, Mc Graw Hill International Editions, 2001.
6. Gerd Keiser, Optical Fiber Communication, McGraw-Hill International, Singapore, 4th edition., 2011.

22OEC04 PRINCIPLES OF COMPUTER COMMUNICATION AND NETWORKS 3 0 0 3

Course Objectives

- To understand the concept of data communication and networking models.
- To study the various networking Components and Networks.
- To explore the routing, addressing and security and management aspects of computer networks.

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

Course Outcomes (COs)

1. Classify the types of computer networks and analyze the seven layers of OSI model.
2. Analyze the basic operations of Routing Algorithms and Routing devices
3. Analyze the local and wide area networking technologies.
4. Apply the ISDN and ATM interface connections in broadband networks.
5. Analyze the security and management techniques related with networks.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	1	1	-	-	-	-	-	-	-	-	-	-	-
2	1	2	2	3	-	-	-	-	-	-	-	-	-	-	-
3	1	1	2	3	-	-	-	-	-	-	-	-	-	-	-
4	1	1	3	-	-	-	-	-	-	-	-	-	-	-	-
5	1	2	3	3	-	-	-	-	-	-	-	-	-	-	-

UNIT I **9 Hours**

NETWORK FUNDAMENTALS

Types of Computer Networks: by Area, by Topology; Communication Services: Serial and Parallel, Synchronous and Asynchrounous, Simplex and Duplex, Analog and Digital; Speed and Capacity; Multiplexing and Switching; Network Architecture: OSI Seven-Layer Network model.

UNIT II **9 Hours**

INTERNETWORKING AND COMPONENTS

Routing Concepts: Routing Algorithms, RIP, RIP-2, OSPF and other routing Protocols; Switches and Hubs: Store and Forward Switch, Cut-Through Switch, Hybrid Switch, Performance of Switches ; Repeaters; Repeater Vs Hubs; Bridges: Standards, Bridges Vs Repeaters; Routers and Gateways.

UNIT III **9 Hours**

LOCAL AND WIDE AREA NETWORKING TECHNOLOGIES

LAN Components and Topologies; Access Techniques; Transmission Protocols and Media; Ethernet and IEEE 802.3 Networks: History, 10-MBPS Ethernet, Switched Ethernet, 100-MBPS Ethernet, Gigabit Ethernet.

UNIT IV **9 Hours**

BROADBAND NETWORKS

ISDN: Evolution, ISDN Channel and Interface Structures; Broadband ISDN: Basics, Principles and General Architecture; Asynchronous Transfer Mode(ATM): Introduction, Concepts, Components, Connection Supported by ATM network and Concept of Virtual Channel and Virtual Path, Traffic control and Congestion Control, Operation and Maintenance aspects.

UNIT V **9 Hours**

NETWORK SECURITY AND MANAGEMENT

Security: Need of Security, Security Threats, Vulnerabilities, Methods, tools and Techniques for Attacks; Network Security: Levels of Security, Cryptosystems; Data Encryption Standard (DES), Public Key Cryptography, Firewalls; Network Management: Functions and Elements, Distribution of Management; Simple Network Management Protocol (SNMP), Remote Network Management Services.

Total: 45 Hours

Reference(s)

1. Michael A.Gallo, William M. Hancock, Computer Communications and Networking Technologies, 1 Ed, Thomson Learning, 2002.
2. Kenneth C. Mansfield, Jr.James L. Antonakos, An Introduction to Computer Networking, 1Ed, Prentice Hall of India, 2002
3. A Shanmugam, S Rajeev, Computer Communication Networks, 1Ed, ISTE Learning Materials Centre, 2001
4. Discrete-Time Signal Processing by Alan V. Oppenheim and Ronald W. Schafer, 3rd edition, 2010, Prentice Hall
5. Digital Signal Processing by Sanjit Mitra, 4th edition, 2011, McGraw-Hill, New York, NY

22OEI01 PROGRAMMABLE LOGIC CONTROLLER 3 0 0 3

Course Objectives

- To impart knowledge about automation and architecture of PLC
- To understand the PLC programming using timers, counters and advanced PLC functions
- To familiarize the student with PLC based applications

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Course Outcomes (COs)

1. Outline the fundamental Concepts of Automation
2. Conclude the architecture, interfacing and communication techniques of PLC
3. Execute the suitable PLC Programming languages
4. Attribute the various functions and instruction sets of PLC
5. Generate a suitable logical programming for given applications

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	1	-	2	2	-	3	-	-	-	-	-	-	-	-
2	2	1	-	2	2	-	3	-	-	-	-	-	-	-	-
3	2	1	-	2	2	-	3	-	-	-	-	-	-	-	-
4	2	1	-	2	2	-	3	-	-	-	-	-	-	-	-
5	2	1	-	2	2	-	3	-	-	-	-	-	-	-	-

UNIT I 10 Hours

INTRODUCTION TO AUTOMATION

Evolution of automation -Types of automation - Fixed, flexible and programmable automation - Batch process and continuous process - open loop system and closed loop system - Function of sensors - Proximity sensors: Capacitive and Inductive - Infrared and Laser Push-buttons and toggle switches - Actuators: Solenoid valve - servo motor - electromagnetic relays.

UNIT II **9 Hours**

ARCHITECTURE OF PLC

Components of PLC - sink and source I/O cards - Processor - Memory: Types of memory, Input and Output modules: Discrete, Analog -Scan time of PLC -Interfacing computer and PLC: RS232, RS485, Ethernet - Selection criteria for PLC.

UNIT III **8 Hours**

PLC PROGRAMMING

Programming languages - Ladder logic components: User and bit Instructions, branch instructions, internal relay instruction Boolean logic using ladder logic programming, Latching -Timers: On Delay timer, OFF Delay timer and Retentive timer - Counters: Up Counter and Down Counter.

UNIT IV **10 Hours**

ADVANCED PLC FUNCTONS

Instructions in PLC: Program Control Instructions, Math Instructions, Data Manipulation Instructions: Data compare operations, Data transfer operations - Sequencer and Shift register instructions- Analog Instructions: PID Controller - Scaling Instructions.

UNIT V **8 Hours**

APPLICATIONS OF PLC

Case Studies: Bottle filling system - Pick and place robot - Car Parking - Traffic light control (4 ways with pedestrian signal) -Elevators - Pneumatic stamping system - alarm annunciator system.

Total: 45 Hours

Reference(s)

1. F.D. Petruzella, Programmable Logic Controllers, Tata Mc-Graw Hill, Third edition, 2015.
2. Benjamin C Kuo, Automatic Control Systems, Prentice Hall of India, New Delhi, 2014.
3. John Park, Steve Mackay, Edwin Wright, Practical data communications for instrumentation and control, Newnes, Elsevier, 2015.
4. K. L.S. Sharma, Overview of Industrial Process Automation, Elsevier, 2014.
5. John W Webb and Ronald A Resis, Programmable Logic Controller, Prentice Hall of India Pvt. Ltd., New Delhi, 2013.

22OEI02	SENSOR TECHNOLOGY	L	T	P	C
		3	0	0	3

Pre-requisite	Assessment Pattern	
● NIL	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To impart knowledge about various sensors in multidisciplinary engineering domain.
- To familiarize students with different applications and its material handling technology
- To understand the concept of sensing circuits and its static and dynamic characteristics

Programme Outcomes (POs)

PO1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
PO3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

Course Outcomes (COs)

The students will be able to

CO1	Conclude the static and dynamic characteristics of measuring instruments.
CO2	Compare the characteristics and working principles of Resistance, Inductance and Capacitance type sensors.
CO3	Construct the interfacing and signal conditioning circuit for measurement system using different types of sensor.
CO4	Analyze and select the suitable sensor for different industrial applications.
CO5	Combine the modern technologies and smart materials to design various sensors.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	1											
2	2	3	2	1	1									
3	1	2	3	3	1									
4	2	1	1	3	3									
5	1	2	1	2	3									

Unit I	SENSORS FUNDAMENTALS AND CHARACTERISTICS	8 Hours

Sensors: Principles of Sensing - Sensor Classification and terminology- Units of Measurements -Measurands- Sensor Characteristics: Static and Dynamic.

Unit II	PHYSICAL PRINCIPLES OF SENSING	8 Hours

Electric Charges, Fields, and Potentials; Capacitance; Magnetism; Induction; Resistance; Piezoelectric Effect; Hall Effect; Temperature and Thermal Properties of Material; Heat Transfer; Light; Dynamic Models of Sensor Elements.

Unit III	INTERFACE ELECTRONIC CIRCUITS	9 Hours

Input Characteristics of Interface Circuits, Amplifiers, Excitation Circuits, Analog to Digital Converters, Direct Digitization and Processing, Bridge Circuits, Data Transmission, Batteries for Low Power Sensors.

Unit IV	SENSORS IN DIFFERENT APPLICATION AREA	10 Hours

Occupancy and Motion Detectors; Position, Displacement, and Level; Velocity and Acceleration; Force, Strain, and Tactile Sensors; Pressure Sensors, Temperature Sensors.

UNIT V	SENSOR MATERIALS AND TECHNOLOGIES	10 Hours

Materials, Surface Processing- MEMS microsystem components- Microfluidics microsystem components - Nano Technology- Smart Materials.

Total	**45 Hours**

References

1. J. Fraden, Handbook of Modern Sensors: Physical, Designs, and Applications, AIP Press, Springer, 2016.
2. D. Patranabis, Sensors and Transducers, 2nd Edition, Prentice Hall India Pvt. Ltd, New Delhi, 2009.
3. Guozhen Shen, Zhiyong Fan, “Flexible Electronics: From Materials to Devices”, 1st Edition, World Scientific Publishing Co, Singapore, 2015.

4. Horowitz, P., and W. Hill. The Art of Electronics. 2nd ed. Cambridge University Press, 1989.

Online Resources:

1. https://nptel.ac.in/courses/112105423
2. https://nptel.ac.in/courses/108108147
3.

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Signature with date

22OEI03	FUNDAMENTALS OF VIRTUAL INSTRUMENTATION	L	T	P	C
		3	0	0	3

Pre-requisite	Assessment Pattern	
● NIL	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- Understand the basic components of Virtual Instrumentation system.
- Learn the developing VIs based on Lab VIEW software.
- To learn to develop applications based on Virtual Instrumentation system.

Programme Outcomes (POs)

PO1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
PO2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
PO3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments
PO12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outcomes (COs)

The students will be able to

CO1	Outline the concepts of traditional instruments and virtual instruments
CO2	Conclude the overview of modular programming and the structuring concepts in VI programming
CO3	Attribute the procedure to install DAQ in various OS and its interfacing methods
CO4	Implement the VI toolsets for specific applications
CO5	Generate the applications using Virtual Instrumentation software

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	1	1										
2	3	3	2	2	2					2	2	2		
3	2	2	2	1										
4	3	3	3	1	2					1	2	2		
5	3	2	2	1	2					1	2	2		

Unit I	INTRODUCTION	9 Hours

Virtual Instrumentation: Historical perspective - advantages - block diagram and architecture of a virtual instrument - Conventional Instruments versus Traditional Instruments - data-flow techniques, graphical programming in data flow, comparison with conventional programming.

Unit II	VI PROGRAMMING TECHNIQUES	9 Hours

VIs and sub-VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, State machine, string and file I/O, Instrument Drivers, Publishing measurement data in the web.

Unit III	DATA ACQUISITION	9 Hours

Introduction to data acquisition on PC, Sampling fundamentals, Input/output techniques and buses. Latest ADCs, DACs, Digital I/O, counters and timers, DMA, Software and hardware installation, Calibration, Resolution, Data acquisition interface requirements - Issues involved in selection of Data acquisition cards - Data acquisition cards with serial communication - VI Chassis requirements. SCSI, PCI, PXI system controllers, Ethernet control of PXI. Networking basics for office & Industrial applications, VISA and IVI.

Unit IV	VI TOOLSETS	9 Hours

Use of Analysis tools, Fourier transforms, power spectrum, correlation methods, windowing and filtering. Application of VI in process control designing of equipment like oscilloscope, Digital multimeter, Design of digital Voltmeters with transducer input Virtual Laboratory, Web based Laboratory.

UNIT V	APPLICATIONS	9 Hours

Distributed I/O modules- Application of Virtual Instrumentation: Instrument Control, Development of process database management system, Simulation of systems using VI, Development of Control system, Industrial Communication, Image acquisition and processing, Motion control. Development of Virtual Instrument using GUI, Real-time systems, Embedded Controller, OPC, HMI / SCADA software, Active X programming.

Total	**45 Hours**

References

1. Lisa K. wells & Jeffrey Travis, LabVIEW for everyone, Prentice Hall, New Jersey,1997.
2. Gary Johnson, LabVIEW Graphical Programming, Second edition, McGraw Hill, Newyork, 1997.
3. Kevin James, PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control, Newness, 2000.

Online Resources:

1. **https://nptel.ac.in/courses/103105064**
2. **https://nptel.ac.in/courses/108105064**

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22OEI04	OPTOELECTRONICS AND LASER INSTRUMENTATION	L	T	P	C
		3	0	0	3

Pre-requisite	Assessment Pattern	
● NIL	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To enhance the student knowledge in fiber optics fundamentals and fabrication.
- To be recognized with industrial applications of fibers
- To understand the fundamental concepts about lasers
- To identify and describe various fiber optic imaging and optoelectronic sensor applications

Programme Outcomes (POs)

PO1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
PO3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

Course Outcomes (COs)

The students will be able to

CO1	Attribute the properties of optical fibers, their light sources and detectors.
CO2	Implement the fiber-optic sensor for the measurement of various physical quantities.
CO3	Conclude the fundamentals of laser, types of laser and its working.
CO4	Outline the applications of laser for industrial applications.
CO5	Differentiate the use of laser instruments for various medical applications.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	1											
2	3	2	1	2										
3	3	2	1											
4	3	2	2	2										
5	3	2	2	2										

Unit I	OPTICAL FIBERS AND THEIR PROPERTIES	9 Hours

Introduction to optical fibers - Light guidance - Numerical aperture - Dispersion - Different types of fibers and their properties - Light Sources for fiber optics, Photo detectors, source coupling, splicing and connectors.

Unit II	INDUSTRIAL APPLICATION OF OPTICAL FIBERS	9 Hours

Fiber optics instrumentation system - optical fiber sensors, Measurement of pressure, temperature, current, voltage and liquid level - fiber optic communication set up - different types of modulators -detectors.

Unit III	LASER FUNDAMENTALS	9 Hours

Fundamental characteristics of lasers: laser rate equation - three level system - four level system -properties of laser beams - laser modes - resonator configuration - Q- switching and mode locking -cavity dumping - types of lasers: gas lasers, solid state lasers, liquid lasers and semiconductor lasers.

Unit IV	INDUSTRIAL APPLICATION OF LASERS	9 Hours

Lasers for measurement of distance and length, velocity, acceleration, atmospheric effects, sonic boom, pollutants - material processing: laser heating, melting, welding and trimming of materials -removal and vaporization - calculation of power requirements of laser for material processing.

UNIT V	HOLOGRAM AND MEDICAL APPLICATIONS	9 Hours

Holography: basic principle, methods - holographic interferometry and application, holography for non-destructive - medical applications of lasers, laser and tissue interactive - laser instruments for surgery, removal of tumors of vocal cards, brain surgery, plastic surgery, gynecology and oncology.

Total	**45 Hours**

References

1. John M. Senior, Optical Fiber Communications - Principles and Practice, Prentice Hall of India, 2010.
2. John F. Ready, Industrial Applications of Lasers, Academic Press, 2012.
3. Gerd Keiser, Optical Fiber Communication, Mc Graw Hill, New York, 2013.

4. S.C. Gupta, Textbook on Fiber Optics Communications and its application, Prentice Hall of India, 2012.
5. John Wilson and J.F.B. Hawkes, Introduction to Opto Electronics, Prentice Hall of India, 2011.
6. R. P. Khare, Fiber Optics and Optoelectronics, Oxford University Press, 2011.

Online Resources:

1. https://nptel.ac.in/courses/102108082
2. https://nptel.ac.in/courses/108102191
3.

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Signature with date

22OME01 DIGITAL MANUFACTURING 3 0 0 3

Course Objectives

- To understand the process of generating 3D Computer Aided Design (CAD) model by different method.
- To explain the constructional features and develop simple program for CNC lathe and Milling machines.
- To provide an exhaustive knowledge on various generic process and benefits of Additive Manufacturing.
- To familiarize about materials and process parameters of liquid and solid based AM techniques.
- To educate powder based methodology and emerging trends with case studies, applications of AM techniques.

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

Course Outcomes (COs)

1. Design a 3D model from the 2D data.
2. Develop a CNC program for simple components.
3. Generate stl file and manipulate parameters of AM machine
4. Select appropriate liquid or solid materials based AM process to the respective application
5. Select appropriate process to fabricate a functional/prototype for aerospace, automotive, electronics, manufacturing and medical applications.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	2	2	-	2	-	-	-	-	-	-	-	-	-	-
2	2	2	2	-	2	-	-	-	-	-	-	-	-	-	-
3	2	2	2	-	2	-	-	-	-	-	-	-	-	-	-
4	2	2	2	-	2	-	-	-	-	-	-	-	-	-	-
5	2	2	2	-	2	-	-	-	-	-	-	-	-	-	-

UNIT I **9 Hours**

CAD MODELING

Introduction - Design process - Stages. CAD - Input and Output devices, Modeling methods - Wire frame modelling, Surface modelling, Solid modelling - Constructive Solid Geometry and Boundary Representation Techniques. CAD/CAM data exchange - IGES, STEP. Product Life cycle management (PLM).

