M.E. (Engineering Design)

2015 Regulations, Curriculum & Syllabi

BANNARI AMMAN INSTITUTE OF TECHNOLOGY

(An Autonomous Institution Affiliated to Anna University, Chennai
Approved by AICTE - Accredited by NBA New Delhi, NAAC with 'A' Grade and ISO 9001:2008 Certified)

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PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

I. To produce engineering graduates who are competent to apply principles of mathematics, science and engineering for solving current problems related to Engineering design.

II. To produce engineering graduates who are capable of effective communication, adapting to multi-disciplinary situations, exhibiting leadership and lifelong learning and research skills.

III. To produce engineering graduates who are responsible for the ethics of their profession and contributions effectively in a team to the benefit of society.

PROGRAMME OUTCOMES (POS)

a) Able to apply knowledge from basic engineering courses to identify, formulate and present solutions to technical problems in various engineering fields related to Engineering Design.

b) Able to apply the engineering design knowledge in analysis, evaluation, development and manufacturing of industrial products.

c) Able to learn the recent techniques, design tools, software and equipment necessary to apply design principles in multiple contexts.

d) Able to conduct experiments, analyze and interpret results.

e) Able to plan, conduct the systematic study of significant research topics within the field.

f) Able to communicate professionally through verbal, written and visual communication to the engineering community.

g) Able to learn and work effectively in a team, exercise initiative and function as a leader.

h) Able to understand the impact of professional engineering solutions to societal and environmental contexts.

i) Able to discharge the professional ethics and responsibilities in engineering practices.

j) Able to develop confidence in self-education and use it for lifelong learning.

MAPPING OF PEOs AND POs

PEO(s)	Programme Outcome (s)									
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
I	x	x		x						
II			x			x	x			x
III					x			x	x	

M.E. Engineering Design (Full Time)
Minimum credits to be earned 78

First Semester

Code No.	Course	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
15ED11	Advanced Numerical Methods*	I	(a)	3	2	0	4
15ED12	Advanced Finite Element Analysis+	I, II	(b),(c),(d)	3	2	0	4
15ED13	Advanced Mechanisms Design and Simulation+	I,II	(b),(c),(d)	3	2	0	4
15ED14	Applied Elasticity and Plasticity	I, II	(a),(b),(c)	3	0	0	3
15ED15	Mechanical Vibrations	I,II,III	(c),(d),(e)	3	2	0	4
	Elective I	-	-	3	0	0	3
15ED17	Geometric Modelling And Simulation Laboratory +	I,II,III	(c),(d),(e),(g),(j)	0	0	4	2
15ED18	Mechanical Vibrations Analysis Laboratory	I, II,III	(c),(d), (e),(g),(j)	0	0	4	2
15GE19	Business English – I$^{\alpha}$	II	(f)	1	0	2	2
			Total	**19**	**8**	**10**	**28**

Second Semester

Code No.	Course	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
15ED21	Research Methodology	I,II,III	(d), (e), (f), (j)	3	0	0	3
15ED22	Design for Manufacture and Assembly+	I,II,III	(b), (c),(e)	3	0	0	3
15ED23	Failure Analysis and Design	I,II, III	(b), (c), (e)	3	0	0	3
15ED24	Computational Fluid Dynamics	I,II,III	(c), (d), (e)	3	2	0	4
	Elective II	-	-	3	0	0	3
	Elective III	-	-	3	0	0	3
15ED27	Computer Aided Design Engineering Laboratory+	I,II,III	(c),(d),(e),(g),(j)	0	0	4	2
15ED28	Technical Seminar	I,II,III	(c), (e), (f),(g)	0	0	2	1
15GE29	Business English – II$^{\alpha}$	II	(f)	1	0	0	1
			Total	**19**	**2**	**6**	**23**

Third Semester

Code No.	Course	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
	Elective-IV	-	-	3	0	0	3
	Elective-V	-	-	3	0	0	3
	Elective-VI	-	-	3	0	0	3
15ED34	Project Work - Phase I	I,II,III	(d),(e),(f),(g), (h), (i), (j)	-	-	-	6
			Total	**9**	**0**	**0**	**15**

Fourth Semester

Code No.	Course	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
15ED41	Project Work - Phase II	I,II,III	(d),(e),(f),(g),(h), (i), (j)	-			**12**

*Common to CAD/CAM, Engineering Design & Industrial Automation And Robotics
+Common to CAD/ CAM and Engineering Design
$^{\alpha}$ Common to all M.E. / M.Tech. Programmes

M.E. Engineering Design (Part Time)

First Semester

Code No.	Course	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
15ED11	Advanced Numerical Methods†	I	(a)	3	2	0	4
15ED12	Advanced Finite Element Analysis+	I, II	(b),(c),(d)	3	2	0	4
15ED13	Advanced Mechanisms Design and Simulation+	I,II	(b),(c),(d)	3	2	0	4
15ED17	Geometric Modelling And Simulation Laboratory +	I,II,III	(c),(d),(e),(g),(j)	0	0	4	2
15GE19	Business English – I$^{\alpha}$	II	(f)	1	0	2	2
			Total	**10**	**6**	**6**	**16**

Second Semester

Code No.	Course	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
15ED21	Research Methodology	I,II,III	(d), (e), (f), (j)	3	0	0	3
15ED22	Design for Manufacture and Assembly+	I,II,III	(b), (c),(e)	3	0	0	3
15ED23	Failure Analysis and Design	I,II, III	(b), (c), (e)	3	0	0	3
15ED27	Computer Aided Design Engineering Laboratory+	I,II,III	(c),(d),(e),(g),(j)	0	0	4	2
15GE29	Business English – II$^{\alpha}$	II	(f)	1	0	0	1
			Total	**10**	**0**	**4**	**12**

Third Semester

Code No.	Course	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
15ED14	Applied Elasticity and Plasticity	I, II	(a),(b),(c)	3	0	0	3
15ED15	Mechanical Vibrations	I,II,III	(c),(d),(e)	3	2	0	4
15ED24	Computational Fluid Dynamics	I,II,III	(c), (d), (e)	3	2	0	4
15ED18	Mechanical Vibrations Analysis Laboratory	I, II,III	(c),(d), (e),(g),(j)	0	0	4	2
			Total	**9**	**4**	**4**	**13**

Fourth Semester

Code No.	Course	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
	Elective I			3	0	0	3
	Elective II			3	0	0	3
	Elective III			3	0	0	3
15ED28	Technical Seminar	I,II,III	(c), (e), (f),(g)	0	0	2	1
			Total	**9**	**0**	**2**	**10**

Fifth Semester

Code No.	Course	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
	Elective IV			3	0	0	3
	Elective V			3	0	0	3
	Elective VI			3	0	0	3
15ED34	Project Work - Phase I	I,II,III	(d),(e),(f),(g), (h), (i), (j)	-	-	-	6
			Total	**9**	**0**	**0**	**15**

Sixth Semester

Code No.	Course	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
15ED41	Project Work - Phase II	I,II,III	(d),(e),(f),(g),(h), (i), (j)		-		12

†Common to CAD/CAM, Engineering Design & Industrial Automation And Robotics
+Common to CAD/ CAM and Engineering Design
$^{\alpha}$ Common to all M.E. / M.Tech. Programmes