UNIT II **10 Hours**

AUTOMATION AND CNC MACHINES

Introduction to Automation - Definition, types, reasons for automating. CNC Machines - Principles, types, features, advantages, applications. CNC Machine structure - Linear motion bearings, Recirculating ball bearings, drive system, and control system. CNC Lathe and Milling programming - Linear and circular interpolation, threading and drilling programs.

UNIT III **7 Hours**

ADDITIVE MANUFACTURING

Introduction - Impact of Additive Manufacturing (AM) and Tooling on Product Development - Distinction between AM and CNC Machining - The Generalized AM Process chain - CAD Model - Input file formats - Generation and Conversion of STL file - File Verification and Repair - Build File Creation - Part Construction - Part Cleaning and finishing - AM Benefits - Classification of AM process

UNIT IV **8 Hours**

LIQUID AND SOLID MATERIAL BASED SYSTEMS

Stereo lithography Apparatus (SLA), Digital Light Processing (DLP), Fused Deposition Modelling (FDM) and Laminated Object Manufacturing (LOM) - Working Principle, Construction, Process, Materials and Applications

UNIT V **11 Hours**

POWDER BASED PROCESSES AND APPLICATIONS OF ADDITIVE MANUFACTURING

Selective Laser Sintering (SLS), Color Jet Printing (CJP), Electron Beam Melting (EBM) and Laser Engineered Net Shaping (LENS) - Working Principle, Construction, Process Variables, Materials and Applications. Reverse Engineering using 3D scanner. Application of Additive Manufacturing in Medical field, Manufacturing, Automotive industries, Aerospace and Electronics and Retail industries.

Total: 45 Hours

Reference(s)

1. Ibrahim Zeid, R.Sivasubramania, CAD/CAM Theory and Practice, Tata McGraw Hill, 2010.
2. M. Aditan, B.S. Pabala, CNC Machines, New age International, 2012.
3. C. K. Chua, K. F. Leong and C. S. Lim, Rapid prototyping: Principles and applications, Cambridge University Press, 2010.
4. D. T.Pham, S. S.Dimov, Rapid manufacturing, Springer-Verlag, London, 2001.
5. I. Gibson, D. W. Rosen, and B. Stucker, Additive Manufacturing Technologies 3D Printing, Rapid Prototyping and Direct Digital Manufacturing, Springer, 2015 http://www.springer.com/978-1-4939-2112-6
6. www.grabcad.com, www.all3dp.com

22OME02 INDUSTRIAL PROCESS ENGINEERING 3 0 0 3

Course Objectives

- To impart the knowledge on production planning methodologies and layout design
- To learn about production planning and its control methods
- To provide the knowledge of work study, process charts and ergonomic condition
- To impart the knowledge on inventory control and material handling
- To learn about system analysis and different types of maintenance processes

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

Course Outcomes (COs)

1. Select proper plant layout for the required production system
2. Plan the resources required for the production and to perform the control methods
3. Apply work study method, prepare charts to outline the process and develop ergonomic condition suitable for the processes.
4. Analyze the inventory required based on production needs and material handling
5. Perform system analysis and use different types of maintenance process for smooth operations.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	3	1	-	1	-	-	-	-	-	-	-	-	-	-
2	3	3	1	-	2	-	-	-	-	-	-	-	-	-	-
3	1	3	3	-	2	-	-	-	-	-	-	-	-	-	-
4	2	3	1	-	2	-	-	-	-	-	-	-	-	-	-
5	2	3	1	-	2	-	-	-	-	-	-	-	-	-	-

UNIT I 9 Hours

INDUSTRIAL ENGINEERING AND PRODUCTION SYSTEM

Industrial engineering - Concept, History and development, Applications, Roles of Industrial engineer-Production management, Industrial engineering versus production management, operations management. Plant layout, Criteria for good layout, Types of layout - Process layout, Product layout, Combination layout and fixed position layout, Flow (material movement) pattern, Workstation Selection and design.

UNIT II **10 Hours**

PROCESS PLANNING AND PRODUCTION CONTROL

Introduction to Process planning-Definition, Procedure, Process selection, Machine capacity, Process sheet.Process analysis - Group technology, classification and coding system, formation of component family - Production planning, loading, scheduling. Production control -dispatching, routing - Progress control bar, curve, Gantt chart, route and schedule chart.

UNIT III **8 Hours**

WORK STUDY AND ERGONOMICS

Work study - Definition, Need, Advantages, objectives of method study and work measurement, method study procedure, Process chart - symbols, outline process chart, flow process chart, principles of motion economy, ergonomics- applications of ergonomic principles in the shop floor- work benches-seating arrangement, Industrial physiology.

UNIT IV **10 Hours**

INVENTORY MANAGEMENT

Inventory control, classification, management, objectives, functions. Economic order quantity, Economic batch quantity, inventory models,ABC analysis, Material Requirement Planning(MRPI), Manufacturing Resource Planning (MRPII), Operating cycle, lean manufacturing, Supply chain management - Material handling.

UNIT V **8 Hours**

SYSTEM ANALYSIS AND MAINTENANCE

System concept - system analysis, systems engineering, value engineering, value control, types of values. Plant maintenance - objectives, importance. Maintenance engineer - duties, functions and responsibilities. Types - breakdown, scheduled, preventive and predictive - Plant maintenance schedule, Condition monitoring.

Total: 45 Hours

Reference(s)

1. Khanna O.P., Industrial Engineering and management, Dhanpat Rai Publications.,2010
2. Martand T.Telsang, Industrial Engineering and Production Management, S Chand Publishers,2006
3. Panneerselvam R., Production and operations management, Heritage Publishers, 2006
4. Ravi Shankar, Industrial Engineering and Management, Golgotia Publications Pvt. Ltd., New Delhi, 2009

22OME03 MAINTENANCE ENGINEERING 3 0 0 3

Course Objectives

- To understand the principles, objectives and importance of maintenance adopted in industry for successful progress.
- To introduce different maintenance categories, its merits and types of lubrication.
- To expose the idea of condition monitoring, methods and instruments used for allied measurements.
- To learn about failure analysis and repair methods for few mechanical elements.
- To promote computerization in maintenance and inventory management.

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Course Outcomes (COs)

1. Explain the principles, objectives and importance of maintenance adopted in industry.
2. Select the suitable maintenance category and lubrication type.
3. Apply the appropriate methods and instruments for condition monitoring.
4. Analyze the failures of mechanical systems and select suitable repair methods.
5. Utilize computers in maintenance and inventory management.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	2	2	1	-	-	-	-	-	-	-	-
4	1	2	1	-	2	2	2	-	-	-	-	-	-	-	-
5	2	2	2	-	1	1	1	-	-	-	-	-	-	-	-

UNIT I **9 Hours**

PRINCIPLES OF MAINTENANCE PLANNING

Basic principles of maintenance planning - Objectives and principles of planned maintenance activity - Importance and benefits of sound maintenance systems - Maintenance organization - Maintenance economics.

UNIT II **9 Hours**

MAINTENANCE CATEGORIES AND LUBRICATION

Maintenance categories - Comparative merits of each category - Preventive maintenance, Maintenance schedules, Repair cycle - Total Productive Maintenance - Principles and methods of lubrication.

UNIT III **9 Hours**

CONDITION MONITORING

Condition based maintenance - Cost comparison with and without Condition Monitoring - Methods and instruments for condition monitoring - Noise, vibration, wear and temperature measurement.

UNIT IV **9 Hours**

FAILURE ANALYSIS AND REPAIR METHODS

Failure analysis - Failures and their development - Role of Non Destructive Testing in failure analysis - Repair methods for bearings, cylinder block, fuel pump, shaft.

UNIT V **9 Hours**

COMPUTER AIDED MAINTENANCE MANAGEMENT

Approach towards Computerization in maintenance - computer-aided maintenance management system (CAMMS) - Advantages of CAMMS - spare parts and inventory centre performance reporting.

FURTHER READING

Retrofitting, objectives, classification of retrofitting, cost effectiveness through retrofitting (economical aspects), circumstances leading to retrofitting, features and selection for retrofitting.

Total: 45 Hours

Reference(s)

1. Srivastava S.K, Maintenance Engineering, S Chand and Company, 2010.
2. Mishra R.C, Pathak K, Maintenance Engineering and Management, Second edition, Prentice Hall India Learning Pvt. Ltd., 2012.
3. Keith Mobley R, Lindley R. Higgins and Darrin J. Wikoff, Maintenance Engineering Handbook, Seventh edition, McGraw-Hill Professional, 2008.
4. Davies A, Handbook of Condition Monitoring: Techniques and Methodology, Springer, 2012.
5. Otegui Jose Luis, Failure Analysis, Fundamentals and Applications in Mechanical Components, Nineteenth edition, Springer, 2014.

22OME04 SAFETY ENGINEERING 3 0 0 3

Course Objectives

- To study the principles of safety management system.
- To introduce the provisions contained in the industrial laws.
- To provide knowledge on safety requirements for engineering industry.
- To learn safety requirement for chemical industry.
- To study the various safety measures adopted in construction industries.

Programme Outcomes (POs)

PO1. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

PO5. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO8. Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

PO12. Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outcomes (COs)

1. Explain safety management system of an industry.
2. Implement the provisions of acts and rules in industries.
3. Implement and review the safety performance followed in various industries
4. Evaluate safety appraisal in chemical industries.
5. Generate safety reports on construction industries.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1					2	1		1							
2					1			3							
3	2											3			
4	2	3							2						
5					2					3					

UNIT I **9 Hours**

SAFETY MANAGEMENT

Concepts - Evolution, International Labour Organization (ILO), National Safety Council, Techniques - Job Safety Analysis (JSA), Safety survey, Safety inspection, Safety Sampling, Accident Reporting and Investigation - Concept of an accident, Accident causation models, cost of accident, investigation, Safety Performance Monitoring - Safety indices.

UNIT II **9 Hours**

SAFETY AND LAW

Factory Act 1948-Safety and Health chapters, Tamil Nadu Factories Rules- Safety and Health chapters, Environment and Pollution Laws, ,Building and other construction works act 1996, Electricity Rules.

UNIT III **9 Hours**

SAFETY IN ENGINEERING INDUSTRIES

Safety in machine shop,- Principles of machine guarding - Personal protective equipment- Safety in handling industrial gases - Safety in cold forming and hot working of metals- Safety in finishing, inspection and testing, heat treatment, electro plating, leak test, radiography.

UNIT IV **9 Hours**

SAFETY IN CHEMICAL INDUSTRIES

Safety in process design, unit operations, pressure vessel, heat exchanger, safety valves -Plant commissioning and inspection, pressure vessel, Plant maintenance and emergency planning, management of maintenance HAZOP study.

UNIT V **9 Hours**

SAFETY IN CONSTRUCTION INDUSTRY

Construction regulations, contractual clauses, permit to work, - Education and training-Hazards of construction and prevention- excavation, scaffolding, dismantling, road works, construction of high rise buildings - Working at heights,-Working on fragile roofs, work permit systems-Construction machinery, cranes, chain pulley blocks, earth moving equipment, conveyors- Manual handling, Safety in demolition work, - Safety in confined spaces

Total: 45 Hours

Reference(s)

1. Blake R.B., Industrial Safety, Prentice Hall, Incorporated, New Jersey,1973.
2. National Safety Council, Accident Prevention Manual for Industrial Operations, Chicago, 1988
3. Subramanian V., The Factories Act, 1948, with Tamil Nadu Factories Rules , 1950, Madras
4. Environmental Pollution Control Act, 1986
5. BOCW Act,1996, Madras Book agency, Chennai-1
6. Explosive Act, 1884, Eastern Book Company, Lucknow -266 001.

22OFD01 **TRADITIONAL FOODS** **3 0 0 3**

Course Objectives

- Understand the importance of traditional foods and food habits
- Know the traditional processing of snack, sweet and dairy food products
- Infer the wide diversity and common features of traditional Indian foods and meal patterns.

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Course Outcomes (COs)

1. Justify the processing methods of traditional foods in terms of its health benefits
2. Assess the production methods of traditional sweets, snacks and dairy products
3. Differentiate Traditional fermented foods products based on its raw material
4. Implement a large scale production of tradition foods for its increased consumption
5. Compare the health aspects of traditional foods with modern foods

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
3	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-

UNIT I **9 Hours**

TRADITIONAL METHODS OF FOOD PROCESSING

Introduction - food culture -geographical features and food. Traditional methods of milling grains - rice, wheat and corn - equipment and processes as compared to modern methods. Equipment and processes for edible oil extraction- comparison of traditional and modern methods. Energy costs, efficiency, yield, shelf life and nutrient content comparisons. Traditional methods of food preservation - sun-drying, osmotic drying, brining, pickling and smoking.

UNIT II **9 Hours**

TRADITIONAL SWEETS, SNACKS AND DAIRY PRODUCTS

Production, formulation, preparation and processing of Indian traditional sweet and snack food products:-Rasgolla, Gulab jamun; formulation and preparation of namkeen, potato chips, banana chips. Acid coagulated and fermented dairy products- paneer, dahi, shrikhand, lassi - processing conditions, defects etc. Fat rich products- Butter, ghee and its processing.

UNIT III **9 Hours**

TRADITIONAL FERMENTED FOOD PRODUCTS

Idli, Soya sauce, fish pickle, dry fish, meat and vegetable fermented products. Various alcohol based products. Ways to increase nutritional quality of food such as enrichment, fortification, fermentation and mutual supplementation. Best cooking and processing methods to retain nutrients

UNIT IV **10 Hours**

COMMERCIAL PRODUCTION OF TRADITIONAL FOODS

Commercial production of traditional breads, snacks, ready-to-eat foods and instant mixes, frozen foods -types marketed, turnover; role of SHGs, SMES industries, national and multinational companies; commercial production and packaging of traditional beverages such as tender coconut water, neera, lassi, buttermilk, dahi. Commercial production of intermediate foods - ginger and garlic pastes, tamarind pastes, masalas (spice mixes), idli and dosa batters

UNIT V **8 Hours**

HEALTH ASPECTS OF TRADIONAL FOODS

Comparison of traditional foods with typical fast foods / junk foods - cost, food safety, nutrient composition, bioactive components; energy and environmental costs of traditional foods; traditional foods used for specific ailments /illnesses.

Total: 45 Hours

Reference(s)

1. Sen and Colleen Taylor, Food Culture in India, Greenwood Press, 2005.
2. Davidar, Ruth N. "Indian Food Science: A Health and Nutrition Guide to Traditional Recipes:" East West Books, 2001.
3. Steinkrus.K.H. Handbook of Indigenous Fermented Foods, CRC press, 1995.
4. Aneja. R.P, Mathur.BN, R.C. Chandan,and Banerjee.A.K. Technology of Indian Milk Products. Dairy India Year Book, 2009.

3 0 0 3

22OFD02 FOOD LAWS AND REGULATIONS

Course Objectives

- Introduce the concept of food hygiene, importance of safe food and laws governing it
- Learn common causes of food borne illness - viz. physical, chemical and biological and identification through food analysis
- Understand food inspection procedures employed in maintaining food quality

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Course Outcomes (COs)

1. Analyse the food safety strategies and nutritional quality of the food
2. Check the food regulatory mechanism and mandatory laws for food products
3. Determine the national and international regulatory agencies
4. Understand and apply the voluntary regulatory standards
5. Assess the implementation of food safety for a food processing industry

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-
2	-	1	-	-	-	1	2	1	-	-	-	-	-	-	-
3	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
4	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
5	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I **10 Hours**

INTRODUCTION

Introduction, concept of food safety and standards, food safety strategies. Food hazards and contaminations - biological (bacteria, viruses and parasites), chemical (toxic constituents / hazardous materials) pesticides residues / environmental pollution / chemicals) and physical hazards. Preventive food safety systems - monitoring of safety, wholesomeness and nutritional quality of food. Prevention and control of physical, chemical and microbiological hazards. Principles of food safety - Establishment: design and facilities - emergency preparedness - Maintenance cleaning and sanitation - personal hygiene - packaging and labelling - transportation - traceability - recall procedure - visitor policy. Adulteration: Intentional and unintentional - Preservatives - antioxidants, sweeteners, flavours, colours, vitamins, stabilizers - indirect additives - organic resides - inorganic residues and contaminants.

UNIT II **10 Hours**

FOOD LAWS

Indian and Food Regulatory Regime (Existing and new), PFA Act and Rules, Food Safety and Quality Requirements, Additives, Contaminants and Pesticide Residue. Food Safety and Standards Act, 2006, FSSAI roles and responsibilities, Essential Commodities Act, 1955, Global Scenario, Codex Alimentarius, WHO/FAO Expert Bodies (JECFA/ JEMRA/JMPR) WHO/FAO Expert Bodies (JECFA/ JEMRA/JMPR). Food safety inspection services (FSIS) and their utilization.

UNIT III **10 Hours**

REGULATIONS

Introduction to OIE & IPPC, Other International Food Standards (e.g. European Commission, USFDA etc). WTO: Introduction to WTO Agreements: SPS and TBT Agreement, Export & Import Laws and Regulations, Export (Quality Control and Inspection) Act, 1963. Role of Agricultural and Processed Food Products Export Development Authority (APEDA), Customs Act and Import Control Regulations, Other Voluntary and mandatory product specific regulations, Other Voluntary National Food Standards: BIS Other product specific standards; AGMARK. Nutritional Labelling, Health claims.

UNIT IV **10 Hours**

STANDARDS

Voluntary Quality Standards and Certification GMP, GHP, HACCP, GAP, Good Animal Husbandry Practices, Good Aquaculture Practices ISO 9000, ISO 22000, ISO 14000, ISO 17025, PAS 22000, FSSC 22000, BRC, BRCIOP, IFS, SQF 1000, SQF 2000. Role of NABL, CFLS.

UNIT V **5 Hours**

IMPLEMENTATION AND RISK ASSESSMENT

Implementation of food safety for a desired food processing industry. Risk assessment studies: Risk management, risk characterization and communication.

Total: 45 Hours

Reference(s)

1. Singal RS (1997). Handbook of indices of food quality and authenticity. Woodhead Publ. Cambridge, UK.
2. Shapton DA (1994). Principles and practices of safe processing of foods. Butterworth Publication, London. Winton AL (1999) Techniques of food analysis, Allied Science Publications New Delhi.
3. Pomeranze Y (2004). Food analysis - Theory and Practice CBS Publications, New Delhi.
4. Jacob MB (1999). The chemical analysis of foods and food products. CBS Publ. New Delhi

22OFD03 POST HARVEST TECHNOLOGY OF FRUITS AND VEGETABLES 3 0 0 3

Course Objectives

- To understand the importance and different methods of post harvest handling and storage of fruits and vegetables.
- To gain knowledge on different preservation methods of fruits and vegetables
- To familiarize with the value added products from fruits and vegetables

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Course Outcomes (COs)

1. Implement the different post harvest handling practices for the storage of fruits and vegetables
2. Analyze the suitable preservation method (sugar, salt or dehydration) to produce value added products from fruits and vegetables
3. Evaluate the requirement of low temperature and irradiation methods to preserve specific fruits and vegetables
4. Apply the concentration and fermentation methods to preserve fruits and vegetables
5. Implement the canning method to preserve fruits and vegetables

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	1	2	1	-	-	1	-	-	-	-	-	-	-	-
2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
3	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
4	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
5	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I **9 Hours**

POST-HARVEST PRACTICES AND PROCESSING

Maturity indices for harvesting; pathological spoilage's during storage, ripening and control measures, Post-harvest handling, sorting & grading, packaging, storage, transportation, Methods of pre-cooling, post-harvest treatments to hasten and delay ripening; Methods of storage at farm level - cold storage, controlled/modified atmosphere storage, Quality management, export requirements, Nutritive value, nutraceutical properties

UNIT II **9 Hours**

PRESERVATION AND VALUE ADDITION

General principles and methods of fruit and vegetable preservation. Preservation using sugar: Principle and Preparation of jam, jelly, marmalade, squash, RTS, carbonated beverages, crush, nectar, cordial, fruit bar, preserves, candies and carbonated fruit beverages. Processing using salt: Principle - Brining - Preparation of pickles, chutney and sauces, ketchup.

UNIT III **9 Hours**

PRESERVATION BY LOW TEMPERATURE AND IRRADIATION

Preservation by low temperature: definition, principle, methods - Refrigeration, freezing. Methods of freezing- changes during freezing. Preparation of frozen foods. Minimal Processing of Fruits and Vegetables - techniques involved - Preservation by irradiation: definition- principle, application, irradiation unit.

UNIT IV **9 Hours**

PRESERVATION BY DRYING

Machineries involved in processing of fruits and vegetables products. Drying and dehydration: definition, principle, Types of driers: Solar, cabinet, spray drier, drum drier, fluidized bed drier. Preparation of product for dehydration. Dehydration principles and equipment. Preparation of fruits - powder production. Problems related to storage of dehydrated products.

UNIT V **9 Hours**

PRESERVATION BY CANNING

Canning: principles, Types of cans, packing of canned products-preparation of canned products - general considerations in establishing a commercial fruit and vegetable cannery, machineries involved in canning and bottling unit- spoilage of canned foods. Bottling of fruit and vegetable. Precautions in canning operations.

Total: 45 Hours

Reference(s)

1. S.Ranganna, HandBook of Analysis and Quality Control for Fruit and Vegetable Products, McGraw Hill Education (India) Private Limited, Chennai, 2017
2. N.W. Desrosier, the Technology of Food Preservation, CBS Publisher & Distributions, New Delhi, 1987.
3. R.P. Srivastava and S. Kumar, Fruit and Vegetable Preservation: Principles and Practices, Second Edition, International Book Distribution Co., Lucknow, 1998.
4. G. Lal, G. Siddappa and G.L. Tondon, Preservation of Fruits and Vegetables, Indian Council of Agricultural Research, New Delhi, 1986.
5. Chakraverty, A.S. Mujumdar, G.S.V. Raghavan and H.S. Ramaswamy, Handbook of Post-harvest Technology, Marcel Dekker Press, USA, 2001.
6. D.K. Salunkhe, and S.S. Kadam, Handbook of Fruit Science and Technology: Production, Composition and Processing, Marcel Dekker, New York, 1995.

22OFD04 CEREAL, PULSES AND OIL SEED TECHNOLOGY 3 0 0 3

Course Objectives

- Understand the application of scientific principles in the processing technologies specific to the materials
- Understand the storage methods and handling techniques followed for cereals, pulses and oil seeds
- Develop the knowledge in the area of Cereals, pulses and oil seed processing and technology

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Course Outcomes (COs)

1. Identify the specific processing technologies employed for cereals
2. Analyse the composition of millets and their nutritional importance
3. Relate the compositional changes and processing methods of pulses and legumes
4. Create the competence in processing of oilseeds technology
5. Relate the storage processing of food grains with quality aspects

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	-	2	-	2	-	-	-	-	-	-	-	-	-
2	1	2	-	2	-	1	-	-	-	-	-	-	-	-	-
3	2	2	-	1	-	2	-	-	-	-	-	-	-	-	-
4	2	3	-	2	-	2	-	-	-	-	-	-	-	-	-
5	2	2	-	2	-	3	-	-	-	-	-	-	-	-	-

UNIT I **9 Hours**

CEREALS

Cereal Grains- Basic agricultural aspects, structure and composition; Storage, Insect control; Processing: Wheat- milling, (Atta and maida), quality aspects of flour, wheat proteins and their function, rheology of flour; wheat based baked products - Bread, Biscuit, Cakes, Extruded products, Pizza, Chapatis, malting and malt products; Rice-Milling, Parboiling, Quick cooking rice, Traditional Indian Products- Puffed Rice, flaked rice, Idli/Dosa/vada mixes and other savouries; Corn- Wet and dry milling, Corn Products - Corn flakes, Corn starch, canned corn products, puffed product; Oats-Milling, Oat Products - Steel cut,rolled oats, quick cooking; Traditional and Fermented cereal products.

UNIT II **9 Hours**

OTHER CEREALS AND MILLETS

Sorghum, Pearl Millet, Finger millet, Foxtail Kodo Millet - Basic agricultural millet, aspects, structure and composition; storage, insect control; processing - pearling, Milling, Malting, Malt based foods, flaked and fermented products; Traditional and Nutritional products based on finger millet.

UNIT III **9 Hours**

PULSES AND LEGUMES

Basic agricultural aspects, structure, composition, storage, insect control, processing Milling/splitting, dhal milling, products - puffed, flakes, flour, legume-based traditional products, flour based Indian sweets and savouries, soya milk, soy protein Isolate, soya paneer

UNIT IV **9 Hours**

OIL SEEDS AND NUTS

Basic agricultural aspects structure, composition, Storage, Insect control; processing: traditional and modern methods of oil extraction, refining, bleaching, deodorizing, hydrogenation; oil blends; applications of different oils and fats in food processing & products.

UNIT V **9 Hours**

STORAGE AND HANDLING

Bag Storage - Advantages and Disadvantages, Cover Plinth Storage Structures, CAP storage (Cover and Plinth Storage). Protection against Rodents, Fungi, Pests and Mites. Fumigation Processes for bag storage piles. Bulk Storage in silos and large Bins. Conveyors and Elevators for feeding and discharging.

Total: 45 Hours

Reference(s)

1. Chakraverty, A.: Post Harvest Technology of Cereals, Pulses and Oilseeds. Oxford and IBH Publishing Co, Calcutta, 1995.
2. Delcour, Jan A. and R. Carl Hoseney., Principles of Cereal Science and Technology, 3rd Edition, American Association of Cereal Chemists, 2010.
3. Karl Kulp, Handbook of Cereal Science and Technology, 2nd Rev. Edition, CRC Press, 2000.
4. N.L.Kent and A.D.Evans, Technology of Cereals (4th Edition) Elsevier Science (Pergaman),Oxford, UK, 1994.
5. Matz, Samuel A., The Chemistry and Technology of Cereals as Food and Feed, 2nd Edition,CBS, 1996.
6. Morris, Peter C. and J.H. Bryce., Cereal Biotechnology, CRC/Wood head publishing, 2004.

22OFT01 FASHION CRAFTSMANSHIP 3 0 0 3

Course Objectives

- To impart theoretical and practical knowledge about various handicraft techniques
- To enhance innovative skills on hand crafts.
- To build confidence on doing handicrafts.

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outcomes (COs)

1. Outline the classification, techniques and criteria for selecting raw materials for making various handicraft materials and produce textile based handicrafts. Produce various decorative and appealing products
2. Design and construct various wall hangings and fashion accessories.
3. Design and construct toys and accessories
4. Design and construct head accessories, home furnishings and paintings
5. Design and construct various decorative and appealing products for interiors

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	1	3	-	-	-	2	-	2	2	-	2	-	-	-
2	3	2	3	-	-	-	1	-	2	3	-	2	-	-	-
3	3	2	3	-	-	-	2	-	2	3	-	2	-	-	-
4	3	2	3	-	-	-	2	-	2	3	-	2	-	-	-
5	3	2	3	-	-	-	2	-	2	3	-	2	-	-	-

UNIT I **9 Hours**

TECHNIQUES OF HANDICRAFT MATERIALS

Definition of Handicraft, Classification: Reusable, Non reusable, Raw materials used in various craft materials: printed, embroidered, stitched and handmade, Criteria for selection of raw materials: material types and end uses.

UNIT II **9 Hours**

DECORATIVE AND APPEALING PRODUCTS - INTERIORS

Designing and Construction procedures for following various decorative and appealing products: Wall hangings - String Art on plywood, Pressed Flower Art frames.

UNIT III **9 Hours**

DECORATIVE AND APPEALING PRODUCTS - ACCESSORIES

Designing and Construction procedures for following various decorative and appealing products: Handbags, Hats, footwear.

UNIT IV **9 Hours**

DECORATIVE AND APPEALING PRODUCTS - ORNAMENTS

Designing and Construction procedures for following various decorative and appealing products: Stone necklace using Macrame Technique, Tribal Jewellery using woollen threads, Floral Jewellery using Resin Technique, Fabric Jewellery using Tie and Dye Technique.

UNIT V **9 Hours**

DECORATIVE AND APPEALING PRODUCTS - FANCY ITEMS

Designing and Construction procedures for following various decorative and appealing products: Jewellery Box, Utility Holder, Gift items. Lampshade decors from cardboard, Driftwood Frames for pictures and Mirrors.

Total: 45 Hours

Reference(s)

1. Handmade in India: A Geographic Encyclopaedia of India Handicrafts. Abbeville press; 1 edition (October 20,2009)
2. Encyclopaedia of Card making Techniques (Crafts), Search Press Ltd, illustrated edition, 2007
3. All about Techniques in Illustration, Barron Educational Series, 2001
4. Printing by Hand: A Modern Guide to printing with Handmade stamps, Stencils and Silk Screens, STC Craft/A Melanie Falick Book, 2008
5. Materials & Techniques in the Decorative Arts: An Illustrated Dictionary, University of Chicago Press, 2000
6. https://www.marthastewart.com/274411/fashion-crafts

22OFT02 INTERIOR DESIGN IN FASHION 3 0 0 3

Course Objectives

- To impart knowledge on interior design.
- To improve the design skills, sustainable with socially-conscious designs

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Course Outcomes (COs)

1. Interpret the elements of interior design concepts and resolve the personality requirements
2. Develop graphical representations of interior design concepts
3. Resolve the space planning requirements of residential home as per CPWD guidelines
4. Determine the aesthetic requirements of interior design components.
5. Appraise the roles and responsibilities of interior designer.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	3	-	-	1	-	-	-	-	-	-	-	-	-
2	3	2	3	-	2	3	-	2	-	-	-	-	-	-	-
3	3	3	3	-	2	2	-	2	-	-	-	-	-	-	-
4	3	3	3	-	2	3	-	2	-	-	-	-	-	-	-
5	3	2	-	-	2		-	3	-	-	-	-	-	-	-

UNIT I 9 Hours
INTRODUCTION

Interior designing - definition, importance, requirements and types - Structural design, Decorative Design -Designing interiors, Good taste; Design themes, types and application. Personality of the Home - Art elements - Line: types, characteristics and importance; form: size and shape, characteristics; Colour - sources, qualities, emotional effects, colour wheel and schemes.

UNIT II **9 Hours**

GRAPHICAL PRESENTATIONS

3D composition; Isometric and Axonometric- Still life- Furniture Sketching- Object Drawing with color rendering - Interior elements, Lighting, plants. Perspective, Axonometric Isometric drawing. Orthographic Projection - Lifts and escalators.

UNIT III **9 Hours**

SPACE PLANNING

Space planning concepts- interiors, circulation. Definition, application of ergonomic principals in interiors. Residential house space planning case study- CPWD guidelines. Lighting for different locations and activities, measurement, ventilation and indoor air quality, noise control methods.

UNIT IV **9 Hours**

INTERIOR COMPONENTS

Application of colour in interiors; Texture - types and significance; Pattern: types and effects; Light - importance. Importance of Furniture Design for Interiors- Ancient Age / Middle Age / Contemporary. Doors, Windows, Staircase designs, False Ceiling, Partitions, Wall Panelling, Comics, Mosaic, Cladding- Flooring and Wall Cladding

UNIT V **9 Hours**

ROLES AND RESPONSIBILITIES OF INTERIOR DESIGNER

Role of an Interior Designer- Responsibility towards society and need of an Interior Designer to better the environment- Ethics and Code of Conduct- Responsibility towards client, contractor and supplier, Estimation. Professional Fees- Work of an Interior Designer- Making of portfolio, JD Annual Design Awards.

Total: 45 Hours

Reference(s)

1. Joanna Gaines, Homebody: A guide to creating spaces you never want to leave, Harper design, 2018.
2. Erin gates, Elements of Style: Designing a Home and a life, Simon and Schuster, 2014.
3. Simon Dodsworth, The Fundamentals of Interior Design, AVA publishing, 2009.
4. V. Mary. Knackstedt, The Interior Design Business Handbook: A Complete Guide to Profitability, Wiley, New Jersey; 2006.
5. M. G. Shah, C. M. Kale, and S.Y. Patki, Building Drawing with an Integrated Approach to Build Environment, Tata McGraw Hill, 2002.
6. Https://eclectictrends.com

22OFT03 SURFACE ORNAMENTATION 3 0 0 3

Course Objectives

- To familiarize the students about the various techniques of surface embellishment with relevance to garment embellishments.
- To aware of various types of embroidery and methods of producing it.
- To make the students confident about doing surface embellishment work

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

Course Outcomes (COs)

1. Analyze the raw material requirements for surface ornamentation and its application
2. Implement hand embroidery stitches on fabric and show the stitch development procedure in diagrammatic representations
3. Apply the machine and computerized embroidery stitches
4. Analyze the surface embellishment techniques and its application
5. Assess the quality maintenance parameters of all embroidered products and analyze the 6 traditional embroidery techniques

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	3	2	-	-	-	-	1	-	-	-	-	-	-	-
2	2	3	2	-	-	-	-	-	2	-	-	-	-	-	-
3	2	3	2	-	3	-	-	-	-	-	-	-	-	-	-
4	2	2	2	-	-	-	-	-	2	-	-	-	-	-	-
5	2	2	2	-	-	-	-	-	2	-	-	-	-	-	-

UNIT I 9 Hours

INTRODUCTION TO SURFACE ORNAMENTATION

Introduction, Definition, Need, Types, Raw materials, Importance of surface ornamentation, Selection of needle, thread and fabric for hand embroidery and machine embroidery. various methods of surface embellishment- embroidery and surface ornamentation.

UNIT II **9 Hours**

HAND EMBROIDERY

General rules for hand embroidery. Types of hand embroidery stitches-Running, Couching, Button hole, Satin, Long & Short, Wheat, Chain, Stem, Herringbone, Cross stitch, Knotted stitches, Fish bone, Fly stitch, Braids, Back, Hem, Seed, Needle weaving, Whip stitches.

UNIT III **9 Hours**

MACHINE EMBROIDERY

General rules for machine embroidery. Types of frames and methods of transferring the designs. Attachments to sewing machines for embroidery, Types of machine embroidery stitches- Eyelet work, Cut work, patch work, Mirror work, Applique, Shaded embroidery, Shadow work, Bead and Sequins work, Vermicelli, Zigzag, Granite stitch. Computerized embroidery machine- Concept of design and development, software used in embroidery machines, process of designing, method and types of stitch application, punching and digitizing.