List of Electives

Code No.	Course	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
15ED51	Product Design and Development	I,II	(b),(c)	3	0	0	3
15ED52	Advanced Strength of Materials	I,II	(a),(b)	3	0	0	3
15ED53	Design of Hydraulic and Pneumatic Systems	I,II	(b),(c)	3	0	0	3
15ED54	Design of Material Handling Equipment	I,II	(b), (c)	3	0	0	3
15ED55	Design of Thermal Systems	I,II	(a), (b)	3	0	0	3
15ED56	Mechatronics System Design	I,II	(b), (c)	3	0	0	3
15ED57	Composite Materials and Mechanics	I,II	(b), (c)	3	0	0	3
15ED58	TRIZ for Product Innovation	I,II	(a), (b), (c)	3	0	0	3
15ED59	Tribology in Design	I,II	(b), (c), (d)	3	0	0	3
15ED60	Reliability Engineering and Total Productive Maintenance	I,III	(b), (h), (i)	3	0	0	3
15ED61	Advanced Tool Design	I,II	(b), (c)	3	0	0	3
15ED62	Geometric Modelling+	I,III	(b), (c)	3	0	0	3
15ED63	Design of Automobile components	I,II	(b), (c)	3	0	0	3
15ED64	Design Optimization of Mechanical Systems+	I,III	(c), (d), (e)	3	0	0	3
15ED65	Product Reliability	I,III	(b), (h), (i)	3	0	0	3
15ED66	Productions and Operations Management	I,II	(b), (c)	3	0	0	3
15ED67	Mechanics of Fracture	I,II	(b), (c)	3	0	0	3
15ED68	Modelling and Simulation of Dynamic Systems	I,II	(b),(c)	3	0	0	3
15ED69	Additive Manufacturing Techniques+	I,II	(b), c)	3	0	0	3
15ED70	Engineering Optimization	I,II	(b), (c)	3	0	0	3
15ED71	TRIZ for Product Innovation	I,II	(a), (b), (c)	3	0	0	3
15ED72	Composite Materials and Mechanics	I,II	(b), (c)	3	0	0	3

One Credit Courses

Code No.	Course	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
15EDXA	Value Engineering	II,III	(g), (h), (i)	1	0	0	1
15EDXB	Concepts of Engineering Design	I,II	(b), (c)	1	0	0	1

+ Common to CAD/ CAM and Engineering Design

15CC11/15ED11/15IR11 ADVANCED NUMERICAL METHODS
(Common to CAD/CAM, Engineering Design &Industrial Automation & Robotics)

3 2 0 4

Course Objectives

- To impart knowledge on algebraic equations, differential Equations, finite difference methods and calculus of variation to solve various engineering problems.
- To understand the various the advanced numerical methods to solve engineering research problems.

Course Outcomes (COs)

The student will be able to

1. Apply partial differential equations, finite difference and calculus of variation methods to solve real time engineering problems.
2. Solve the various engineering research problems using advanced numerical methods.

Unit I
Algebraic Equations

Systems of linear equations-Gauss Elimination method, pivoting techniques, Thomas algorithm for tri diagonal system–Jacobi, Gauss Seidel, SOR iteration methods-Systems of nonlinear equations-Fixed point iterations, Newton Method-Eigen value problems- power method, inverse power method, Faddeev–Leverrier Method.

9 Hours

Unit II
Ordinary Differential Equations

RungeKutta Methods for system of Initial value problems, numerical stability, Adams-Bash forth multi step method, solution of stiff Ordinary Differential Equations, shooting method, Boundary value problems-Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

9 Hours

Unit III
Finite Difference Methods for Partial Differential Equation

Parabolic equations- explicit and implicit finite difference methods, weighted average approximation-Dirichlet and Neumann conditions– Two dimensional parabolic equations– ADI method; First order hyperbolic equations– method of characteristics, different explicit and implicit methods- numerical stability analysis, method of lines–Wave equation- Explicit scheme-Stability of above schemes..

9 Hours

Unit IV
Finite Difference Methods for Elliptic Equations

Laplace and Poisson's equations in a rectangular region-Five point finite difference schemes, Leibmann's iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates-finite difference schemes–approximation of derivatives near a curved boundary while using a square mesh.

9 Hours

Unit V
Calculus of Variation

Introduction to variation problems - Euler s equation – Functional dependent on First and higher order derivatives – Functional dependent on functions of several independent variables- some applications –Direct methods- Ritz method

9 Hours

Unit VI$

Applied Numerical Methods with MATLAB for Engineering Problems- Case Studies

Total: 45+30 Hours

Reference(s)

1. Saumyen Guhaand Rajesh Srivastava, *Numerical methods for Engineering and Science*, Oxford Higher Education,NewDelhi,2010.
2. S. K. Gupta, *Numerical Methods for Engineers*, New Age Publishers, 2015.
3. R. L. Burden and J. D. Faires, Numerical *Analysis – Theory and Applications*, Cengage Learning, India Edition, NewDelhi, 2009
4. M. K. Jain, S. R. Iyengar, M. B. Kanchi, Jain, *Computational Methods for Partial Differential Equations*, New Age Publishers, 2016.
5. K. W. Mortonand D. F. Mayers, *Numerical solution of partial differential equations*, Cambridge University press, Cambridge, 2002.
6. Steven C. Chapra, *Applied Numerical Methods with MATLAB for Engineers and Scientists*, McGraw-Hill, 2012.
7. C. F. GeraldandP. O. Wheatley, *Applied Numerical Analysis*, Pearson Education 2003.

15ED12/15CC12 ADVANCED FINITE ELEMENT ANALYSIS
(Common to CAD/CAM & Engineering Design)

3 2 0 4

Course Objectives

- To impart knowledge on finite element procedures of one, two dimensional and iso- parametric elements to solve structural related problems.
- To understand the procedures of finite element methods to solve fluid, heat transfer and vibration field problems.

Course Outcomes (COs)

The student will be able to

1. Apply the finite elements procedures of one, two dimensional and iso-parametric elements to solve the various structural related engineering problems.
2. Solve heat transfer, fluid flow and vibration related real time engineering problems using advanced finite element methods.

Unit I

One Dimensional Elements

Relevance of finite element analysis in design – FEM procedure-Modelling and discretization, Interpolation, elements, nodes, coordinate system and Degrees-of-Freedom - Applications of FEA. Bar, beam, Truss and Frame element–, stiffness matrices, Assembly matrix, Boundary conditions, Solution-Application problems.

10 Hours

Unit II

Two Dimensional Elements

Plane Stress and Strain-Constant strain triangular elements (CST) -Linear strain triangular elements (LST) - Bilinear and Rectangular elements – Tetrahedron, hexahedral and Axisymmetric Elements-.

9 Hours

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Unit III
Iso-parametric Elements
Introduction –Iso-parametric three, four, eight and nine node elements - Bilinear elements – Lagrange polynomial shape function, Jacobian matrix, strain- displacement matrix, stress-strain relationship matrix, stiffness matrix– Applications

9 Hours

Unit IV
Fluid Flow and Heat Transfer Analysis
Finite element formulated equations of basic flow problems - One dimensional fluid flow Finite element formulation - problem. Formulation of two dimensional heat transfer linear triangular elements problems.

8 Hours

Unit V
Dynamic and Plate Analysis
Dynamic equations – Consistent and lumped mass matrices – one dimensional element - stiffness, mass and force matrices - Introduction to thin plate theory, Finite triangular plate - stiffness matrix-Jacobian matrix -shell element- Grid sensitivity test.

9 Hours

Unit VI$
Non -linear analysis, Solution Techniques –Case studies –h and p elementsformulation.

Total: 45+30 Hours

Reference(s)
1. D. L .Logan, *A First Course in the Finite Element Method*, Cengage Learning, 2012.
2. S. S. Bhavikati, *Finite Element Analysis*, New Age International Publishers, 2010.
3. S. S. Rao, *The Finite Element Method in Engineering*. Elsevier Publishers, 2014.
4. J. N. Reddy, *AnIntroduction to the Finite Element Method*, Tata McGraw Hill International, 2009.
5. J. Ramachandran, *Boundary and Finite Element Theory and Problems*, Narosa Publishing House, 2000.
6. http://nptel.ac.in/courses/112106130/

15ED13/15CC13 ADVANCED MECHANISMS DESIGN AND SIMULATION
(Common to CAD/CAM & Engineering Design)

3 2 0 4

Course Objectives
- To understand the layout of linkages and kinematic analysis of various links.
- To study the synthesis analysis of four bar, cam and coupler curve based mechanisms.
- To impart the knowledge of kinematics simulations of various mechanisms.