UNIT IV **9 Hours**

EMBELLISHMENT TECHNIQUES

Materials used and Applications. Types of embellishment techniques- fabric painting-hand, Stencil-dabbing and Spraying. Dyeing and printing-advanced tie and dye techniques, batik and block printing. Trimmings and decorations-Laces, Pompons, Fringes, Tassels, Tucks, Show buttons, Crocheting.

UNIT V **9 Hours**

TRADITIONAL EMBROIDERIES OF INDIA AND CARE

Care and maintenance of embroidered articles-care and maintenance methods for embroidered apparel, pressing. Traditional Embroideries of India-Phulkari, Kasuti, Kashmiri embroidery, Kutch work, Chikkankari, Kantha.

Total: 45 Hours

Reference(s)

1. Ruth Chandler, Modern Hand Stitching-Dozens of stitches with creative free-form variations,2014
2. Sophie Long, Mastering the Art of Embroidery: Traditional Techniques and Contemporary Applications for Hand and Machine Embroidery, Heritage Publishers, London, 2013
3. Christen Brown ,Embroidered & Embellished, C&T Publishing, 2013
4. Sheila Paine, Embroidered Textiles, Thames and Hudson Publisher, UK, 1990.
5. Gail Lawther, Inspirational Ideas for Embroidery on Clothes & Accessories, Search Press Ltd, UK, 1993.
6. http://www.needlenthread.com/tag/hand-embroidery-stitches

22OPH01 **NANOMATERIALS SCIENCE** **3 0 0 3**

Course Objectives

- Impart knowledge on Nanoscience
- Explore different techniques of producing nanomaterials
- Create expertise on the applications of nanomaterials in various fields

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO12. Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outcomes (COs)

1. Analyze the origin of nanomaterials from ancient applications to modern nanotechnology
2. Compare the different types of methods adopted for synthesizing nanomaterials
3. Analyze the characterization techniques for analyzing nanomaterials
4. Analyze the magnetic properties of nanomaterials and their applications in data storage and spintronics
5. Organize the nanomaterials developed for advanced technological applications

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2	1	1	-	-	-	-	-	-	1	-	-
2	3	2	2	1	1	-	-	-	-	-	-	1	-	-
3	3	2	2	1	1	-	-	-	-	-	-	1	-	-
4	3	2	2	1	1	-	-	-	-	-	-	1	-	-
5	3	2	2	1	1	-	-	-	-	-	-	1	-	-

UNIT I **9 Hours**

NANO SCALE MATERIALS

Introduction - Feynman's vision - national nanotechnology initiative (NNI) - past, present, future - classification of nanostructures, nanoscale architecture - effects of the nanometer length scale - changes to the system total energy, and the system structures - effect of nanoscale dimensions on various properties - differences between bulk and nanomaterials and their physical properties.

UNIT II **9 Hours**

NANOMATERIALS SYNTHESIS METHODS

Top down processes - mechanical milling, nanolithography and types based on radiations - Bottom up process physical method: physical vapour deposition, RF sputtering, CVD - chemical method: colloidal and sol-gel methods - template based growth of nanomaterials - ordering of nanosystems, self-assembly and self-organization.

UNIT III **9 Hours**

CHARACTERIZATION TECHNIQUES

General classification of characterization methods - analytical and imaging techniques - microscopy techniques - electron microscopy, scanning electron microscopy, transmission electron microscopy, atomic force microscopy - diffraction techniques - X-ray spectroscopy - thermogravimetric analysis of nanomaterials.

UNIT IV **9 Hours**

SEMICONDUCTOR NANOSTRUCTURES

Quantum confinement in semiconductor nanostructures - quantum wells, quantum wires, quantum dots, super lattices-epitaxial growth of nanostructures-MBE, metal organic VPE, LPE - carbon nanotubes-structure, synthesis and electrical properties – applications - quantum well laser - quantum efficiency of semiconductor nanomaterials

UNIT V **9 Hours**

NANOMACHINES AND NANODEVICES

Microelectromechanical systems (MEMS) and Nanoelectromechanical systems (NEMS) - fabrication, actuators-organic FET- principle, description, requirements, integrated circuits- single electron transistor - organic photovoltaic cells - spintronics

Total: 45 Hours

Reference(s)

1. W A Goddard and D W Brenner, Handbook of Nanoscience, Engineering, and Technology, CRC Press, 2012
2. Charles P Poole, Jr and Frank J Owens, Introduction to Nanotechnology, Wiley Interscience, 2007
3. Guozhong Cao, Y Wang, Nanostructures and Nanomaterials-Synthesis, Properties & Applications, Imperials College Press, 2011
4. T Pradeep, NANO: The Essentials Understanding Nanoscience and Nanotechnology, McGraw - Hill Education (India) Ltd, 2012
5. Robert W Kelsall, Ian W Hamley, Mark Geoghegan, Nanoscale Science and Technology, John Wiley and Sons Ltd, 2006
6. Viswanathan B, AuliceScibioh M, Fuel cells: Principles and Applications, University Press, 2009

22OPH02 SEMICONDUCTOR PHYSICS AND DEVICES 3 0 0 3

Course Objectives

- Impart knowledge in physical properties of semiconducting materials
- Analyze the factors affecting the operation of semiconductor devices
- Apply the physics of semiconductors to develop semiconductor devices

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO12. Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outcomes (COs)

1. Analyze the formation of drift current due to the movement of charge carriers under an electric field
2. Analyze the energy band diagram in thermal equilibrium and space charge width of PN junction
3. Analyze the operation of a Bipolar Junction Transistor (BJT) in active, cutoff, and saturation modes
4. Apply the principles of charge storage in floating-gate transistors for non-volatile memory applications
5. Outline the efficiency factors affecting the performance of opto-electronic devices

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2	1	1	-	-	-	-	-	-	1	-	-
2	3	2	2	1	1	-	-	-	-	-	-	1	-	-
3	3	2	2	1	1	-	-	-	-	-	-	1	-	-
4	3	2	2	1	1	-	-	-	-	-	-	1	-	-
5	3	2	2	1	1	-	-	-	-	-	-	1	-	-

UNIT I 9 Hours

ENERGY BANDS AND CARRIER TRANSPORT PROPERTIES

Energy Bands: Formation of energy bands - doping effects - energy levels - electron and hole concept in semiconductor. Carrier transport: Carrier drift-drift current density - conductivity- diffusion current density - total current density

UNIT II 9 Hours

P-N JUNCTION

Basic structure and fabrication process of p-n junction - current - voltage characteristics - energy band diagram - equilibrium Fermi levels - depletion region - junction breakdown phenomena - zener - avalanche breakdown.

UNIT III **9 Hours**

BIPOLAR JUNCTION TRANSISTOR

The basic transistor action - operation in the active mode - current gain - static characteristics - carrier distribution in emitter, base and collector region - modes of operation - current - voltage characteristics of common base and emitter configuration - frequency response and switching of bipolar transistor.

UNIT IV **9 Hours**

MOSFET

The ideal MOS diode - basic fundamentals and characteristics - types - CMOS and BiCMOS - CMOS inverter - MOSFET on insulator - thin film transistor (TFT) - silicon on insulators (SOI) devices - MOS Memory structures - DRAM and SRAM.

UNIT V **9 Hours**

PHOTONIC DEVICES

Radiative transitions and optical absorption-light emitting diodes-organic LED - infrared LED - semiconductor laser - temperature effect - photo detector - photo diode - silicon and compound semiconductor solar cells – efficiency.

Total: 45 Hours

Reference(s)

1. Donald A Neamen, Semiconductor Physics and Devices, Tata McGraw Hill, 2012
2. S M Sze and M K Lee, Semiconductor Devices, Physics and Technology, John-Wiley & Sons, 2015
3. Ben G Streetman and S K Banerjee, Solid State Electronic Devices, Pearson Education Ltd, 2015
4. C Kittel, Introduction to Solid State Physics, John-Wiley & Sons, 2012
5. J Millman and C Halkias, Electronic Devices and Circuits, Tata McGraw Hill, 2010
6. Hagen Klauk, Organic Electronics: Materials, Manufacturing and Applications, Wiley-VCH, 2006

22OPH03 **APPLIED LASER SCIENCE** **3 0 0 3**

Course Objectives

- Impart knowledge on laser science
- Explore different strategies for producing lasers
- Create expertise on the applications of lasers in various fields

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO12. Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outcomes (COs)

1. Analyze the role of energy levels and excitation processes in laser action
2. Compare the different types of lasers based on pumping method, active medium and energy levels
3. Compute the rotation of earth, velocity and distance using lasers and apply the same for day today applications
4. Analyze the role of lasers in surgical and endoscopy applications
5. Apply the laser techniques in industrial applications

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2	1	-	-	-	-	-	-	-	1	-	-
2	3	2	2	1	-	-	-	-	-	-	-	1	-	-
3	3	2	2	1	-	-	-	-	-	-	-	1	-	-
4	3	2	2	1	-	-	-	-	-	-	-	1	-	-
5	3	2	2	1	-	-	-	-	-	-	-	1	-	-

UNIT I **9 Hours**

LASER FUNDAMENTALS

Introduction - principle - absorption and emission of light - thermal equilibrium - Einstein's prediction - Einstein's relations - A and B coefficients - condition for large stimulated emission - spontaneous and stimulated emission in optical region - light amplification - condition for light amplification - population inversion- Components of lasers - pumping methods - pumping mechanisms - optical resonator.

UNIT II **9 Hours**

LASER BEAM CHARACTERISTICS AND TYPES

Characteristics of laser - Classification of lasers - principle, construction, working, energy level diagram and applications of molecular gas laser (CO_2 laser) - liquid laser (dye laser) - excimer laser - Solid state laser (Nd:YAG laser) - semiconductor laser (homojunction laser).

UNIT III **9 Hours**

LASERS IN SCIENCE

Introduction - Harmonic generation (SHG) - Stimulated Raman emission - lasers in chemistry - laser in nuclear energy - lasers and gravitational waves - rotation of the earth - measurement of distance - Light detection And Ranging (LIDER) - velocity measurement – holography.

UNIT IV **9 Hours**

LASERS IN MEDICINE AND SURGERY

Light induced biological hazards: Eye and skin - Eye laser surgery - photocoagulations - homeostasis - dentistry - laser angioplasty - different laser therapies - advantages & disadvantages - laser endoscopy.

UNIT V **9 Hours**

LASERS IN INDUSTRY

Applications in material processing: laser welding - hole drilling - laser cutting- Lasers in electronics industry: information storage - bar code scanner- Lasers in defence: laser based military weapons - laser walls.

Total: 45 Hours

Reference(s)

1. K Thiyagarajan and A K Ghatak, LASERS: Fundamentals and Applications, Springer, USA, 2015
2. M N Avadhanulu, An Introduction to Lasers Theory and Applications, S. Chand Publisher, 2013
3. W Koechner, M Bass, Solid State Lasers: a graduate text, Springer Verlag, New York, 2006
4. K P R Nair, Atoms, Molecules and Lasers, Narosa Publishing House, 2009
5. K R Nambiar, Lasers: Principles Types and Applications, New Age International Publications, 2006
6. A. Sennaroglu, Solid-State Lasers and Applications, CRC Press, 2006

22OPH04 **BIOPHOTONICS** **3 0 0 3**

Course Objective:

- To understand the light-matter interaction in biological cells or tissues by using the principles of optics and lasers.
- To apply the properties of biological cells or tissues in biomedical applications by various optical imaging, sensing and activation techniques.
- To analyze the concepts of Modern optical measurement techniques and devices in early detection of disease and cure them.

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Use research–based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

Course Outcomes (COs)

1. Analyze the fundamental laws of optics and their role in light interaction with biological cells and tissues
2. Apply the principles of light interaction with biological tissues to enhance imaging resolution and contrast
3. Use laser tweezers techniques to infer the activities of cells (tissues) and explain the single molecule detection processes in medical diagnosis.
4. Outline the properties of ultra short laser pulses and tissue engineering to rectify the affecting factors in biological cells.
5. Compare the various types of bio-imaging methods to detect the infected cells and molecules in biological science.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	2	2	1	-	-	-	-	-	-	-	-	-
2	3	3	2	2	1	-	-	-	-	-	-	-	-	-
3	3	3	2	2	1	-	-	-	-	-	-	-	-	-
4	3	3	2	2	1	-	-	-	-	-	-	-	-	-
5	3	3	2	2	1	-	-	-	-	-	-	-	-	-

Unit I **9 Hours**

INTRODUCTION TO BIOPHOTONICS

Light as Photon Particles - Coherence of light - lasers - classification of lasers - Mechanisms of Non-linear Optics (NLO) processes associated with Biophotonics - Light scattering mechanisms: Rayleigh scattering, Miescattering, Brillouin Scattering, Raman Scattering -Different light sources – Quantitative description of light: Radiometry

Unit II **9 Hours**

PHOTOBIOLOGY

Interaction of light with cells and tissues - Light – TissueInteractionVariables - Light - Tissue Interaction Theory: Radiative Transport Theory - Photo process in biopolymers - In Vivo Photo excitation - photo-induced physical, chemical, thermal and mechanical effects in biological systems - Optical biopsy - Single molecule detection

Unit III **9 Hours**

BIONANO PHOTONICS

Laser Microtools, Semiconductor quantum dots for bioimaging, Metallic nanoparticles and nanorods for biosensing - Optical biosensors: Fibre-Optic, evanescent wave, surface Plasmon resonance (SPR) based biosensors– biomaterials for photonics - Principle and design of laser tweezers - laser trapping and dissection for biological manipulation.

Unit IV **9 Hours**

TISSUE ENGINEERING WITH LIGHT

Basics of tissue optics: Light absorption and scattering in tissues, Wavelength effects and spectra - the therapeutic window, Light penetration intissues - Absorbing agents in tissues and blood - Skinoptics, response the UV radiation, Optical parameter soft issues - tissue welding - tissue contouring - tissuere generation - Femto laser surgery - low level light therapy and photo dynamic therapy

Unit V **9 Hours**

BIO-IMAGING TECHNIQUES AND ITS APPLICATIONS

An overview of optical imaging - Fluorescence Microscopy - Scanning Microscopy - Invivo Confocal Microscopy - Multi photon Microscopy - Optical Coherence Tomography (OCT) - Fluorescence Resonance Energy Transfer (FRET) imaging - fluorescence lifetime imaging Microscopy (FLIM) - Nonlinear optical imaging - Coherent Anti - stokes Raman Scattering - Bioimaging Applications.

LASER SAFETY (only Self-study purpose not for the course credit)

Laser radiation hazards including effects on the eye and skin, Maximum Permissible exposure (MPE), Laser Hazard classification

Reference(s)

1. Paras N Prasad, Introduction to Biophotonics, Wiley Inter-science, A John Wiley & Sons, Inc., Publication, 2003
2. Andrew GWebb, Introduction to Biomedical Imaging, IEEE Press, 2002
3. Lihong V Wang and HSin-i Wu, Biomedical Optics: Principles and Imaging, Wiley2007
4. R Splinter and B A Hooper, An Introduction to Biomedical Optics, Wiley Inter science , Taylor & Francis, 2007
5. D E Chandler and R W Roberson, Bioimaging Current Concepts in Light and Electron Microscopy, Jones and Bartlett publishers, 2008
6. Peter Torok and Fu-Jen Kao, Optical Imaging and Microscopy: Techniques and Advanced Systems, Springer, 2004

22OPH05 PHYSICS OF SOFT MATTER 3 0 0 3

Course Objectives

- To recognize the properties of soft matter and hard matter
- To understand the fundamental interactions of colloids and gels
- To explain the structure and phase behavior of liquid crystals and supramolecules
- To summarize the soft matter proprties of structures and components of life

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Course Outcomes (COs)

1. Identify the salient features of soft matter and hard matter
2. Exemplify the fundamental interactions and stability of colloids and gels
3. Illustrate the structure and properties of liquid crystals
4. Outline the aggregation and phase behavior of surfactants, polymers, copolymers and block copolymers
5. Analyze the soft matter behavior of nucleic acids, proteins, polysaccharides and membranes

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
3	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
4	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
5	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I 9 Hours

CONDENSED MATTER

Intermolecular forces-Condensation and freezing-mechanical response: Hookean solid-Newtonian liquid-viscoelasticity. Glasses: relaxation time-viscosity- glass forming liquids. Soft matter: length scales-fluctuations and Brownian motion

UNIT II 9 Hours

COLLOIDAL DISPERSIONS & GELS

Forces between colloidal particles: vander Waals forces-electrostatic double layer forces-steric hindrance-depletion interactions. Stability and phase behaviour: Crystallisation-strong colloids-weak colloids.Physical and chemical gels-classical theory of gelation-elasticity of gels

UNIT III **9 Hours**

LIQUID CRYSTALS

Liquid crystal phases-distortions and topological defects-electrical and magnetic properties-polymer liquid crystals-Fredricks transition and liquid crystal displays

UNIT IV **9 Hours**

SUPRAMOLECULAR SELF ASSEMBLY

Aggregation and phase separation-types of micelles- bilayers and vesicles. Phase behaviour of concentrated surfactant solutions-phase separation in polymers, copolymers and block copolymers

UNIT V **9 Hours**

SOFT MATTER IN NATURE

Components and structures of life-Nucleic acids-proteins-interaction between proteins-polysaccharides-membranes

Total: 45 Hours

REFERENCES

1. Richard A L Jones, Soft Condensd Matter, Oxford University Press, UK, 2002
2. Masao Doi, Soft Matter Physics,Oxford University Press, UK, 2013.
3. Ian W. Hamley, Introduction to Soft Matter, John Wiley & Sons, 2007
4. A. Fernandez-Nieves, A M Puertas, Fluids, Colloids and Soft materials: An Introduction to Soft Matter Physics, John Wiley & Sons, 2016
5. Maurice Kleman, Oleg D. Lavrentovich, Soft Matter Physics: An Introduction, Springer-Verlag, New York, 2003.

22OCH01 CORROSION SCIENCE AND ENGINEERING

3 0 0 3

Course Objectives

- Analyse the loss incurred due to corrosion in different sectors and terminologies related to corrosion
- Identify forms and types of corrosion with suitable mechanism
- Apply various methods of corrosion control, corrosion testing and monitoring

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Course Outcomes (COs)

1. Apply fundamental principles of corrosion science to calculate corrosion rates, analyze metal degradation and interpret Pourbaix diagrams to predict corrosion behavior in various industrial environments.
2. Compare different corrosion types on metals when exposed to air, water and at high temperatures (> 100 C)
3. Analyze the mechanism of corrosion on steel, iron, zinc and copper metal surfaces
4. Analyze the rate of corrosion on metals using electrochemical methods of testing
5. Analyze the correct materials, design and operation conditions to reduce the likelihood of corrosion in new equipment and constructions

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2	-	-	-	-	-	1	-	-	-	-	-	-	-	-
3	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
4	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
5	3	3	-	-	-	-	1	-	-	-	-	-	-	-	-

UNIT I **9 Hours**

CORROSION

Importance of corrosion - spontaneity of corrosion - units of corrosion rate (mdd and mpy) - direct and indirect damage by corrosion - importance of corrosion prevention in industries - Pilling Bedworth ratio and its significance - passivation - area relationship in both active and passive states of metals - Pourbaix diagrams of Mg, Al and Fe and their advantages and disadvantages

UNIT II **7 Hours**

TYPES OF CORROSION

Eight forms of corrosion: uniform, galvanic, crevice corrosion, pitting, intergranular corrosion, selective leaching, erosion corrosion and stress corrosion-Catastrophic oxidation corrosion

UNIT III **9 Hours**

MECHANISM OF CORROSION

Hydrogen embrittlement - corrosion fatigue - filiform corrosion - fretting damage and microbes induced corrosion. Corrosion mechanism on steel, iron, zinc and copper metal surfaces

UNIT IV **10 Hours**

CORROSION RATE AND ITS ESTIMATION

Rate of corrosion: Factors affecting corrosion. Electrochemical methods of polarization: Tafel extrapolation polarization and linear polarization. Weight loss method - testing for intergranular susceptibility and stress corrosion. Non-destructive testing methods: Visual testing - liquid penetrant testing - magnetic particle testing - Ultrasonic monitoring, and eddy current testing

UNIT V **10 Hours**

CORROSION CONTROL METHODS

Fundamentals of cathodic protection - types of cathodic protection (sacrificial anodic and impressed current cathodic protection). Stray current corrosion, problems and its prevention. Protective coatings: Metal coatings: Hot dipping (galvanizing, tinning and metal cladding) - natural inhibitors. Selection of suitable design for corrosion control

Total: 45 Hours

Reference(s)

1. Mouafak A. Zaher, Introduction to Corrosion Engineering, Create Space Independent Publishing Platform, 1st Edition, 2016.
2. E. McCafferty, Introduction to Corrosion Science, Springer, 1st Edition, January 2010.
3. R. Winstone Revie and Herbert H. Uhlig, Corrosion and Corrosion Control: An Introduction to Corrosion Science and Engineering, 4th Edition, John Wiley & Science, 2008.
4. Mars G. Fontana, Corrosion Engineering, Tata McGraw Hill, Singapore, 2nd Edition, 2008.
5. David E.J. Talbot and James D.R. Talbot, Corrosion Science and Technology, Second Edition (Materials Science & Technology), CRC Press, 2nd Edition, 2007.

22OCH02 **POLYMER SCIENCE** **3 0 0 3**

Course Objectives

- Explain the properties of different polymers with its mechanism
- Select the appropriate polymerization techniques to synthesize the polymers
- Identify suitable polymers for various industrial applications

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

Course Outcomes (COs)

1. Apply knowledge of polymerization mechanisms to predict the formation of different polymer products under various reaction conditions and catalysts
2. Apply suitable polymerization techniques to synthesize the high quality polymers
3. Apply the structural, thermal, and mechanical properties of polymers for different industrial applications
4. Apply the polymer processing methods to design polymer products
5. Analyze the polymers used in electronic and biomedical applications.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
3	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
4	1	1	2	-	-	-	-	-	-	-	-	-	-	-	-
5	1	3	2	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I **10 Hours**

POLYMERS AND ELASTOMERS

Classification of polymers - Mechanism: Addition polymerization - free radical, cationic, anionic and co-ordination (Ziegler-Natta) polymerization - copolymerization - condensation polymerization (nylon- 6,6) -ring opening polymerization (nylon-6). Elastomers: Natural rubber and synthetic rubber: styrene
-butadiene rubber (SBR), butyl, neoprene, thiocol rubbers. High performance polymers: polyethers, polyether ether ketone (PEEK), polysulphones and polyimides

UNIT II **8 Hours**

POLYMERIZATION TECHNIQUES

Homogeneous and heterogeneous polymerization - bulk polymerization (PMMA, PVC) - solution polymerization - polyacrylic acid, suspension polymerization (ion-exchange resins) - emulsion polymerization (SBR) - advantages and disadvantages of bulk and emulsion polymerization. Melt solution and interfacial poly-condensation

UNIT III **8 Hours**

CHARACTERIZATION AND TESTING

Characterization of polymers by Infrared Spectroscopy (IR) and Nuclear Magnetic Spectroscopy (NMR) - Thermal properties: TGA and DSC - Testing tensile strength - Izod impact - Compressive strength - Rockwell hardness - Vicot softening point - water absorption

UNIT IV **9 Hours**

POLYMER PROCESSING

Moulding: Compression - injection - extrusion and blow mouldings. Film casting - calendering. Thermoforming and vacuum formed polystyrene - foamed polyurethanes. Fibre spinning: melt, dry and wet spinning. Fibre reinforced plastics fabrication: hand-layup - filament winding and pultrusion

UNIT V **10 Hours**

SPECIALITY POLYMERS

Preparation and properties of heat resistant and flame retardant polymers. Polymers for electronic applications: liquid crystalline, conducting and photosensitive polymers – E waste management. Polymer for biomedical applications: artificial organs, controlled drug delivery, Scaffolds in tissue Engineering –waste management.

Total: 45 Hours

Reference(s)

1. V. R. Gowarikar, N. V. Viswanathan and Jayadev Sreedhar, Polymer Science, New Age International (P) Ltd, New Delhi, 2021.
2. Joel R. Fried, Polymer Science and Technology, Prentice Hall of India (P). Ltd., 2014.
3. R. J. Young and P. A. Lovell, Introduction to Polymers, CRC Press, New York, 2011.
4. F. W. Billmeyer, Text Book of Polymer Science, John Wiley & Sons, New York, 2008.
5. Barbara H. Stuart, Polymer Analysis, John Wiley & Sons, New York, 2008.
6. George Odian, Principles of Polymerization, John Wiley & Sons, New York, 2004.

22OCH03 ENERGY STORING DEVICES 3 0 0 3

Course Objectives

- Compare the energy density of commercialized primary and secondary batteries.
- Classify the fuel cells and compare their efficiency in different environmental conditions.
- Demonstrate the various energy storage devices and fuel cells.

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Course Outcomes (COs)

1. Apply the parameters required for operation of a cell to evaluate the capacity of energy storage devices.
2. Compare the electrodes, electrolyte and cell reactions of different types of primary, secondary batteries and infer the selection criteria for commercial battery systems with respect to commercial applications.
3. Analyze fuel cells based on its construction, production of current and applications.
4. Analyze the methods of storing hydrogen fuel with its environmental applications.
5. Analyze the future prospects of renewable energy, hydrogen economy, and the efficiency of various generations of solar cells in energy production.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2	3	-	-	-	-	1	-	-	-	-	-	-	-	-
3	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
4	2	2	-	-	-	-	1	-	-	-	-	-	-	-	-
5	3	3	-	-	-	-	1	-	-	-	-	-	-	-	-

UNIT I **6 Hours**
BASICS OF CELLS AND BATTERIES

Components - classification - operation of a cell - theoretical cell voltage - capacity - specific energy - energy density of lithium and lead acid battery - charge efficiency- charge rate - charge retention - closed circuit voltage - open circuit voltage current density - cycle life - discharge rate-over charge-over discharge

UNIT II **10 Hours**

BATTERIES FOR PORTABLE DEVICES AND ELECTRIC VEHICLES

Primary batteries: zinc-carbon - magnesium,and mercuric oxide - recycling/safe disposal of used cells. Secondary batteries: lead acid - nickel-cadmium - lithium ion batteries - rechargeable zinc alkaline battery. Reserve batteries: Zinc-silver oxide - lithium anode cell - photogalvanic cells. Battery specifications for cars and automobiles. Extraction of metals from battery materials.

UNIT III **10 Hours**

TYPES OF FUEL CELLS

Importance and classification of fuel cells: Description, working principle, components, applications and environmental aspects of the following types of fuel cells: alkaline fuel cells - phosphoric acid - solid oxide - molten carbonate and direct methanol fuel cells

UNIT IV **10 Hours**

HYDROGEN AS A FUEL

Sources and production of hydrogen: Electrolysis and photocatalytic water splitting. Methods of hydrogen storage: High pressurized gas - liquid hydrogen type - metal hydride. Hydrogen as engine fuel - features, application of hydrogen technologies in the future – limitations.

UNIT V **9 Hours**

ENERGY AND ENVIRONMENT

Future prospects of renewable energy and efficiency of renewable fuels - economy of hydrogen energy. Solar Cells: First, second, third and fourth generation solar cell - photobiochemical conversion cell.

Total: 45 Hours

Reference(s)

1. S.P. Jiang and Q. Li, Introduction to fuel cells, Springer, 2021.
2. M.M. Eboch, The Future of Energy: From solar cells to flying wind farms, Capstone publishers, 2020.
3. N. Eliaz and E. Gileadi, Physical electrochemistry, fundamentals, techniques and applications, Wiley, 2019.
4. J. Garche and K. Brandt, Electrochemical power sources: Fundamentals systems and applications, Elsevier, 2018.
5. A. Iulianelli and A. Basile, Advances in hydrogen production, storage and distribution, Elsevier, 2016.

22OMA01 GRAPH THEORY AND COMBINATORICS 3 0 0 3

Course Objectives

- This course comprehends the graphs as a modeling and analysis tool in computer science & Engineering
- It introduces the structures such as graphs & trees and techniques of counting and combinations, which are needed in number theory based computing and network security studies in Computer Science.

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Course Outcomes (COs)

1. Apply the basic ideas of Graph and its characteristics.
2. Assess the characteristics of trees and its properties.
3. Predict the coloring of graphs and its applications in the respective areas of engineering.
4. Compute the permutations and combinations in the engineering field.
5. Demonstrate the types of generating functions and their applications in engineering.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
3	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
4	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
5	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I **9 Hours**

INTRODUCTION

Graphs - Introduction - Isomorphism - Sub graphs - Walks, Paths, Circuits - Connectedness - Components - Euler graphs - Hamiltonian paths and circuits - Trees - Properties of trees - Distance and centers in tree - Rooted and binary trees.

UNIT II **9 Hours**

TREES, CONNECTIVITY

Spanning trees - Fundamental circuits - Spanning trees in a weighted graph - cut sets - Properties of cut set - All cut sets - Fundamental circuits and cut sets - Connectivity and separability - Network flows - 1-Isomorphism - 2-Isomorphism - Combinational and geometric graphs - Planer graphs - Different representation of a planer graph.

UNIT III **9 Hours**

MATRICES, COLOURING AND DIRECTED GRAPH

Chromatic number - Chromatic partitioning - Chromatic polynomial - Matching - Covering - Four color problem - Directed graphs - Types of directed graphs - Digraphs and binary relations - Directed paths and connectedness - Euler graphs.

UNIT IV **9 Hours**

PERMUTATIONS

Fundamental principles of counting - Permutations and combinations - Binomial theorem - combinations with repetition - Combinatorial numbers - Principle of inclusion and exclusion - Derangements - Arrangements with forbidden positions.

UNIT V **9 Hours**

GENERATING FUNCTIONS

Generating functions - Partitions of integers - Exponential generating function - Summation operator - Recurrence relations - First order and second order - Non-homogeneous recurrence relations - Method of generating functions.

Total: 45 Hours

Reference(s)

1. Narsingh Deo, Graph Theory: With Application to Engineering and Computer Science, Prentice Hall of India, 2003
2. Grimaldi R.P., Discrete and Combinatorial Mathematics: An Applied Introduction, Addison Wesley, 1994.
3. Rosen K.H., Discrete Mathematics And Its Applications, McGraw Hil, 2007
4. Clark J. & Holton D.A., A First Look at Graph Theory, Allied Publishers, 1995.
5. Mott J.L., Kandel A. & Baker T.P., Discrete Mathematics for Computer Scientists and Mathematicians, Prentice Hall of India, 1996.
6. Liu C.L., Elements of Discrete Mathematics, McGraw Hill, 1985.

22OGE01 PRINCIPLES OF MANAGEMENT 3 0 0 3

Course Objectives

- To develop cognizance about importance of management principles.
- Extract the functions and responsibilities of managers.
- To Study and understand the various HR related activities.
- Learn the application of the theories in an organization.
- Analyze the position of self and company goals towards business.

Program Outcomes (POs)

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

Course Outcomes (COs)

1. Students will be able to understand the basic concepts of Management.
2. Have some basic knowledge on planning process and its Tools & Techniques.
3. Ability to understand management concept of organizing and staffing.
4. Ability to understand management concept of directing.
5. Ability to understand management concept of controlling.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	-	-	-	2	-	3	-	-	-	-
2	-	-	-	-	-	-	-	-	2	-	2	-	-	-	-
3	-	-	-	-	-	-	-	-	2	-	2	-	-	-	-
4	-	-	-	-	-	-	-	-	3	-	2	-	-	-	-
5	-	-	-	-	-	-	-	-	2	-	2	-	-	-	-

UNIT I 9 Hours

INTRODUCTION TO MANAGEMENT AND ORGANIZATIONS

Definition of Management Science or Art Manager Vs Entrepreneur-types of managers - Managerial roles and skills Evolution of Management Scientific, Human Relations, System and Contingency approaches Types of Business organization - Sole proprietorship, partnership, Company - public and private sector enterprises - Organization culture and Environment Current Trends and issues in Management.

UNIT II 9 Hours

PLANNING

Nature and purpose of planning - Planning process - Types of planning – Objectives - Setting objectives - Policies - Planning premises - Strategic Management - Planning Tools and Techniques - Decision making steps and process.

UNIT III **9 Hours**

ORGANISING

Nature and purpose – Formal and informal organization - Organization chart - Organization Structure Types - Line and staff authority - Departmentalization - Delegation of authority - Centralization and decentralization - Job Design - Human Resource - Management - HR Planning, Recruitment, Selection, Training and Development, Performance Management, Career planning and management

UNIT IV **9 Hours**

DIRECTING

Foundations of individual and group behaviour - Motivation-Motivation theories - Motivational techniques - Job satisfaction - Job enrichment - Leadership-types and theories of leadership - Communication-Process of communication - Barrier in communication Effective communication-Communication and IT.

UNIT V **9 Hours**

CONTROLLING

System and process of controlling - Budgetary and non-Budgetary control techniques - Use of Computers and IT in Management control - Productivity problems and management - Control and Performance-Direct and preventive control - Reporting.

Total: 45 Hours

Reference(s)

1. Robbins S, Management, (13th ed.), Pearson Education, New Delhi, 2017.
2. Stephen A. Robbins and David A. Decenzo and Mary Coulter, Fundamentals of Management, Pearson Education, 7th Edition, 2011.
3. Robert Kreitner and Mamata Mohapatra, Management, Biztantra, 2008.
4. L. M. Prasad, Principles and Practice of Management. 7th Edition, Sultan Chand & Sons, 2007.
5. P. C. Tripathi and P. N. Reddy, Principles of Management, Fourth Edition, Tata McGraw Hill, 2008.

22OGE02 ENTREPRENEURSHIP DEVELOPMENT I 3 0 0 3

Course Objectives

- Learn the basics and scope of the Entrepreneurship
- Understand the generation of ideas of the Entrepreneurship
- Evolve the legal aspects of the business
- Learn to analyze the various business finance
- Learn the basics of the Operations Management

Program Outcomes (POs)

PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

Course Outcomes (COs)

1. Analyze the role of entrepreneurship in economic development.
2. Explain the types of ideas that to be used for entrepreneurship development.
3. Examine the legal aspects of business and its association.
4. Examine the sources of business and its analysis.
5. Analyze the different modes of operation management.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	1	2	-	2	-	-	-	-	-	-
2	-	-	-	-	-	1	2	-	2	-	-	-	-	-	-
3	-	-	-	-	-	1	2	-	2	-	-	-	-	-	-
4	-	-	-	-	-	1	2	-	2	-	-	-	-	-	-
5	-	-	-	-	-	1	2	-	2	-	-	-	-	-	-

UNIT I 9 Hours
BASICS OF ENTREPRENEURSHIP
Nature, scope and types of Entrepreneurship, Entrepreneur Personality Characteristics, Entrepreneurship process. Role of entrepreneurship in economic development

UNIT II 9 Hours
GENERATION OF IDEAS
Creativity and Innovation, Lateral Thinking, Generation of Alternatives, Fractional, Reversal Method, Brain Storming, Analogies

UNIT III **9 Hours**

LEGAL ASPECTS OF BUSINESS

Contract act-Indian contract act, Essential elements of valid contract, classification of contracts, sale of goods act- Formation of contract of sale, negotiable instruments- promissory note, bills and cheques, partnership, limited liability partnership (LLP), companies act-kinds, formation, memorandum of association, articles of association.