Course Outcomes (COs)
The student will be able to
1. Determine and analyze the kinematics attributes of various links.
2. Design the four bar, cam and coupler curve based mechanisms of real time applications.
3. Model and simulate simple mechanisms used in various applications.

Unit I
Introduction
Introduction to kinematics and mechanisms-Mobility analysis-Formation of one degree of freedom multi loop kinematic chains-Grass motion concepts-compliant and equivalent mechanisms.

8 Hours

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Unit II
Kinematic Analysis
Position Analysis-vector loop equations for four bar, slider crank, inverted slider crank, geared five bar and six bar links-Analytical and Graphical methods-displacement, velocity and acceleration analysis of simple mechanisms.

10 Hours

Unit III
Path Curvature Theory
Fixed and moving centrodes-Inflection points and inflection circle-Euler Savary equation-Bobillier's construction-Hartmann's construction-cubic of stationary curvature.

8 Hours

Unit IV
Synthesis of Four bar Mechanisms
Type and number synthesis- linkage concept-Dimensional synthesis-Function generation, path generation and motion generation-Graphical methods-Pole technique and inversion technique-Point position reduction-two, three and four position synthesis of four bar mechanisms-Analytical methods-Freudenstein's equation-Bloch's synthesis.

10 Hours

Unit V
Synthesis of CAM and Coupler Curve basedMechanisms
Cognate linkages-parallel motion linkages-design of six bar, Single dwell, double dwell and double stroke-multi dwell -CAM mechanisms - determination of optimum size of cams-mechanism defects.

9 Hours

Unit VI$
Case Study-Kinematic analysis of spatial mechanisms-simulation mechanisms using software package.

Total: 45+30 Hours

Reference(s)

1. J. J. Uicker, G. R. Pennock and J.E. Shigley, *Theory of Machines and Mechanisms*, Oxford University Press, NY, 2011.
2. Amitabha Ghosh and Asok Kumar Mallik, *Theory of Mechanism and Machines*, East West Press, New Delhi, 2006.
3. Robert L. Nortron, *Kinematics and Design of Machinery,* McGraw Hill Higher Education, 2nd revised edition, 2012.
4. David H. Myszka, *Machines & Mechanisms: Applied Kinematic Analysis,* Pearson Education, 4threvised edition, 2011.
5. R.L. Nortron, *Design of Machinery*, McGraw Hill, 2012.
6. J. Kenneth, Waldron and Gary L. Kinzel, *Kinematics*, *Dynamics and Design of Machinery*, John Wiley-Sons, 2004.
7. A. Hernandez, *Kinematic analysis of mechanisms via a velocity equation based in a geometric matrix*, *Mechanism and machine theory*, vol. 38(12), pp1413-1429, 2013.

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

15ED14 APPLIED ELASTICITY AND PLASTICITY

3 0 0 3

Course Objectives

- To understand the elasticity and plasticity theories for formulations based on principles of continuum mechanics.
- To understand the plastic stress strain relations, criteria of yielding and elasto- plastic problems.

Course Outcomes (COs)

The student will be able to

1. Formulateand apply the continuum mechanicsin various metal forming operations.
2. Model the elastic and plastic behaviour of structural engineering materials.

Unit I
Analysis of stress and strain

Stress at a point, stress tensor, stress concentration factor, stress transformations, principal stresses, octahedral stress, equations of equilibrium, strain tensor, principal strains, strain-displacement relations, compatibility conditions, measurement of surface strains using strain gauges.

9 Hours

Unit II
Constitutive equations

General theory, generalized Hooke's law, equations of elasticity, formulation of the general elasticity problem, boundary conditions, two dimensional problems in rectangular and polar co-ordinates, Airy's stress function- Membrane stresses-Membrane stresses in axisymmetric shells, meridonial stress and circumferential stress.

9 Hours

Unit III
Contact stresses

Introduction, geometry of contact surfaces, notation and meaning of terms, expressions for principal stresses, method of computing contact stresses – Analytical and numerical method.

9 Hours

Unit IV
Plasticity

Plastic flow and its microscopic and macroscopic descriptions, stress-strain curves of real materials, definition of yield criterion, concept of a yield surface in principal stress space, yield criteria, Teresa, von Misses, difference between Tresca and von Mises criteria.

9 Hours

Unit V
Plastic Strain Analysis

Prandtl-Reuss and Levy-Mises equations, deformation in plane stress-yielding of thin sheet in biaxial and uniaxial tension. Plane strain deformation-stress tensor, hydrostatic and deviatoric components, plastic potential, plastic instability, effect of strain rates and temperature effects on flow stress. Introduction to slip line theory, weighted residual method.

9 Hours

Unit VI[$]

Case studies - Simple and Unsymmetrical Bending, Shear Centre and experimental stress analysis using software.

Total: 45Hours

Reference(s)

1. S. P. Timoshenko and J. N. Goodier, *Theory of Elasticity*, McGraw Hill International Editions, 2005.
2. G E. Dieter, *Mechanical Metallurgy*, McGraw Hill, 2007.

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

3. W. David and A. Rees, *Basic Engineering Plasticity*, Elsevier, 2006.
4. A. P. Boresi , R J. Schmidt and O. M. Sidebottom , *Advanced Mechanics of Materials*, John Wiley and Sons, Inc., 2003.
5. L. S. Srinath, *Advanced mechanics of solids,* Tata McGraw Hill Education, Second reprint, 2008.
6. Jinxing Liu and Ai KahSoh ,*Bridging strain gradient elasticity and plasticity toward general loading histories*, Mechanics of Materials , Volume 78, pp11–21, 2014.
7. P. Nardinocchi, L. Teresi and V. Varano, The *elastic metric: A review of elasticity with large distortions*, International Journal of Non-Linear Mechanics Volume 56, pp34–42, 2013.
8. J.L. Chaboche, *A review of some plasticity and viscoplasticity constitutive theories*, International Journal of Plasticity, Vol 24, Issue 10, pp1642–1693, 2008.

15ED15 MECHANICAL VIBRATIONS

3 2 0 4

Course Objectives

- To study various free and forced vibration analysis of single and multi-degree of freedom linear vibration systems.
- To understand the mathematical models and differential equations of real time vibration system.
- To learn the operating principles of various vibration measuring instruments.

Course Outcomes (COs)

The student will be able to

1. Analysis of free and forced vibration for single and multi-degree of freedom linear vibration systems.
2. Develop mathematical model of continuous mass vibrating system.
3. Measure and control the vibration on mechanical system.

Unit I

Fundamentals of Vibration

Basic concept of vibration- classification, Analysis Procedure-Mass, spring and Damping elements-Harmonic Motion - Free vibration of damped and undamped system- harmonically excited vibration-Equation of motion, Response of damped system under harmonic force, Response of Damped system under base excitation and rotating unbalance - Duhamel's Integral–Impulse Response function.

10 Hours

Unit II

Two Degree Freedom System

Equation of motion– Free and Forced vibration Analysis- Coordinate Couplings and Principal Coordinates- Transfer function approach-Lagrange's equation- applications.

8 Hours

Unit III

Multi-Degree Freedom System

Influence Coefficients and stiffness coefficients- Flexibility Matrix and Stiffness Matrix – Eigen Values and Vectors- Matrix Iteration Method –Approximation Methods-Dunkerley, Rayleigh's and Holzer Method.

9 Hours

Unit IV

Continuous Systems

Introduction- Longitudinal, Transverse and torsional vibrations of string, beam and shaft –boundary conditions- governing equations- Rayleigh Method, Rayleigh – Ritz method – applications

9 Hours

Unit V
Vibration Measurement and Control
Transducer – Vibration Pickups – Frequency Measuring Instruments – Vibration exciter – dynamic Testing Machine – Machine Condition Monitoring and diagnosis- Control of vibration and natural frequencies – vibration Isolation – Vibration Absorber.

9 Hours

Unit VI$
Case study -forced vibration with elastically coupled viscous dampers and experimental modal analysis.