UNIT IV **9 Hours**

BUSINESS FINANCE

Project evaluation and investment criteria (cases), sources of finance, financial statements, break even analysis, cash flow analysis.

UNIT V **9 Hours**

OPERATIONS MANAGEMENT

Importance – functions - deciding on the production system - facility decisions: plant location, plant layout (cases), capacity requirement planning - inventory management (cases) - lean manufacturing, Six sigma.

Total: 45 Hours

Reference(s)

1. Hisrich, Entrepreneurship, Tata McGraw Hill, New Delhi: 2005
2. Prasanna Chandra, Projects Planning, Analysis, Selection, Implementation and Reviews, Tata McGraw-Hill Publishing Company Limited, New Delhi: 2000.
3. Akhileshwar Pathak, Legal Aspects of Business, Tata McGraw Hill: 2006

22OGE03 ENTREPRENEURSHIP DEVELOPMENT II 3 0 0 3

Course Objectives

- Evolve the marketing mix for promotion the product / services
- Handle the human resources and taxation
- Learn to analyze the taxation
- Understand the Government industrial policies and supports
- Preparation of a business plan

Program Outcomes (POs)

PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

Course Outcomes (COs)

1. Examine the strategies and plans in marketing management.
2. Analyze the cases involved in human resource management.
3. Classify the direct and indirect taxes in business.
4. Analyze the supports given by government for improving the business.
5. Examine the various steps involved in preparing the business plan.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	1	2	-	2	-	-	-	-	-	-
2	-	-	-	-	-	1	2	-	2	-	-	-	-	-	-
3	-	-	-	-	-	1	2	-	2	-	-	-	-	-	-
4	-	-	-	-	-	1	2	-	2	-	-	-	-	-	-
5	-	-	-	-	-	1	2	-	2	-	-	-	-	-	-

UNIT I 9 Hours

MARKETING MANAGEMENT

Marketing environment, Segmentation, Targeting and positioning, Formulating marketing strategies, Marketing research, marketing plan, marketing mix (cases)

UNIT II 9 Hours

HUMAN RESOURCE MANAGEMENT

Human Resource Planning (Cases), Recruitment, Selection, Training and Development, HRIS, Factories Act 1948 (an over view)

UNIT III **9 Hours**

BUSINESS TAXATION

Direct taxation, Income tax, Corporate tax, MAT, Tax holidays, Wealth tax, Professional tax (Cases). Indirect taxation, Excise duty, Customs, Sales and Service tax, VAT, Octroi, GST (Cases

UNIT IV **9 Hours**

GOVERNMENT SUPPORT

Industrial policy of Central and State Government, National Institute - NIESBUD, IIE, EDI. State Level Institutions - TIIC, CED, MSME, Financial Institutions

UNIT V **9 Hours**

BUSINESS PLAN PREPARATION

Purpose of writing a business plan, Capital outlay, Technical feasibility, Production plan, HR plan, Market survey and Marketing plan, Financial plan and Viability, Government approvals, SWOT analysis.

Total: 45 Hours

Reference(s)

1. Hisrich, Entrepreneurship, Tata McGraw Hill, New Delhi: 2005
2. Philip Kotler., Marketing Management, Prentice Hall of India, New Delhi: 2003
3. Aswathappa K, Human Resource and Personnel Management - Text and Cases, Tata McGraw Hill: 2007.
4. Jain P C., Handbook for New Entrepreneurs, EDII, Oxford University Press, New Delhi: 2002.
5. Akhileshwar Pathak, Legal Aspects of Business, Tata McGraw Hill: 2006.
6. http://niesbud.nic.in/agencies.html

22OGE04 **NATION BUILDING, LEADERSHIP AND SOCIAL RESPONSIBILITY** **3 0 0 3**

Course Objectives

- To understand the importance of National Integration, Patriotism and Communal Harmony
- To outline the basic awareness about the significance of soft skills in professional and inter-personal communications and facilitate an all-round development of personality
- To analyze the different types of responsibility role of play for the improvement of society

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO3. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO12. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outcomes (COs)

1. Apply the understanding of religion-cultural diversity of the country and its impact on the lives of the people and their beliefs
2. Build a sense of responsibility, smartness in appearance and improve self confidence
3. Develop the sense of self-less social service for better social & community life
4. Apply the importance of Physical and Mental health and structure of communication organization and various mode of communication
5. Analyze the organizational structure, entry modes, and operational roles of Indian armed forces, CAPF, and NCC while developing leadership capabilities.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	-	1	-	-	-	1	-	-	-	-	3	-	-	-
2	2	-	2	-	-	-	2	-	-	-	-	2	-	-	-
3	2	-	1	-	-	-	1	-	-	-	-	2	-	-	-
4	2	-	3	-	-	-	3	-	-	-	-	3	-	-	-
5	2	-	1	-	-	-	1	-	-	-	-	2	-	-	-

UNIT I **9 Hours**

NATIONAL INTEGRATION

Importance & Necessity, Factors Affecting National Integration, Unity in Diversity. Threats to National Security. Water Conservation and Rain Harvesting, Waste Management and Energy Conservation. Leadership Capsule-Traits-Indicators-Motivation-Moral Values-Honor Code-Case Studies: Shivaji, Jhansiki Rani, Case Studies–APJ Abdul kalam, Deepa Malik, Maharana Pratap, N Narayan Murthy Ratan Tata Rabindra Nath Tagore, role of NCC cadets in 1965 war.

UNIT II **9 Hours**

PERSONALITY DEVELOPMENT AND LEADERSHIP

Intra & Interpersonal skills - Self-Awareness- &Analysis, Empathy, Critical & creative thinking, Decision making and problem solving, Communication skills, Group Discussion – copping with stress and emotions, changing mindset, Public Speaking, Time Management, Social skills, Career counseling, SSB procedure and Interview skills.

UNIT III **9 Hours**

SOCIAL SERVICE, COMMUNITY DEVELOPMENT AND ENVIRONMENTAL AWARENESS

Basics of social service and its need, Types of social service activities, Objectives of rural development programs and its importance, NGO's and their contribution in social welfare, contribution of youth and NCC in Social welfare. Protection of children & women safety, Road/ Rail Travel Safety, New initiatives, Cyber and mobile security awareness.

Disaster management Capsule-Organization-Types of Disasters-Essential Services-Assistance-Civil Defence Organization

UNIT IV **9 Hours**

HEALTH, HYGIENE AND COMMUNICATION

Sanitation, First Aid in Common Medical Emergencies. Health, Treatment and Care of Wounds. Yoga-Introduction, Definition, Purpose, Benefits. Asanas-Padamsana, Siddhasana, Gyan Mudra, Surya Namaskar, Shavasana, Vajrasana, Dhanurasana, Chakrasana, Sarvaangasana, Halasanaetc.

Obstacle Training Contact: Obstacle training - Intro, Safety measures, Benefits, Straight balance, Clear Jump, Gate Vault, ZigZagBalance, High Wall etc.

COMMUNICATION: Basic Radio Telephony (RT) Procedure-Introduction, Advantages, Disadvantages, Need for standard- Procedures-Types of Radio Telephony Communication-Radio telephony procedure, Documentation.

UNIT V **9 Hours**

ARMED FORCES AND NCC GENERAL

Introduction to Digital Signal Processors- Basic Classification-Features TMS320C6713 Architecture-Functional Unit-Pipelining- Addressing Modes -Instruction set Simple Assembly Language Program.

Total: 45 Hours

Reference(s)

1. Director General NCC Website: https://indiancc.nic.in/ncc-general-elective-subject-course- design/
2. Grooming Tomorrow's Leaders, published by DG, NCC. https://indiancc.nic.in/
3. Youth in Action, published by DG, NCC. https://indiancc.nic.in/
4. The Cadet, Annual Journal of the NCC. https://indiancc.nic.in/
5. Précis Issued by respective Service Headquarters on specialized subject available to PI Staff as reference material. https://indiancc.nic.in/

22OAI01 FUNDAMENTALS OF DATA SCIENCE 3 0 0 3

Course Objectives

- To learn the basics of data science and statistical inference.
- To understand the concept of data pre-processing.
- To visualize the processed data using visualization techniques

Program Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering, fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Course Outcomes (COs)

1. Interpret the basics of data science and exploratory data analysis.
2. Represent the useful information using mathematical skills.
3. Demonstrate the usage of statistical inference and regression models.
4. Perform various data operations for cleaning and grouping of data.
5. Implement the visualization of data using visualization tools.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-
2	3	3	3	3	3	-	-	-	-	-	-	-	-	-	-
3	3	3	3	3	3	-	-	-	-	-	-	-	-	-	-
4	3	3	3	3	3	-	-	-	-	-	-	-	-	-	-
5	3	3	3	3	3	-	-	-	-	-	-	-	-	-	-

UNIT I 9 Hours
INTRODUCTION

Need for data science – benefits and uses – facets of data – data science process – setting the research goal – retrieving data – cleaning, integrating, and transforming data – exploratory data analysis – build the models – presenting and building applications.

UNIT II **9 Hours**

DESCRIPTIVE STATISTICS I

Frequency distributions – Outliers – relative frequency distributions – cumulative frequency distributions – frequency distributions for nominal data – interpreting distributions – graphs – averages – mode – median – mean – averages for qualitative and ranked data – describing variability– range – variance – standard deviation – degrees of freedom – interquartile range.

UNIT III **9 Hours**

DESCRIPTIVE STATISTICS II

Normal distributions – z scores – normal curve problems – finding proportions – finding scores – more about z scores – correlation – correlation coefficient for quantitative data – computational formula for correlation coefficient – regression – regression line – least squares regression line – standard error of estimate – interpretation of r2.

UNIT IV **9 Hours**

PYTHON FOR DATA HANDLING

Basics of Numpy arrays – aggregations – computations on arrays – comparisons, masks, boolean logic – fancy indexing – structured arrays – Data manipulation with Pandas – data indexing and selection – operating on data – missing data – hierarchical indexing – combining datasets – aggregation and grouping.

UNIT V **9 Hours**

DATA VISUALIZATION

Types of data visualization: Exploratory, Explanatory, visualization with matplotlib – line plots – scatter plots – visualizing errors – density and contour plots – histograms, binnings, and density – threedimensional plotting– geographic data – data analysis using statmodels and seaborn – graph plotting using Plotly - Visualization Tools: Tableau

Total: 45 Hours

Reference(s)

1. David Cielen, Arno D. B. Meysman, and Mohamed Ali, “Introducing Data Science”, Manning Publications, 2016. (Unit I)
2. Robert S. Witte and John S. Witte, “Statistics”, Eleventh Edition, Wiley Publications, 2017. (Units II and III)
3. Jake VanderPlas, “Python Data Science Handbook”, O’Reilly, 2016. (Units IV and V)
4. Allen B. Downey, “Think Stats: Exploratory Data Analysis in Python”, Green TeaPress, 2014

22OIT01 **DATA STRUCTURES** **3 0 0 3**

Course Objectives

- To understand the basic concepts such as Abstract Data Types, Linear and Non-Linear Data structures
- To analyze the performance of algorithms using time and space complexity.
- To understand the behavior of Linear and Non-Linear data structures
- To choose the appropriate data structures for a specified application
- To write programs in C++ to solve problems using various data structures.

Programme Outcomes (POs)

PO1 Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO5 Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO7 Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Course Outcomes (COs)

1. Analyze the performances of the sorting and searching algorithms
2. Apply linked list linear data structures operations using dynamic memory allocation
3. Apply stack and Queue data structure operations to solve computational problems
4. Design tree data structures and hashing techniques for effective searching of data
5. Build algorithms for solving real world problems using Graph data structure

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	2	-	2	-	-	-	-	-	-	-	-	-	-
2	3	3	2	-	2	-	2	-	-	-	-	-	-	-	-
3	3	3	2	-	2	-	2	-	-	-	-	-	-	-	-
4	3	3	2	-	2	-	2	-	-	-	-	-	-	-	-
5	3	3	2	-	2	-	2	-	-	-	-	-	-	-	-

UNIT I **8 Hours**

INTRODUCTION

Introduction to data structures-types of data structures- Pseudo code - Abstract data types - ADT Implementations performance analysis- time complexity and space complexity- basics of OOPS concepts.

UNIT II **9 Hours**

SORTING AND SEARCHING TECHNIQUES

Searching methods: Linear and binary search methods, Sorting techniques: Insertion Sort - Selection Sort - Bubble Sort - Merge sort - Quick sort.

UNIT III **11 Hours**

LINEAR DATA STRUCTURES

Stack operation - Stack ADT - Applications of stack - Queues operations - Queue ADT - Queue applications – Linked List - Circular - Doubly linked list.

UNIT IV **11 Hours**

TREE

Basic Tree concepts - Binary Trees - Tree Traversals - Binary Search Trees – B Tree - Heap concepts - Heap ADT

UNIT V **6 Hours**

GRAPHS

Introduction – types of graph- Shortest Path Algorithms: Unweighted Shortest Paths - Dijkstra's Algorithm. Minimum Spanning Tree: Prim's Algorithm - Kruskal's Algorithm- graph search methods DFS, BFS

Total: 45 Hours

Reference(s)

1. A Abirami, Priya R L , Advanced Data Structures and Algorithms , BPB publisher, 2023 March.
2. Data Structures using C++, Special Edition-MRCET, Tata McGraw-Hill Publishers 2017.
3. Data structures and Algorithms in C++, Michael T.Goodrich, R.Tamassia and Mount, Wiley student edition, John Wiley and Sons, 2011.
4. Data structures and Algorithm Analysis in C++, Mark Allen Weiss, Pearson Education. Ltd., Second Edition, 2013.
5. D.S. Malik, Data Structures Using C++, Second Edition 2010

22OIT02 **C++ PROGRAMMING** **2 0 2 3**

Course Objectives

- To understand the concept of Object-Oriented Programming
- To apply the Object-Oriented concepts to solve problems using C++

Programme Outcomes (POs)

PO1 Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2 Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3 Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO5 Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

Course Outcomes (COs)

1. Implement C++ programs using classes and objects.
2. Develop C++ programs using the concept of Inheritance.
3. Design applications using virtual functions.
4. Understand the concept of Operator overloading.
5. Develop GUI applications using C++ library classes

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	-	-	2	-	-	-	-	-	-	-	-	-	-
2	1	2	-	-	2	-	-	-	-	-	-	-	-	-	-
3	1	3	2	-	2	-	-	-	-	-	-	-	-	-	-
4	1	3	1	-	2	-	-	-	-	-	-	-	-	-	-
5	1	3	3	-	2	-	-	-	-	-	-	-	-	-	-

UNIT I **5 Hours**

BASICS OF C++ PROGRAMMING

C++ Program Structure, Character Set and Tokens, Data Type, Type Conversion, Preprocessor Directives, Namespace, Input/output Streams and Manipulators, Dynamic Memory Allocation with new and delete, Control Statements. Functions: Function Overloading, Inline Functions, Default Argument, Pass by Reference, Return by Reference, Scope and Storage Class. Pointers: Pointer variables declaration & initialization, Operators in pointers, Pointers and Arrays, Pointer and Function.

UNIT II **6 Hours**

CLASSES & OBJECTS

A Simple Class and Object, accessing members of class, Initialization of class objects: (Constructor, Destructor), Default Constructor, Parameterized Constructor, Copy Constructor, The Default Copy Constructor, Objects as Function Arguments, Returning Objects from Functions, Structures and Classes, Memory allocation for Objects, Static members, Member functions defined outside the class.

UNIT III **7 Hours**

OPERATOR OVERLOADING & INHERITANCE

Fundamental of operator overloading, Restriction on operator overloading, Operator functions as a class member, Overloading unary and binary operator, Introduction to inheritance, Derived Class and Base Class, Access Specifiers (private, protected, and public), Types of inheritance.

UNIT IV **6 Hours**

VIRTUAL FUNCTION & POLYMORPHISM

Concept of Virtual functions, Late Binding, Abstract class and pure virtual functions, Virtual Destructors, Virtual base class, Friend function and Static function, Assignment and copy initialization, Copy constructor, This pointer, Concrete classes, Polymorphism and its roles.

UNIT V **6 Hours**

FUNCTION TEMPLATES AND EXCEPTION HANDLING

Function templates, Function templates with multiple arguments, Class templates, templates and inheritance, Exceptional Handling (Try, throw and catch), Use of exceptional handling.

List of Laboratory Experiments

Experiment 1 **3 Hours**

Introduction to Object Oriented Programming- Classes and Objects.

Experiment 2 **5 Hours**

Programs using Constructor, Destructor

Experiment 3 **4 Hours**

Programs on operator overloading.