Total: 45+30 Hours

Reference(s)

1. S. S. Rao, *Mechanical Vibrations*, Pearson Education, 2004.
2. W.T. Thomson,*Theory of Vibration with Applications*, CBS Publishers and Distributors, New Delhi, 2006.
3. A.K. Mallik, *Principles of Vibration Control*, Affiliated East-West Press Pvt. Ltd, 2004.
4. R. N. Iyengar, *Elements of Mechanical Vibration*, I K International Publishing House Pvt. Ltd, New Delhi, 2007.
5. S. Graham Kelly and Shashidar K. Kudari, *Mechanical Vibrations*, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2007.
6. M. J. Griffin and J. Griffin,*Human response to vibration: Reviews and abstracts*, Journal of Sound and Vibration, Volume 27, Issue 4, pp 597-600, 22 April 1973.
7. http://nptel.ac.in/courses/112103111.

15ED17/15CC17 GEOMETRIC MODELLING AND SIMULATION LABORATORY
(Common to CAD/CAM & Engineering Design)

0 0 4 2

Course Objectives
- To provide hand on training to create surface, two and three dimensional modeling of machine components using modeling software.
- To provide the hands on training to simulate various simple mechanisms.

Course Outcomes (COs)
Students will be able to
1. Model and assembly of various components of mechanical products using modelling software.
2. Draw the different kind of mechanism and assembly of machine part.

List of Experiments
1. Assembly modeling of various parts of the clamping device which are used in machines.
2. Assembly modelling of various parts of the center lathe.
3. Assembly modelling of piston, gudgeon pin and the crank shaft of IC engine with limits and tolerance.
4. Assembly modelling of various parts of the butterfly valve.
5. Assembly modelling of various parts of pulley supports.
6. Assembly modelling of various parts of Fixture parts with limits and tolerances.
7. Assembly modeling of various parts of the shaper tool head parts
8. Surface modeling a piston of an I.C. engine.
9. Assembly modelling and simulation of a valve operating mechanism of internal combustion engine.
10. Assembly modelling and simulation of a Mechanism of Hand Pump.
11. Assembly modelling and simulation of a Mechanism of wiper.
12. Assembly modelling and simulation of a transmission system used in automobiles

Total: 60 Hours

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

15ED18 MECHANICAL VIBRATIONS ANALYSIS LABORATORY

0 0 4 2

Course Objectives

- To measure and record the vibration response of mechanical systems.
- To provide training on model and simulate the vibration response of real mechanical systems.
- To train to design a vibration controller on real world system like rotary pendulum and active suspension systems.

Course Outcomes (COs)

Students will be able to

1. Measure and record vibration on various Mechanical vibration systems.
2. Model and simulate the vibration response of real mechanical vibration systems.
3. Design a controller for vibration control of mechanical system.

List of Experiments

1. Determination of natural frequency, displacement, acceleration and velocity of structure using vibration exciter and accelerometer.
2. Modelling and simulation of kinematic analysis of slider crank mechanism using MATLAB and interpret the results.
3. Modelling and simulation of kinematic analysis of four bar mechanism using MATLAB and interpret the results.
4. Simulation of given Linear System /Nonlinear System (Step, Ramp and Sine Wave signal) using MATLAB and interpret the results.
5. Frequency Response Analysis (Draw the Phase Margin and Gain Margin, Bode Plots) of given system using MATLAB and evaluate the system Stability.
6. Real time control of PID controllers and its effects on the feedback loop response. Investigation on the characteristic of speed controller of DC MotorQUANSER QUBE SERVO.
7. Design a position controller of DC motor for accurate position of object using robot manipulator.
8. Determination of natural frequency, displacement, of cantilever beams using strain gauge and interprets the results.
9. Determination of suspension travel limit and acceleration of automobile suspension system using Quarter car suspension test rig.
10. Determination of natural Frequency, displacement and acceleration of singe degree mass spring system.
11. Stability analysis of given linear system by Root Locus / Nyquist Plot Method using MATLAB and evaluate the system Stability.
12. Real time Position control of Rotary inverted Pendulum using QUANSER QUBE SERVO kit.

Total: 60 Hours

15GE19 BUSINESS ENGLISH – I

1 0 2 2

Course Objectives

- To acquire skills for using English in workplace effectively.
- To communicate for essential business needs.
- To prepare students for taking BEC Vantage level examination which is an International Benchmark for English language proficiency of Cambridge English Language Assessment (CELA).

Course Outcomes (COs)

The students will be able to

1. Enable students to get International recognition for work and study.
2. Use English confidently in the International business environments.
3. Take part in business discussion, read company literature, write formal and informal business correspondences and listen and understand business conversations.

Unit I

Grammar and Vocabulary

Comparison of adjectives – forming questions – asking complex questions – expressing purpose and function – tenses – conditionals – time statements – modal verbs – active and passive voice – articles – direct and indirect speech – cause and effect – relative pronouns – expressions followed by – ing forms – countable / uncountable – acronyms – marketing terms / vocabulary – financial terms – collocations – discourse markers.

10 Hours

Unit II

Listening

Purposes of listening – features of listening texts – potential barriers to listening – specific listening skills – strategies to use when listening– distinguishing relevant from irrelevant information – gap filling exercise – multiple-choice options – note completion – matching and multiple choice questions – listening for specific information, gist, topic, context and function.

7 Hours

Unit III

Speaking

Word and sentence stress – clear individual sounds – turn taking – initiating and responding - intonation patterns – pronunciation – mother tongue intrusion– conversation practice – turn-taking and sustaining the interaction by initiating and responding appropriately.

10 Hours

Unit IV

Reading

Purposes of reading – potential barriers to reading – paraphrasing – identifying facts and ideas – skimming and scanning for information – matching statements with texts– spotting reference words – understanding text structure – understanding the ideas in a text – distinguishing between the correct answer and the distractor – understanding cohesion in a text – deciphering contextual meaning of words and phrases – cloze – proof reading – transcoding.

9 Hours

Unit V

Writing

Paragraphing a text – using appropriate connectives – editing practice –Longer Documents: writing a proposal.

10 Hours

Total: 45 Hours

Reference(s)
1. Guy Brook-Hart, *BEC VANTAGE: BUSINESS BENCHMARK Upper-Intermediate – Student's Book*, 1st Edition, Cambridge University Press, New Delhi, 2006.
2. Cambridge Examinations Publishing, *Cambridge BEC VANTAGE – Self-study Edition*, Cambridge University Press, UK, 2005.

15ED21 RESEARCH METHODOLOGY

3 0 0 3

Course Objectives
- To understand some basic concepts of engineering research and its methodologies.
- To identify various sources of information for literature review and data collection.
- To families the various procedures to formulate appropriate research problem and design of experiments.

Course Outcomes (COs)
The students will be able to
1. Demonstrate the concepts of engineering research and its methodologies.
2. Understand the various methods used to collect the data to research.
3. Formulate appropriate research problem and conduct the experiments using systematics methods.

Unit I
Introduction
Definition, mathematical tools for analysis, Types of research, exploratory research, conclusive research, modelling research, algorithmic research, Research process- steps.
Data collection methods- Primary data – observation method, personal interview, telephonic interview, mail survey, questionnaire design. Secondary data- internal sources of data, external sources of data.

9 Hours

Unit II
Sampling Methods
Scales – measurement, Types of scale – Thurstone's Case V scale model, Osgood's Semantic Differential scale, Likert scale, Q- sort scale. Sampling methods- Probability sampling methods – simple random sampling with replacement, simple random sampling without replacement, stratified sampling, cluster sampling. Non-probability sampling method – convenience sampling, judgment sampling, quota sampling.

9 Hours

Unit III
Hypotheses Testing
Testing of hypotheses concerning means -one mean and difference between two means -one tailed and two tailed tests, concerning variance – one tailed Chi-square test.