Experiment 4 **5 Hours**

Programs on Inheritance

Experiment 5 **3 Hours**

Programs on Virtual Function

Experiment 6 **3 Hours**

Programs on Friend Function

Experiment 7 **3 Hours**

Programs on exception handling

Experiment 8 **4 Hours**

Programs on Function and Class Templates

Total: 60 Hours

Reference(s)

1. Kumar Mukhopadhyaya, Value Engineering Mastermind - From Concepts to Certification, Response. Business Books from SAGE, Los Angeles / London / New Delhi / Singapore / Washington DC, 2014.
2. Anil Kumar Mukhopadhyaya, Value Engineering -Concepts, Techniques and Applications, Response Books, A Division of SAGE Publications, New Delhi / Thousand Oaks / London, 2003
3. R. D. Miles, Techniques of Value analysis & Engineering, McGraw Hill, 2000.
4. E. Midge Arthur, Value Engineering -A Systematic Approach, McGraw Hill Book Co., New York, 2000.
5. Zimmerman, Value Engineering - A Practical Approach, CBS Publishers & Distributors, New Delhi, 2000.

22OIT03 **PROGRAMMING IN JAVA** **2 0 2 3**

Course Objectives

- To understand the concept of Object-Oriented Programming
- To develop console applications using Java.
- To develop GUI applications using Java library classes.

Programme Outcomes (POs)

PO1 Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2 Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3 Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO5 Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

Course Outcomes (COs)

1. Implement Java programs using classes and objects.
2. Develop Java programs using the concept of Inheritance.
3. Design applications using functions, files and exceptions.
4. Develop console applications using Java OOPS.
5. Develop GUI applications using Java library classes

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2			2										
2	1	2			2										
3	1	3	2		2										
4	1	3	1		2										
5	1	3	3		2										

UNIT I **6 Hours**

INTRODUCTION TO OOP AND JAVA FUNDAMENTALS

Object Oriented Programming — Abstraction — objects and classes — Encapsulation- Inheritance — Polymorphism- OOP in Java — Characteristics of Java — The Java Environment — Java Source File - Structure — Compilation. Fundamental Programming Structures in Java — Defining classes in Java — constructors, methods -access specifiers — static members -Comments, Data Types, Variables, Operators, Control Flow, Arrays , Packages — JavaDoc comments.

UNIT II **6 Hours**

INHERITANCE AND INTERFACES

Inheritance — Super classes- sub classes –Protected members — constructors in sub classes- the Object class — abstract classes and methods- final methods and classes — Interfaces — defining an interface, implementing interface, differences between classes and interfaces and extending interfaces — Object cloning -inner classes, Array Lists — Strings.

UNIT III **6 Hours**

EXCEPTION HANDLING AND I/O

Exceptions — exception hierarchy — throwing and catching exceptions — built-in exceptions, creating own exceptions, Stack Trace Elements. Input / Output Basics — Streams — Byte streams and Character streams — Reading and Writing Console — Reading and Writing Files.

UNIT IV **6 Hours**

MULTITHREADING AND GENERIC PROGRAMMING

Differences between multi-threading and multitasking, thread life cycle, creating threads, synchronizing threads, Inter-thread communication, daemon threads, thread groups. Generic Programming — Generic classes — generic methods — Bounded Types — Restrictions and Limitations.

UNIT V

EVENT DRIVEN PROGRAMMING

Graphics programming — Frame — Components — working with 2D shapes — Using color, fonts, and images — Basics of event handling — event handlers — adapter classes — actions — mouse events — AWT event hierarchy — Introduction to Swing — layout management — Swing Components — Text Fields, Text Areas — Buttons- Check Boxes — Radio Buttons — Lists- choices- Scrollbars — Windows –Menus — Dialog Boxes.

List of Laboratory Experiments

Experiment 1 **4 Hours**

Introduction to Object Oriented Programming- Classes and Objects.

Experiment 2 **5 Hours**

Programs using inheritance and polymorphism

Experiment 3 **5 Hours**

Programs on operator overloading.

Experiment 4 **5 Hours**

Programs on exception handling

Experiment 5 **5 Hours**

Programs on multi-threading in java

Experiment 6 **6 Hours**

Programs on java swing

Total: 60 Hours

Reference(s)

1. Herbert Schildt, Java: The Complete Reference, Eleventh Edition, McGraw-Hill Education, 2018.
2. D.T. Editorial Services, Java 8 Programming Black Book, second edition, Dreamtech Press,2015.
3. Vaskaran Sarcar, Interactive Object-Oriented Programming in Java, Second edition, Apress, 2019

22OIT04 **FUNDAMENTALS OF DATABASE MANAGEMENT SYSTEMS** **2 0 2 3**

Course Objectives

- Understand functional components of the Database Management System
- Understand need for concurrency and transaction property
- Compare and contrast various indexing strategies in different database systems

Programme Outcomes (POs)

PO1 Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2 Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3 Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO5 Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Course Outcomes (COs)

1. Identify and analyze the essential concepts and key issues involved in the design of a relational database
2. Apply the concepts of normalization and ER model to guarantee an efficient database
3. Analyze the concurrent execution of transaction process and various recoveries from failures
4. Apply indexing and query optimization techniques for a database design
5. Analyze the various advanced database systems for efficient data storage & NOSQL concepts.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	-	2	-	2	-	-	3	-	-	-	-	-	-	-
2	2	3	3	-	2	-	-	-	-	-	-	-	-	-	-
3	3	-	2	-	3	-	-	-	-	-	-	-	-	-	-
4	3	-	3	-	3	-	-	-	-	-	-	-	-	-	-
5	3	2	3	-	-	-	-	-	-	-	-	-	-	-	-

UNIT I **6 Hours**

RELATIONAL DATABASES

Purpose of Database System - Views of data - Data Models - Database System Architecture - Introduction to relational databases - Relational Model - Keys - Relational Algebra - SQL fundamentals - Advanced SQL features.

UNIT II **6 Hours**

DATABASE DESIGN

Entity-Relationship model - E-R Diagrams - Enhanced-ER Model - ER-to-Relational Mapping - Functional Dependencies - First, Second, Third Normal Forms, - Boyce/Codd Normal Form-Multivalued Dependencies and Fourth Normal Form

UNIT III **6 Hours**

TRANSACTION

Transaction Concepts - ACID Properties - Schedules - Serializability - Concurrency Control -Need for Concurrency - Locking Protocols - Two-Phase Locking - Deadlock - Transaction Recovery - Save Points - Isolation Levels.

UNIT IV **6 Hours**

FILE AND QUERY PROCESSING

RAID - File Organization - Organization of Records in Files - Indexing and Hashing -Ordered Indices - Static Hashing - Dynamic Hashing - Query Processing Overview - Algorithms for SELECT and JOIN operations.

UNIT V

ADVANCED DATABASES

Distributed Databases: Architecture, Data Storage, Transaction Processing - Object-based Databases: Object Database Concepts, Object-Relational features, ODMG Object Model, ODL, OQL - Graph Database.

List of Laboratory Experiments

Experiment 1 **5 Hours**

Data Definition Commands, Data Manipulation Commands for inserting, deleting, updating and retrieving Tables with suitable examples

Experiment 2 **5 Hours**

Implementation of different types of operators in SQL

- Arithmetic Operators
- Logical Operators
- Comparison Operator
- Special Operator
- Set Operation

Experiment 3 **3 Hours**

Database Querying - Simple queries, Nested queries, Sub queries & Joins

Experiment 4 **3 Hours**

Implement

- Group By & having clause
- Order by clause
- Indexing

Experiment 5 **4 Hours**

Create a student database table currently stored as a single table. Normalize these structures to meet the 3NF requirements and draw ER model Diagram

Experiment 6 **5 Hours**

Implementation of Database Backup & Recovery commands, Rollback, Commit & Savepoint.

Experiment 7 **5 Hours**

Develop database for a BOOK PUBLISHING COMPANY.

Total: 60 Hours

Reference(s)

1. Abraham Silberschatz, Henry F. Korth, S. Sudharshan, Database System Concepts, Sixth Edition, Tata McGraw Hill, 2011.
2. Ramez Elmasri, Shamkant B. Navathe, Fundamentals of Database Systems, Sixth Edition, Pearson Education, 2011.
3. C.J.Date, A.Kannan, S.Swamynathan, An Introduction to Database Systems, Eighth Edition, Pearson Education, 2006.
4. Raghu Ramakrishnan, Database Management Systems, Fourth Edition, McGraw-Hill College Publications, 2015.
5. G.K.Gupta,Database Management Systems, Tata McGraw Hill, 2011.

Online Resource(s)

1. https://www.geeksforgeeks.org/introduction-of-dbms-database-management-system-set-1/
2. https://www.javatpoint.com/dbms-tutorial
3. https://onlinecourses.nptel.ac.in/noc22_cs91

22OAG01 RAINWATER HARVESTING TECHNIQUES 3 0 0 3

Course Objectives

- To enhance the awareness about water resources management and conservation.
- To acquire knowledge about water harvesting techniques and their implementation. To practice the design aspects of sustainable rainwater harvesting solutions for communities.

Programme Outcomes (POs)

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Course Outcomes (COs)

1. Assess the sources, availability and challenges in water resources management
2. Assess various water harvesting systems in practice
3. Execute design considerations for comparing surface runoff harvesting methods
4. Compare the characteristics and impacts of flood water harvesting techniques
5. Evaluate various rainwater harvesting methods for groundwater recharging

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	-	-	-	-	-	3	-	-	-	-	-	-	-	-
2	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
3	1	1	3	-	-	-	2	-	-	-	-	-	-	-	-
4	1	2	3	-	-	-	2	-	-	-	-	-	-	-	-
5	1	1	3	-	-	-	2	-	-	-	-	-	-	-	-

UNIT I 8 Hours

WATER RESOURCES AND CONSERVATION CHALLENGES

Global water distribution – primary and secondary sources of water – technical, social and cultural aspects; Global challenges in water and climate – water scarcity – water pollution – Indian scenario; Water resources management – public participation – integrated approach; Water governance – water sharing plans – policy, schemes and concerns

UNIT II **10 Hours**

WATER RESOURCES AND CONSERVATION CHALLENGES

Principles of water harvesting for rural and urban – collection at micro and macro levels, flow control, storage and uses; Rainwater harvesting systems – traditional and contemporary – groundwater recharge; Water resources inventory – site analysis – database collection – water allocation principles based on demand and supply; Traditional water harvesting systems – practices in India – references in old texts – reasons for their deterioration – way forward; Watershed-based approach – project planning at micro and macro levels – community participation – rain centres.

UNIT III **9 Hours**

SURFACE RUNOFF HARVESTING

Short-term and micro-level harvesting techniques for runoff – terracing and bunding – rock and ground catchments; Long-term and macro-level harvesting techniques for runoff – farm ponds – percolation ponds and nala bunds; Design considerations – site selection – selection of runoff coefficients – computation of rainwater runoff volume – hydrograph analysis – cost estimation; Design of storage structures – storage capacity – selection of component – methods of construction

UNIT IV **9 Hours**

FLOOD WATER HARVESTING

Floods – causes of urban floods and droughts – characteristics of water spread – impacts; Flood water harvesting – permeable rock dams – water spreading bunds – flood control reservoir; Design considerations – computation of flood water quantity; Trenching and Diversion Structures – types – site selection – design criteria – most economic section – design consideration of ditch system

UNIT V **9 Hours**

GROUNDWATER HARVESTING

Rooftop rainwater harvesting – recharge pit – recharge trench – tube well – recharge well; artificial recharge – gully plug – dug well – percolation tank – nala bunds – recharge shaft; Groundwater harvesting – aquifer characteristics – subsurface techniques – infiltration wells – recharge wells – groundwater dams; Design of drainage system – types – design criteria – filter design – causes of failures

Total: 45 Hours

Reference(s)

1. Theib YO, Dieter P, Ahmed YH, Rainwater Harvesting for Agriculture in the Dry Areas, CRC Press, Taylor and Francis Group, London, 2012.
2. Lancaster, Brad. Rainwater Harvesting for Drylands and Beyond, Volume 1, 3rd edition, Rainsource Press. 2019.
3. Das M, Open Channel Flow, Prentice Hall of India Pvt. Ltd., New Delhi, 2008.
4. Michael AM, Ojha TP, Principles of Agricultural Engineering, Volume II, 4th Edition, Jain Brothers, New Delhi, 2003.
5. Suresh R, Soil and Water Conservation Engineering, Standard Publisher Distributors, New Delhi, 2014.
6. Singh G, Venkataramanan C, Sastry G, Joshi BP, Manual of Soil and Water Conservation Practices, CSWCR&TI, Dehradun, 1990

22OEE01 VALUE ENGINEERING 3 0 0 3

Course Objectives

- To understand the concept of value engineering in order to reduce cost of product or process or service.
- To implement creative and innovative techniques using FAST diagram.
- To study benefits of Value Engineering for various industries.

Programme Outcomes (POs)

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outcomes (COs)

1. Apply the concepts of value and value engineering to prepare a job plan.
2. Analyze the cost and worth of a product/service using the principles of economics.
3. Evaluate the value of a product/service to take managerial decisions.
4. Apply the soft skills in understanding team building, team work and report writing.
5. Asses the functions and values of product/services in industries using case studies.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	-	-	-	-	-	-	-	-	-	3	1	-	-	-
2	-	-	-	-	-	-	-	-	-	1	3	1	-	-	-
3	-	-	-	-	-	-	-	-	-	-	3	1	-	-	-
4	-	-	-	-	-	-	-	-	-	1	3	2	-	-	-
5	-	-	-	-	-	-	-	-	-	2	3	1	-	-	-

UNIT I **8 Hours**
INTRODUCTION TO VALUE ENGINEERING

Historical perspective of Value Engineering, Aims and objectives of Value Engineering, Concept of Value, Value Engineering concerned with Economic Value, Value Engineering Job plan.

UNIT II **9 Hours**
FUNCTIONAL ANALYSIS

Function-Cost-Worth analysis: Function Analysis System Technique (FAST); Review of principles of engineering economics

UNIT III **10 Hours**

EVALUATION OF VALUE ENGINEERING

Evaluation of function, Problem setting system, problem solving system, setting and solving management - decision - type and services problem, evaluation of value

UNIT IV **9 Hours**

HUMAN ASPECTS IN VALUE ENGINEERING

Team building; Life cycle costing; Managing Value Engineering Study; Value Engineering Report writing; Presentation Skill - Individual and Team Presentations; Implementation and follow-up.

UNIT V **9 Hours**

BENEFITS OF VALUE ENGINEERING

Classification of hazardous zones-intrinsically safe and explosion proof electrical apparatus-increase safe Value Engineering Case studies in the Industries like Manufacturing; Construction; Health Care; Process.

Total: 45 Hours

Reference(s)

1. Kumar Mukhopadhyaya, Value Engineering Mastermind - From Concepts to Certification, Response. Business Books from SAGE, Los Angeles / London / New Delhi / Singapore / Washington DC, 2014.
2. Anil Kumar Mukhopadhyaya, Value Engineering -Concepts, Techniques and Applications, Response Books, A Division of SAGE Publications, New Delhi / Thousand Oaks / London, 2003
3. R. D. Miles, Techniques of Value analysis & Engineering, McGraw Hill, 2000.
4. E. Midge Arthur, Value Engineering -A Systematic Approach, McGraw Hill Book Co., New York, 2000.
5. Zimmerman, Value Engineering - A Practical Approach, CBS Publishers & Distributors, New Delhi, 2000.

22OEE02 **ELECTRICAL SAFETY** **3 0 0 3**

Course Objectives

- To provide knowledge on basics of electrical fire and statutory requirements for electrical safety
- To understand the causes of accidents due to electrical hazards
- To know the various protection systems in Industries from electrical hazards
- To know the importance of earthing
- To distinguish the various hazardous zones and applicable fire proof electrical devices

Programme Outcomes (POs)

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

Course Outcomes (COs)

1. Analyze the basic concepts in electrical circuit and hazards involved in it.
2. Analyze the electrical hazards in the workplace and its impacts.
3. Examine the operation of various protection systems from electrical hazards.
4. Analyze the various safety procedures involved in the industries.
5. Explore the different hazardous zones in Industries and their safety measures.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	1	-	-	-	2	1	-	-	-	-	-	-	-	-
2	1	1	-	-	-	1	2	2	-	-	-	-	-	-	-
3	1	1	-	-	-	2	-	2	1	-	-	-	-	-	-
4	1	1	-	-	-	2	1	-	-	-	-	-	-	-	-
5	1	1	-	-	-	2	1	2	1	-	-	-	-	-	-

UNIT I **9 Hours**

INTRODUCTION

Objectives of safety and security measures - Hazards associated with electric current and voltage - principles of electrical safety - working principles of major electrical equipment - Typical supply situation - Indian electricity act and rules - statutory requirements from electrical inspectorate-International standards on electrical safety.

UNIT II **9 Hours**

ELECTRICAL HAZARDS

Primary and secondary hazards-shocks, burns, scalds, falls-human safety in the use of electricity-Energy leakage-clearances and insulation-classes of insulation-voltage classifications-excess energy-current surges- over current and short circuit current-heating effects of current- Lightning, hazards, lightning arrestor, - national electrical safety code ANSI.