9 Hours

Unit IV
Design of Experiments
Introduction, Types - Full and Fractional factorial Design- Orthogonal Array Design - Taguchi techniques - Regression Models - Response Surface Methods.

9 Hours

Unit V
Optimization and Report Writing
Optimization – classification- methods- genetic, particle swarm and artificial bee colony algorithms. Report writing- Types of report, guidelines to review report and typing instructions - oral presentation.

9 Hours

Unit VI[$]

Case Study: apply Research Methodology principles into design and manufacturing field.

Total: 45 Hours

Reference(s)

1. Kothari, C.R., *Research Methodology –Methods and techniques*, New Age Publications, New Delhi, 2009.
2. Panneerselvam, R., *Research Methodology*, Prentice-Hall of India, New Delhi, 2004.

15ED22/15CC22 DESIGN FOR MANUFACTURE AND ASSEMBLY
(Common to CAD/CAM & Engineering Design)

3 0 0 3

Course Objectives

- To understand the selection of materials, methods, fit and tolerance concepts to design a product.
- To familiarize the basic concept of design for castings, welding, sheet metal, forging and manufacturing Processes.
- To understand the basic procedure of design for assembly and environments.

Course Outcomes (COs)

The students will be able to

1. Select the materials, methods, fit and tolerance to design of a product.
2. Demonstrate the design procedure for castings, welding, forging, sheet metal and manufacturing Processes.
3. Demonstrate the guidelines to minimize the environmental impacts using Recyclability and remanufacture concepts.

Unit I

Introduction to Tolerances

Tolerances- Limits, Fits, tolerance Chains, Charts and identification of functional dimensions- Design for manufacturability considerations - Geometric tolerances- Indian standards, ASME standards and Applications- surface finish.

7 Hours

Unit II

Design for Castings, Welding, Sheet Metal and Forging Processes

Materials- Selection Factors- Space factor - Size - Weight - Surface properties and Manufacturing methods. Design for castings- parting line, Minimization of core – Design for welding process - Welding defects – Design for Sheet metal operations- Design for Forging process- Case Studies.

12 Hours

Unit III

Design for Machining Processes

Design features for machining – Lathe, Drilling, Milling operations- Keyways - Doweling, Counter sunk screws - Simplification by separation and amalgamation- Design for machinability, economy, clampability and accessibility- factors for reducing machining area.

12 Hours

Unit IV

Design for Assembly

Rules and methodologies to design components-manual, automatic and flexible assembly- DFMA Tools- concurrent engineering – Redesign, DFA-index, poke-yoke, lean and six sigma concepts, design for manual and automatic assembly.

7 Hours

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Unit V
Design for the Environment
Introduction – Environmental objectives – Global issues – Regional and local issues – Guide lines, Methods and applications – Lifecycle assessment –Techniques to reduce environmental impact – Design to minimize material usage – Design for disassembly – Design for Recyclability – Design for remanufacture.

7 Hours

Unit VI$
Computer aided design for assembly and Environment using software- Case Studies Problems.

Total: 45 Hours

Reference(s)

1. A. K. Chitale and R. C. Gupta, *Product Design and Manufacturing*, Prentice Hall Inc. 2007.
2. G. Boothroyd, P. Dewhurst and W. Knight, *Product Design for Manufacture and Assembly*, Marcell Dekker, 2002.
3. Bryan R. Fischer, *Mechanical Tolerance stackup and analysis*, Marcell Dekker, 2004.
4. M. F. Spotts, *Dimensioning and Tolerance for Quantity Production*, Prentice Hall Inc., 2002.
5. J. G. Bralla, *Hand Book of Product Design for Manufacturing*, McGraw Hill Publications, 2000.
6. J. Lesko, *Industrial Design, Materials and Manufacture Guide*, John Willy and Sons, Inc, 2000.
7. http://nptel.ac.in/courses/107103012.

15ED23 FAILURE ANALYSIS AND DESIGN

3 0 0 3

Course Objectives
- To impart knowledge about various modes of failure which leads to safe design.
- To learn about large variety of fracture mechanisms and fracture modes associated with failure.
- To provide fundamental knowledge of corrosion and environmentally-assisted cracking.

Course Outcomes (COs)
The students will be able to
1. Understand the various modes of failure and material behavior in fracture loading.
2. Demonstrate fracture mechanisms and fracture, creep, fatigue, corrosion and wear failures.
3. Implement of failure analysis principles in innovative applications.

Unit I
Materials and Design Process
Factors affecting the behavior of materials in components, effect of component geometry and shape factors, design for static strength, stiffness, designing with high strength and low toughness materials, material selection process, introduction to stress, two dimensional and three dimensional state of stress, Mohr's circle two and three dimensions, hydrostatic stress, von-Mises, maximum shear stress (Tresca), octahedral shear stress.

9 Hours

Unit II
Fracture Mechanics
Ductile fracture, brittle fracture, cleavage-fractography, ductile to brittle transition, factors affecting ductile to brittle transition, fracture mechanics approach to design-energy criterion, stress intensity approach, time dependent crack growth and damage - Linear Elastic Fracture Mechanics: Griffith theory, energy release rate, Instability and R-curve, stress analysis of cracks-stress intensity factor, Crack growth instability analysis.

9 Hours

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Unit III
Fatigue
Statistical nature of fatigue, signal-noise curve, low cycle fatigue, strain life equations, structural feature of fatigue, fatigue crack propagation, effect of stress concentration, size, surface properties, metallurgical variables on fatigue, case studies, designing against fatigue, detail design, improvements after failure and service, fatigue of bolts, welded and adhesive joints. Fatigue Tests-Purpose, specimen, fatigue test procedures, evaluation of fatigue test results, crack growth measurement. Creep, stress rupture, elevated temperature fatigue, super plasticity.

9 Hours

Unit IV
Corrosion and Wear Failures
Types of corrosion, Factors influencing corrosion failures, analysis of corrosion failures, stress corrosion cracking - sources, characteristics of stress corrosion cracking, procedure of analysing stress corrosion cracking, various types of hydrogen damage failures, corrective and preventive action. Types of wear, lubricated and non – lubricated wear, wear on different materials, different methods of wear measurement. Role of friction on wear, analysis of wear failures, wear tests - ferrography.

9 Hours

Unit V
Failure Analysis Tools
Reliability concept and hazard function, application of Poisson, exponential and Weibull distribution for reliability, bathtub curve, parallel and series system, failure mode effect analysis - definition-Design, types, process, industrial case studies / Projects.

9 Hours

Unit VI$
Relationship of failure analysis to the design process, factors related to failures, failure theories for brittle materials, wear testing machines pin on disc.

Total: 45 Hours

Reference(s)

1. T. L. Anderson, *Fracture Mechanics: Fundamentals and Applications*, CRC Press, 2005.
2. F.Michael and Ashby, *Material Selection in Mechanical Design*, Butterworth Heinemann, 2004.
3. ASM Metals Handbook, *Failure Analysis and Prevention*, ASM Metals Park, Ohio, USA, Vol.10, 2002.
4. J.E. Shigley and Mische, *Mechanical Engineering Design, McGraw Hill, 2000.*
5. Yiannis Papadopoulos, *Engineering failure analysis and design optimization with HiP-HOPS" Engineering Failure Analysis*, Volume 18, Issue 2, pp 590–608, March 2011.
6. F. Rui, Martins, *Failure analysis of bilge keels and its design improvement*, Engineering Failure Analysis, Volume 27, pp 232–249, January 2013.
7. http://nptel.ac.in/courses/112101005/28.

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

15ED24 COMPUTATIONAL FLUID DYNAMICS

3 2 0 4

Course Objectives

- To acquire the knowledge to formulate the governing equations in Fluid flow and Heat transfer problems.
- To impart knowledge on numerical methods to solve the simple problems in Fluid flow applications.
- To familiarize the advanced computational fluid dynamics methods in real time problems.