UNIT III **9 Hours**

ELECTRICAL SAFETY EQUIPMENT

Fuse, circuit breakers and overload relays - safe distance from lines - capacity and protection of conductor joints and connections, overload and short circuit protection - earth fault protection. FRLS insulation - insulation and continuity test - system grounding - equipment grounding - earth leakage circuit breaker (ELCB) - ground fault circuit interrupter - electrical guards - Personal protective equipment.

UNIT IV **9 Hours**

ELECTRICAL SAFETY OPERATION AND MAINTENANCE

Role of environment in selection - protection and interlock - discharge rod and earthing devices - safety in the use of portable tools - preventive maintenance - installation – earthing, specifications, earth resistance, earth pit maintenance - Fire Extinguishers - CO2 and Dry Powder schemes.

UNIT V **9 Hours**

HAZARDOUS AREAS

Classification of hazardous zones-intrinsically safe and explosion proof electrical apparatus-increase safe equipment-their selection for different zones-temperature classification-grouping of gases-use of barriers and isolators-equipment certifying agencies – electrical safety standards. (IS, API and OSHA standards)

Total: 45 Hours

Reference(s)

1. Fordham Coope W., “Electrical Safety Engineering, Butterworth and Company”, London, Third Edition, 2013.
2. “Indian Electricity Act and Rules”, Government of India.
3. “Power Engineers”, Handbook of TNEB, Chennai, 2010.
4. “Accident prevention manual for industrial operations”, N.S.C., Chicago, 1982.
5. John Cadick, P.E., Mary Capelli-Schellpfeffer, Dennis K. Neitzel, Al Winfield, “Electrical Safety Handbook”, Fourth Edition, Tata Mcgraw Hill, 2014.

22OCB01 INTERNATIONAL BUSINESS MANAGEMENT 3 0 0 3

Course Objectives

- To enable the students to understand the fundamentals of international business
- To provide competence to the students on making international business decisions
- To enable the students to understand the financial and promotional assistance available for exporters

Programme Outcomes (POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Course Outcomes (COs)

1. Demonstrate the role and importance of digital marketing in today's rapidly changing business environment.
2. Discover the techniques to help organizations to utilize social media for digital marketing.
3. Analyze the key elements and campaign effectiveness of E-Mail marketing and mobile marketing.
4. Evaluate the effectiveness of a digital marketing campaign using Google Analytics.
5. Apply advanced practical skills to plan, predict and manage digital marketing campaign

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	-	-	-	-	-	2	-	-	-	-	-	-	-	-
2	3	-	-	-	-	-	2	-	-	-	-	-	-	-	-
3	3	-	-	-	-	-	2	-	-	-	-	-	-	-	-
4	3	-	-	-	-	-	2	-	-	-	-	-	-	-	-
5	3	-	-	-	-	-	2	-	-	-	-	-	-	-	-

UNIT I **9 Hours**

INTRODUCTION

Definition, Drivers of International Business, Domestic Vs. International Business, Trade and Investment Theories: Interventionist Theories, Free Trade Theories, Theories Explaining Trade Patterns: PLC Theory, The Porter Diamond, Factor Mobility Theory.

UNIT II **9 Hours**

GLOBALIZATION

Globalization: Implications, Challenges - Protectionism: Tariff Barriers, Non-Tariff Barriers- Forms of Integration, Role of WTO and IMF in International Business, Economic, Political, Cultural and Technological Environments.

UNIT III **9 Hours**

INTERNATIONAL BUSINESS STRATEGIES

Market Entry Strategies, Multinational Strategy, Production Strategy, Marketing Strategy, Human Resource Strategy.

UNIT IV **9 Hours**

FOREIGN EXCHANGE

Foreign Exchange Market – Functions, Theories of Exchange Rate Determination, Exchange Rate Forecasting, Convertibility of Currency, Risks associated with Foreign Exchange.

UNIT V **9 Hours**

EXPORTS AND ETHICS IN INTERNATIONAL BUSINESS

Exports – Risks, Management of Exports, Regulatory frameworks, Export financing, Countertrade, Ethics – Issues, Dilemma and Theory.

Suggested Self-Study Topics: Liberalization, GATT, Standardization Vs. Differentiation, FEMA, EXIM Policy Total

Total: 45 Hours

Reference(s)

1. John D Daniels, Lee H.Radebaugh, and Sullivan, "International Business", New Delhi: Pearson Education, 2018.
2. Charles W L Hill and Arun Kumar Jain, "International Business", New Delhi: Tata McGraw Hill, 2017.
3. Francis Cherunilam, "International Business", New Delhi: Prentice Hall of India, 2020.
4. Simon Collinson, Rajneesh Narula, Alan M. Rugman, "International Business", New Delhi: Pearson Education, 2020.
5. K.Aswathappa, "International Business", New Delhi: Tata McGraw Hill, 2020.

22OBM01 **OCCUPATIONAL SAFETY AND HEALTH IN PUBLIC HEALTH EMERGENCIES** **3 0 0 3**

Course Objectives

- Students will be able to know about Occupational safety and health (OSH)
- Students will be able to discuss about risks faced by emergency responders during disease outbreaks and other emergencies
- Students will be able to create awareness on necessary strategies for managing OSH in emergency situations

Course Outcomes (COs)

1. Practice the occupational safety measures by the scientific knowledge to overcome the risks faced by emergency responders
2. Apply appropriate strategies and tools in Occupational safety and healthcare
3. Analyse common risks for safety and health in emergencies
4. Adapt appropriate occupational safety practices in chemical accidents
5. Guide Occupational safety measures in radiation incidents

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	-	3	2	1	-	-	-	1	-	-	-	2	-	2	-
2	-	2	2	2	-	-	-	1	-	-	-	2	-	2	-
3	-	3	2	2	-	-	-	1	-	-	-	2	-	2	-
4	-	2	2	2	-	-	-	1	-	-	-	2	-	2	-
5	-	3	2	2	-	-	-	1	-	-	-	2	-	2	-

UNIT I **9 Hours**

MANAGEMENT ASPECTS

Management system approach to occupational safety and health hazards and risks – rights, duties and responsibilities of employers and workers during outbreaks and emergencies – Emergency responders health monitoring and surveillance

UNIT II **9 Hours**

STRATEGIES AND TOOLS

International Health Regulations, 2005 – Incident command system for managing outbreaks and emergencies – Occupational safety and health controls – Strategies for infection prevention and control

UNIT III **9 Hours**

COMMON RISKS FOR SAFETY AND HEALTH IN EMERGENCIES

Vector-borne diseases, water and food-borne diseases, Vaccine-preventable diseases – Heat stress - Slips, trips and falls - Road traffic injuries – Ergonomic hazards - Violence – Psychological stress during outbreaks and injuries

UNIT IV **9 Hours**

OCCUPATIONAL SAFETY AND HEALTH IN CHEMICAL INCIDENTS

Emergencies caused by chemical incidents – occupational safety and health hazards and risks of chemicals – Personal Protective Equipment – Decontamination of emergency response personnel – medical surveillance of emergency responders

UNIT V **9 Hours**

OCCUPATIONAL SAFETY AND HEALTH IN RADIATION INCIDENTS

Sources and scenarios of radiation incidents – guidance for protection of emergency responders - Occupational health surveillance of persons occupationally exposed to radiation in emergencies

Total: 45 Hours

Reference(s)

1. Emergency responder health monitoring and surveillance. National Response Team technical assistance document. Atlanta (GA): National Institute for Occupational Safety and Health; 2012.
2. Emergency response framework (ERF). Geneva: World Health Organization; 2013
3. Guidelines on occupational safety and health management systems, second edition. Geneva: International Labour Organization; 2009.
4. OSH management system: a tool for continual improvement. Geneva: International Labour Organization; 2011
5. OECD Environmental Outlook to 2050: the consequences of inaction. Paris: Organization for Economic Co-operation and Development; 2012.

22OBM02 AMBULANCE AND EMERGENCY MEDICAL SERVICE MANAGEMENT 3 0 0 3

Course Objectives

- Understand the ambulance & transport management and allied services.
- Compare the ambulance design and equipment, transportation and corporate Profit.
- Carry-out various acts governing transport management.

Course Outcomes (COs)

1. Identify ambulance services, types and allied services
2. Formulate minimum ambulance rescue equipment and developing a transportation Strategy.
3. Understand the Emergency response team, Transportation interfaces, Transportation Service Characteristics& regulatory reforms involved.
4. Identify ambulance services, types and allied services
5. Formulate minimum ambulance rescue equipment and developing a transportation Strategy.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	2	-	-	-	-	-	-	-	-	-	-	-	2	-
2	2	-	-	-	-	-	-	-	-	-	-	-	-	3	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
4	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
5	2	-	-	-	-	-	-	-	-	-	-	-	2	-	-

UNIT I 9 Hours

INTRODUCTION

Introduction-transportation ambulance types-Advanced Life Support Ambulance-Basic Life Support Ambulance-Patient Transport Ambulance-Emergency services-Ambulances-Allied services-telephone management

UNIT II 9 Hours

AMBULANCE DESIGN AND EQUIPMENT

Design and Equipment of Ambulances -Minimum Ambulance Rescue Equipment-Emergency drugs medicines Recruitment validation Training to handle in house Ambulance emergency procedures Checklist measures Roles of paramedics, midwives, community nurses, hospice workers in emergency handling via ambulance

UNIT III 9 Hours

TRANSPORTATION REGULATION FOR EMERGENCY MEDICAL SERVICE

Crisis Management-Anxiety & Stress Management-the Emergency response team-police assistance- Information handling & processing-Establishing customer service levels - Developing and Reporting customer service standards - Impediments to an Effective customer Service strategy - Improving customer Service Performance Transportation

UNIT IV **9 Hours**

AMBULANCE PREVENTIVE MAINTENANCE

Legal obligationsSwitch Console Front, Main Electrical, Patient Compartment Climate Oxygen system On board Suction system 110/12 VOLT system, Modular Body, Medical Equipment - Cot & Stretcher, safety belts-driver(s), passenger, Patients-child restraint device- incubator

UNIT V **9 Hours**

THE MOTOR VEHICLE ACT

The Motor Vehicle Act, 1988- Rules of the road Regulations 1989- Overall Dimensions of Motor Vehicles (Prescription of conditions for exemption) Rules 1991-Use of Red light on the top front of the vehicle

Total: 45 Hours

Reference(s)

1. Fawcett,"Supply Chain Management", Pearson Education India, 01-Sep-2008 - 600 pages.
2. B. Feroz, A. Mehmood, H. Maryam, S. Zeadally, C. Maple and M. A. Shah, "Vehicle-Life Interaction in Fog-Enabled Smart Connected and Autonomous Vehicles," in IEEE Access, vol. 9, pp. 7402-7420, 2021, doi: 10.1109/ACCESS.2020.3049110.
3. R. Jin, T. Xia, X. Liu, T. Murata and K. -S. Kim, "Predicting Emergency Medical Service Demand With Bipartite Graph Convolutional Networks," in IEEE Access, vol. 9, pp. 9903-9915, 2021, doi: 10.1109/ACCESS.2021.3050607.
4. Les Pringle,"Call the Ambulance",Transworld Publishers, 2010.
5. Edward J. Bardi, John Joseph Coyle, Robert A. Novack"Management of Transportation", Thomson/South-Western, 2006

22OBM03 HOSPITAL AUTOMATION 3 0 0 3

Course Objectives

- Introduce the concepts of hospital systems and need for central monitoring
- Exemplify the power generation, utility and protection systems.
- Apply the distributed and central monitoring functions in hospital environment

Course Outcomes (COs)

1. Identify the factors in central power generating and monitoring systems
2. Analyze the sensors and actuators for the automation systems
3. Classify the equipment types and its applications.
4. Apply software tools and digital computer for monitoring of parameters and medical data handling
5. Design central monitoring station for hospitals for control and surveillance applications

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-
2	-	2	-	-	-	-	-	-	-	-	-	-	-	2	-
3	-	2	-	-	-	-	-	-	-	-	-	-	3	-	-
4	-	2	-	-	-	-	-	-	-	-	-	-	-	2	-
5	3	-	-	-	-	-	-	-	-	-	-	-	-	2	-

UNIT I **9 Hours**

AUTOMATION IN HEALTHCARE

Introduction to automation Role of automation in healthcare Remote Patient Monitoring Maximizing resources on patient care Reducing variability, Automating clinician and patient interactions through products.

UNIT II **9 Hours**

POWER GENERATION AND MEDICAL GAS PRODUCTION

Power generator, Battery : Maintenance and troubleshooting, energy conservation and monitoring system - Automation in dryer, compressor, air conditioning, lighting, heating systems.

UNIT III **9 Hours**

AUTOMATION IN PIPING

Monitoring of flow and pressure of medical gas System components Vacuum control units Automatic changeover system - Types of Outlets - Leakage test- Prevention and safety automation.

UNIT IV **9 Hours**

INSTRUMENTATION SYSTEMS

Optical sensors , Pressure Sensors - Ultrasonic Sensors - Tactile Sensors - Thermal sensors -Biosensor - Linear Actuators, Central monitoring station - Alarm system - Regulation and standards.

9 Hours

UNIT V
APPLICATIONS

Business intelligence & executive dashboards - Radio-Frequency Identification (RFID)- based patient and asset tracking solutions - Tablet-based applications for bed side access to doctors/nurses - Healthcare CRM for patient relationship management - Patient kiosk, tele-health – HIS integration.

Total: 45 Hours

Reference(s)

1. Khandpur RS, Handbook of Biomedical Instrumentation, Prentice Hall of India, New Delhi, 3 rd edition, 2014.
2. Joseph J. Carr and John M. Brown, Introduction to Biomedical Equipment Technology, Pearson Education India, Delhi, 4 th edition 2008
3. Curtis Johnson D Process Control Instrumentation Technology, Prentice Hall of India, 8th edition 2006
4. John V. Grimaldi and Rollin H. Simonds., Safety Management, All India Travelers Book seller, New Delhi, 1989
5. N.V. Krishnan, Safety in Industry, Jaico Publisher House, 1996.

OPEN ELECTIVE (OFFERED TO OTHER DEPARTMENT STUDENTS)

22OBT01 **BIOFUELS** **3 0 0 3**

Course Objectives

- To understand and explore the scope of biofuels, the most efficient renewable source of energy.
- To develop the expertise in the technology pertaining to their generation and employment in order to surrogate the existing conventional fuels and hence strives towards sustainable development.
- To give way to bolster green technology and incline towards more eco-friendly options.

Programme Outcomes (POs)

PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2 Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4 Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6 The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7 Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, demonstrate the knowledge of, and need for sustainable development.
PSO3 Conceive, Plan and Deploy societal projects for environmental protection using bioresources.

Course Outcomes (COs)

1. Apply the bio-resources that can be used for the production of biofuels.
2. Analyze the physical and chemical properties of the biodiesel.
3. Analyze the mechanisms of improvising the quality and performance of engines using biofuels.
4. Analyze the bio-fuel conversion technologies and their environmental attributes.
5. Evaluate the designing aspects of major unit processes/operations of an integrated bio- refinery.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	1	2	-	-	-	3	-	-	-	-	-	-	-	1
2	2	1	-	3	-		1	-	-	-	-	-	-	-	3
3	1	2	-	2	-	2	3	-	-	-	-	-	-	-	2
4	2	3	-	-	-	2	3	-	-	-	-	-	-	-	3
5	1	2	3	3	-	-	1	-	-	-	-	-	-	-	-

UNIT I **9 Hours**

CLASSIFICATION AND RESOURCES

Introduction, biofuel as a renewable energy, classification of biofuels - First, second, third and fourth generation biofuels, different plant sources as biofuel feedstocks, Biogases, physical and chemical characteristics of vegetable oils - iodine number, hydroxyl, acid values, rancidity, hydrogenolysis and hydrolysis, Food vs energy.

UNIT II **9 Hours**

BIODIESEL

Definition, basics and chemistry of biodiesel, vegetable oils in biodiesel production, Trans-esterification: Chemical methods, enzymatic methods and types of catalysts, separation and purification, physical properties and characterization of biodiesel - Cloud point, pour point, cold filter plugging point, flash point, viscosity and cetane number.

UNIT III **9 Hours**

QUALITY BIODIESEL AND ENVIRONMENT

Producing Quality Biodiesel, quality control, test methods, ASTM specifications. Oxidative and thermal stability, estimation of mono, di, triglycerides and free glycerol, engine performance test, blending of ethanol with biodiesel, blending of biodiesel with high-speed diesel (HSD) and their combustion properties.

UNIT IV **9 Hours**

BIOETHANOL AND BIOGASES

Ethanol as a fuel, microbial and enzymatic production of ethanol from biomass - lignocellulose, sugarcane, sugar beet, corn, wheat starch, and purification - wet and dry milling processes, saccharification- chemical and enzymatic. Production of bio methane and biohydrogen.

UNIT V **9 Hours**

BIOREFINERIES

Definition and types of biorefineries, co-products of biorefineries-oil cake and glycerol, purification of glycerol obtained in biodiesel plant; anaerobic and thermal gasification of biomass, economics of biorefineries.

Total: 45 Hours

Reference(s)

1. Caye Drapcho, John Nghiem and Terry Walker, Biofuels Engineering process technology, McGraw Hill Professional, 2008.
2. Mousdale, Biofuels, CRC Press, 2008.
3. Ahindra Nag, Biofuels Refining and Performance, McGraw-Hill Professional, 2007.
4. Lisbeth Olsson, Biofuels (Advances in Biochemical Engineering/ Biotechnology), Springer,2007.