Course Outcomes (COs)

The students will be able to

1. Formulate governing partial differential equations of fluid flow and heat transfer problems.
2. Solve and find the solution to fluid dynamics problems using suitable numerical methods.
3. Understand the advanced computational fluid dynamics methods in real time problems.

Unit I
Introduction

Introduction-Impact and applications of CFD in diverse fields - governing equations of fluid dynamics-continuity – momentum and energy - generic integral form for governing equations -Initial and Boundary conditions -Classification of partial differential equations-Hyperbolic, Parabolic, Elliptic and Mixed types - Applications and Relevance.

9 Hours

Unit II
Numerical Methods

Basic Aspects of Discretization, Discretization techniques -Finite difference, Finite volume and Finite element method -Comparison of discretization by the three methods. Introduction to Finite differences, Difference equations, Uniform and non-uniform grids, numerical errors, Grid independence test and Optimum step size.

10 Hours

Unit III
Conduction and Convection

Steady One dimensional conduction -two and three - dimensional conduction-Steady one - dimensional convection and Diffusion - Transient one - dimensional and two - dimensional conduction- Explicit, Implicit, Crank - Nicolson, ADI scheme - Stability criterion.

9 Hours

Unit IV
Computational Fluid Dynamics Procedures

Pressure Correction SIMPLE algorithm, Practical guidelines for CFD simulation processes, Grid Generation types, problem setup, types of boundary conditions.

8 Hours

Unit V
Turbulence Models

Mixing length model, two equation (k-Є) models– High and low Reynolds number models– Structured Grid generation– Unstructured Grid generation – Mesh refinement–Adaptive mesh.

9 Hours

Unit VI$

Case studies on transient conduction, boundary layer over a flat plate, convection analysis of internal and external flow.

Total: 45+30 Hours

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Reference(s)

1. J. D. Anderson., Jr. *Computational Fluid Dynamics- The Basic with Applications*, Tata McGraw Hill Publishing Company Pvt Ltd., New Delhi, 2004
2. P. Ghosdastidar, *Computational Fluid Flow and Heat Transfer*, Tata McGraw Hill Publishing Company Pvt Ltd., New Delhi, 2003
3. K. A. Hoffman, *Computational Fluid Dynamics for Engineering*, Engineering Education System, Austin, Texas 2005.
4. Muralidhar and T. Sundarajan, *Computational Fluid Flow and Heat Transfer*, Narosa Publishing House, New Delhi, 2002.
5. S. V. Patankar, *Numerical Heat Transfer and Fluid Flow*, Hemisphere, New York, 2004.
6. T. J. Chung, *Computational Fluid Dynamics*, Cambridge University Press, Chennai 2003.

15ED27/15CC27 COMPUTER AIDED DESIGN ENGINEERING LABORATORY
(Common to CAD/CAM & Engineering Design)

0 0 4 2

Course Objectives

- To understand the finite element procedures to solve one, two and three dimensional problems using software.
- To provide training to solve the structural, thermal, fluid flow and vibration related real world problems using software.
- To understand the interpretation concepts of results obtained from finite element post process.

Course Outcomes (COs)

The student will be able to

1. Create model, mesh and analyze of mechanical components using finite element analysis software.
2. Solve the structural, thermal, fluid flow and vibration related real world problems using software.
3. Simulate and Interpret results obtained from finite element post process.

List of Exercises

1. When a truss is subjected to certain temperature, what happens to the truss? When another truss is loaded in all the three axes, how will be its behavior?
2. When one end of a rigid body is hinged and other end loaded with two supports in between by a copper rod and a steel rod, what will be the member forces and stresses?
3. Contemplate, how the shear stress and bending stress will occur a beam of ‘I’ section which is simply supported at the ends and load acting at the center?
4. If a closed cylinder made of steel is subjected to an internal pressure, how far the axial stress and hoop stress will influence the cylinder wall?
5. When a Belleville spring is subjected to a load on the inner edge of the spring, how does the spring deflect?
6. Considering a culvert in which load is distributed uniformly at top, symmetric and assuming plain strain condition, find the maximum stress and deflection that occurring the culvert.
7. A thermal storage device with a phase change material (PCM) is used to conserve energy during high energy demand periods. The PCM used is paraffin wax which is surrounded by a metallic pipe subjected to a constant temperature. Estimate the time required to completely melt the wax from its solid-state.
8. When a solid stepped cantilever bar of circular cross section is subjected to a twisting moment, how will be the maximum twist and shear stress?
9. Conduct a harmonic forced response test by applying a cyclic load (harmonic)at the end of a cantilever beam with load acting in a range of frequency. Suggest a suitable method in which maximum displacement to occur.

10. Perform various hardness testing methods for a given material and suggest a suitable method for the given load range.
11. Contemplatewhensteadystateconductionwillbeattainedforagivencomponentwiththespecified boundary condition.

Total: 60 Hours

15GE29 BUSINESS ENGLISH – II

1 0 0 1

Course Objectives

- To acquire skills for using English in business environment.
- To communicate appropriately in business contexts.
- To prepare students for taking BEC Vantage level examination conducted by the Cambridge English Language Assessment (CELA).

Course Outcomes (COs)

The students will be able to

1. Enable students to acquire business terms for communication.
2. Use English confidently in the business contexts.
3. Take part in business discussion and write formal and informal business correspondences.

Unit I

Speaking

Non-verbal communication – agreeing / disagreeing, reaching decisions, giving and supporting opinions – making mini presentations – extending on conservations – collaborative task – tongue twisters.

6 Hours

Unit II

Writing

Business letters – fax – Shorter Documents: e-mail - memo – message - note – report writing – formal / informal styles.

9 Hours

Total: 15 Hours

Reference(s)

1. Guy Brook-Hart, *BEC VANTAGE: BUSINESS BENCHMARK Upper-Intermediate – Student's Book*, 1st Edition, Cambridge University Press, New Delhi, 2006.
2. Cambridge Examinations Publishing, *Cambridge BEC VANTAGE – Self-study Edition*, Cambridge University Press, UK, 2005.

15ED51 PRODUCT DESIGN AND DEVELOPMENT

3 0 0 3

Course Objectives

- To acquire knowledge about the opportunities and challenges in product development.
- To understand the standard procedures involved in concept development and design process.
- To understand Intellectual Property Rights (IPR)applied in engineering practices.

Course Outcomes (COs)

The student will be able to

1. Demonstrate the social, environmental and ethical concerns to be addressed during Product development.
2. Realize the modelling and embodiment Principles used in product development process.
3. Understand the concepts of robust design and development of physical models using product design theory.

Unit I
Introduction
Product Development- Characteristics, Duration, Challenges, Organizations. Development Process - Processes, Process Flow. Product Planning - Identifying Opportunities, Prioritization, Resource allocation and Pre-Project Planning. Customer Needs - Data gathering, Organizing Needs

9 Hours

Unit II
Concept Development
Product and Target specification, various steps in concept generation, Brainstorming, Morphological analysis, Selection of Concepts - Subjective decision making, Criteria ranking, Criteria weighting, Datum method, Design Evaluation method, Principles of Computer aided decision making

9 Hours

Unit III
Design Process
Concept Testing - Survey, Response and Interpretation. Product Architecture, Platform planning, System level design issues. Embodiment design - Introduction, Size and strength, Scheme drawing, Form design, Provisional material and process determination, Design for assembly and manufacture, Industrial design. Modelling - Introduction, Mathematical modelling, Optimization, Scale models, Simulation

10 Hours

Unit IV
Planning for Manufacture and Management
Detail Design - Factor of safety, Selection procedure for bought out components, Material Selection, Robust design, Experimental Plan. Design Management - Management of design for quality, Project planning and control, Production Design Specification (PDS), Quality Function Deployment (QFD) process, Design review, Value analysis/engineering

9 Hours

Unit V
Intellectual Property Rights and Project Economics
Intellectual Property Rights - Introduction, Study prior inventions, Write the description of theinvention, Refine Claims, Pursue application. Economics and Management - Financial Model, Project Trade - Off, Accelerating Projects, Project Execution

8 Hours

Unit VI[$]
Case studies: Customer input for successful product design and Time management in new product Development.

Total: 45 Hours

Reference(s)
1. T. Karl, Ulrich and D. Steven, and Eppinger, *Product Design and Development,* McGraw Hill, 2009.
2. G. E. Dieter, *Engineering Design*, McGraw - Hill International, 2013.
3. Ken Hurst, *Engineering Design Principles*, Elsevier Science and Technology Books, 2010.
4. E. Deborah and Bouchoux, *Intellectual Property Rights*, Cengage Learning India Pvt.**,** 2008.
5. Kevin N. Otto, Kristin L. Wood, *Product Design*, Pearson education, 2009.
6. Stephen Rosenthal, *Effective Product Design and Development*, Business One Orwin, Homewood,ISBN, 1-55623-603-4, 1992.
7. www.me.mit/2.7444.

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

15ED52 ADVANCED STRENGTH OF MATERIALS

3 0 0 3

Course Objectives

- To understand the calculation of stresses and strains in components under normal, shear and torsional loading conditions.
- To acquire knowledge on the concept of unsymmetrical bending, curved beam, plates and contact stresses.

Course Outcomes (COs)

The student will be able to

1. Calculate stresses, strains and deformation under different loading conditions.
2. Solve the problems related to unsymmetrical bending, non-circular sections, plates and contact stresses.

Unit I
Elasticity

Stress - Strain relations and equilibrium equations of elasticity in Cartesian, Polar and Spherical coordinates-Differential equations of equilibrium-Compatibility-Boundary conditions -Airy's stress -Representation of three-dimensional stress of a tension-Generalized Hook's law.

9 Hours

Unit II
Shear Centre and Unsymmetrical Bending

Location of shear center for various sections - Shear flows - Stresses and deflections in beams subjected to unsymmetrical loading - Kern of a section.

8 Hours

Unit III
Curved Flexible Members and Stresses in Plates

Circumference and radial stresses – Deflections-Curved beam with restrained ends-Closed ring subjected to concentrated load and uniform load-Chain links and crane hooks-Stresses in circular and rectangular plates due to various types of loading and end conditions.

10 Hours

Unit IV
Torsion of Non-Circular Sections

Torsion of rectangular cross section-St.Venants theory-Elastic membrane analogy-Prandtl's stress function-Torsional stress in hollow thin walled tubes.

8 Hours

Unit V
Stresses in Rotating Member and Contact Stresses

Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness with allowable speeds-Methods of computing contact stress-Deflection of bodies in point and line contact applications.

10 Hours

Unit VI$

Case study on state of stress at the bucket of a tractor, case study on structural analysis of a non-bonded flexible riser cross section.

Total: 45 Hours

Reference(s)

1. S. Timoshenko and Goodier, *Theory of Elasticity*, McGraw Hill Publications, 2001.
2. A. P. Boresi, R. J. Schmidt and O. M. Sidebottom, *Advanced Mechanics of Materials*, John Wiley and Sons, Inc., 2008.
3. Wang, *Applied Elasticity*, McGraw Hill, 2006.

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

4. Robert D. Cook, Warren C. Young, *Advanced Mechanics of Materials*, Mc-Millan Pub. Co., 2008.
5. L. S. Srinath, *Advanced mechanics of solid*, Tata McGraw Hill Education, Second reprint, 2008.
6. J. Chakrabarty, *Theory of plasticity*, 3rd Edition, Elsevier India, 2009.
7. E.P. Popov, *Engineering Mechanics of Solids*, Prentice Hall of India, 2010.
8. http://nptel.iitm.ac.in/video.php?courseId=1006.

15ED53 DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS

3 0 0 3

Course Objectives

- To familiarize the various hydraulic and pneumatics components and its applications.
- To understand the various design procedures of hydraulic and pneumatic systems used in various applications.
- To acquire knowledge in electro-hydraulic and pneumatic systems using Programmable Logic controller and microprocessor based programs.

Course Outcomes (COs)

The student will be able to

1. Select various hydraulic and pneumatics components for industrial applications.
2. Design circuits in hydraulic and pneumatic systems for various applications.
3. Write the Programmable Logic controller and microprocessor programme used in electro-hydraulic and pneumatic systems.

Unit I

Oil Hydraulic Systems and Hydraulic Actuators

Fluids – Properties - Types of Fluid power system - Hydraulic Power Generators – Selection and specification of pumps - Pump characteristics. Linear and Rotary Actuators – Selection - Specification and characteristics.

7 Hours

Unit II

Control and Regulation Elements

Direction Control Valves – Check valve, pilot operated check valve, Three-Way valves - Four – Way valves, Manually Actuated Valves, Mechanical Actuated Valves and Pilot - Actuated Valves, Solenoid - Actuated Valves - Shuttle Valves. Pressure Control Valves – Simple Pressure Relief Valves, Compound Pressure Relief Valves - Pressure Reducing Valves - Unloading Valves - Sequence Valves, Counter Balance Valves - Flow Control Valves – Needle Valves. Non-Pressure - Compensated Valves, Pressure – Compensated Valves - Non-return and safety valves - Actuation systems.

11 Hours

Unit III

Hydraulic Circuits

Reciprocation - Quick return – Sequencing - Synchronizing Circuits - Accumulator circuits - Industrial circuits - Press circuits - Hydraulic milling machine – Grinding - Planning - Copying – Forklift - Earth mover circuits, Design and selection of components - Safety and emergency mandrels.

9 Hours

Unit IV

Pneumatic Systems and Circuits

Compressors – Principal –Types - Control elements, position and pressure sensing - Logic circuits - Switching circuits - Fringe conditions modules and these integration - Sequential circuits - Cascade methods - Mapping methods - Step counter method - Compound circuit design - Combination circuit design.

9 Hours

Unit V
Installation, Maintenance and Special Circuits
Pneumatic equipment- Selection of components - Design calculations – Application - Fault finding - Hydro pneumatic circuits - Use of microprocessors for sequencing - PLC, Low cost automation - Robotic circuits.

9 Hours

Unit VI$
Application of pneumatic systems in machines used in manufacturing.

Total: 45 Hours

Reference(s)
1. Antony Esposito, *Fluid Power with Applications*, Pearson education,7th Edition 2008.
2. A. Dudley, Pease and J. J. Pippenger, *Basic fluid power*, Prentice Hall. 2010.
3. Andrew Parr, *Hydraulics and Pneumatics (HB),*Jaico Publishing House, 2006.
4. W. Bolton, *Pneumatic and Hydraulic Systems*, Butterworth –Heinemann, 2006.
5. Elise Berliner, PhD, BerrinOzbilgin, MBA, and Deborah A. Zarin, MD, Rockville, Md, *A systematic review of pneumatic compression for treatment of chronic venous insufficiency and venous ulcers*, Journal of Vascular Surgery, 2003, pp.539-544.
6. MitarJocanović, DragoljubŠević, VeliborKaranović, Ivan Beker and Slobodan Dudić, *Increased efficiency of hydraulic system through reliability theory and monitoring of system operating parameters*, Journal of Mechanical Engineering, 58(4), pp.281-288, 2012.

15ED54 DESIGN OF MATERIAL HANDLING EQUIPMENT

3 0 0 3

Course Objectives
- To impart knowledge on operating principles of various material handling systems and their limitations.
- To understand the design procedures of various materials handling equipment used in industry.

Course Outcomes (COs)
The student will be able to
1. Demonstrate the working principles of material handling equipment like Hoists, Conveyors and elevators
2. Design and select various material handling equipment used in industry.

Unit I
Materials Handling Equipment
Introduction – Importance of material handling – Principle of material handling – Factors influences the choice of material handling - Material handling Equipment – Types - Selection and applications –Scope of material handling.

9 Hours

Unit II
Design of Hoists
Design of hoisting elements: Hemp and wire ropes - Design of ropes – Pulleys - Pulley systems - Sprockets and drums - Load handling attachments - Design of forged hooks and eye hooks – Brakes-shoe - Band and cone types.

9 Hours

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Unit III
Drives of Hoisting Gear
Hand and power drives - Traveling gear - Rail traveling mechanism - Cantilever and monorail cranes –Slewing - Jib and luffing gear - Cogwheel drive - Selecting the motor ratings.

9 Hours

Unit IV
Conveyors
Types - Description - Design and applications of Belt conveyors - Apron conveyors and escalators - Pneumatic conveyors - Screw conveyors.

9 Hours

Unit V
Elevators
Bucket elevators: Design - Loading and bucket arrangements - Cage elevators - Shaft way – Guides - Counter weights - Hoisting machine - Design of fork lift trucks.

9 Hours

Unit VI$
Case study on popular material handling equipment used in engineering industries.

Total: 45 Hours

Reference(s)
1. Charles Reese, *Material handling Systems*, Taylor and Francis, 2005.
2. Kari H. E.Kroemer, *Ergonomic Design of Material Handling Systems*, CRC Press USA, 2004.
3. Myer Kutz, *Environmental Conscious Materials Handling*, Wiley series In Environmentally Conscious Engineering, 2010.
4. R. B. Chowdary and G. R. N.Tagore ,*Material Handling Equipments*, Khanna Publishers, 2003.
5. M. Alexandrov, *Materials Handling Equipments*, MIR Publishers, 2002.
6. KalaikathirAchchagam, *Design Data Book*, P.S.G. Tech, Coimbatore, 2012.
7. V. Wankhade and Suman Sharma, *Design Improvement for Enhancing the Performance of drag Conveyor Chain and its Cost Reduction*, Journal of Scientific & Industrial Research Vol. 65, pp. 619-624, August 2006.

15ED55 DESIGN OF THERMAL SYSTEMS

3 0 0 3

Course Objectives
- To familiarize the working principles of various components of thermal systems.
- To understand the design procedures of Pumps, Heat Exchangers, Condensers and Evaporators.

Course Outcomes (COs)
The student will be able to
1. Demonstrate the construction and working principle of thermal systems and thermal equipment.
2. Design and select the thermal components of various thermal systems.

Unit I
Introduction
Design Principles, workable systems, optimal systems, matching of system components, economic analysis, depreciation, gradient present worth factor.

9 Hours

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Unit II
Mathematical Modelling
Equation fitting, nomography, empirical equation, regression analysis, different modes of mathematical models, selection, computer programmes for models.

9 Hours

Unit III
Design and Modelling of Thermal Equipment
Design and Modelling-Heat exchangers, evaporators, condensers, absorption and rectification columns, compressor, pumps, simulation studies, information flow diagram, solution procedures.

9 Hours

Unit IV
Systems Optimization
Objective function formulation, constraint equations, mathematical formulation, Calculus method, dynamic programming, geometric programming, linear programming methods, solution procedures.

9 Hours

Unit V
Dynamic behaviour of thermal system
Transient / unsteady state simulation, Steady state simulation, Laplace transformation, feedback control loops, stability analysis, nonlinearities.

9 Hours

Unit VI$
Failure analysis in heat exchangers and pumps

Total: 45 Hours

Reference(s)

1. R. F. Boehm, *Developments in the Design of Thermal System*, Cambridge University Press, 2005.
2. Y.Jaluria, *Design and Optimization of Thermal Systems*, McGraw- Hill, 2007.
3. L. C. Burmeister, *Elements of Thermal-Fluid System Design*, Prentice Hall, 2000.
4. F.P. Incropera and D.P. Dewitt, *Introduction to Heat Transfer*, Wiley, 2001.
5. R.K. Shah and D. P. Sekulic, *Fundamentals of heat exchanger design*, john Wiley and Sons, Inc., 2003.
6. Govind N Kulkarni, Shireesh B. Kedare, SantanuBandyopadhyay, *Design of solar thermal systems utilizing pressurized hot water storage for industrial applications*, Solar Energy, vol. 82, pp. 686–699, 2008.

15ED56 MECHATRONICS SYSTEM DESIGN

3 0 0 3

Course Objectives
- To acquire knowledge on modern mechatronics components and its applications.
- To impart the knowledge on design and selection procedures of microprocessors and their interfacing with mechanical systems.

Course Outcomes (COs)
The student will be able to
1. Integrate electronics, mechanical devices, actuators, sensors and computer control technologies for the building a mechatronics device.
2. Design and select suitable microprocessors for the mechanical systems.

Unit I
Introduction
Introduction to Mechatronics system – Key elements – Mechatronics Design process – Types of Design – Traditional and Mechatronics designs – Advanced approaches in Mechatronics - Man

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

machine interface, industrial design - Safety features–optimization of Mechatronic design- Fault Diagnosis.

9 Hours

Unit II

System Modelling and Identification

Mathematical models–Block diagram modelling–Analogy approach–Impedance diagrams–Models for Electrical, Mechanical, Electro-mechanical and Fluid systems–System Identification–Least square method–Closed loop identification–joint input/output identification–State estimators–Model Validation.

9 Hours

Unit III

Sensors and Transducers

Introduction - Performance Terminology - Displacement, Position and Proximity – Velocity and Motion - Fluid pressure - Temperature sensors - Light sensors - Selection of sensors – Signal processing - Servo systems. Memory-metal actuators, Shape memory alloys.

9 Hours

Unit IV

Microprocessors in Mechatronics

Introduction - Architecture - Pin configuration - Instruction set - Programming of Microprocessors using 8085 instructions - Interfacing input and output devices - Interfacing D/A converters and A/D converters – Applications - Temperature control - Stepper motor control - Traffic light controller.

9 Hours

Unit V

Real Time Interfacing

Introduction to data acquisition and control systems, overview of I/O process, virtual Instrumentation, interfacing of various sensors and actuators with PC, Condition monitoring, SCADA systems.

9 Hours

Unit VI$

Sensors in Automobile – Mechatronic Control in Automated Manufacturing – Artificial intelligence and Fuzzy LogicandMicro sensors Applications in Mechatronics.

Total: 45 Hours

Reference(s)

1. M. B. Histand and G.D. Alciatore, *Introduction to Mechatronics and Measurement Systems*, McGraw - Hill International, 2007.
2. DevdasShetty and Richard A Kolk, *Mechatronics System Design*, PWS Publishing Company, USA, 2006.
3. S. Ramesh, Gaonkar, *Microprocessor Architecture*, Programming and Applications Wiley Eastern, 2006.
4. W. Bolton, *Mechatronics*, Pearson Education Asia, New Delhi, 2007.
5. L. J. Kamm, *Understanding Electro-Mechanical Engineering*, An Introduction to Mechatronics, Prentice- Hall, 2003.
6. P. K. Ghosh and P R. Sridhar, *Introduction to Microprocessors for Engineers and Scientists*, Prentice Hall, 2008.

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

15ED57 COMPOSITE MATERIALS AND MECHANICS

3 0 0 3

Course Objectives

- To understand the fundamental concepts of various composite materials and its behavior.
- To acquire knowledge about various techniques involved in the manufacturing of Polymer, Metal and Ceramic Matrix Composites.
- To learn the procedures involved in the design and failure analysis of various composites.

Course Outcomes (COs)

The student will be able to

1. Demonstrate the manufacturing techniques of Polymer, Metal and Ceramic Matrix Composites.
2. Design a suitable composite by adopting the standard design and failure analysis procedures.
3. Select suitable composite materials for specific engineering applications.

Unit I

Introduction to Composite Materials

Definition- Classifications - Matrix materials- Polymers-metals-ceramics- properties-Reinforcements-particles- whiskers - Fibers: glass- ceramic- aramid and carbon fibers -fabrication and properties. Metal Matrix Composites: classifications- particle reinforced- dispersed strengthened- fiber reinforced composites - rule of mixture- matrix/reinforcement interface-wettability- advantages -limitations and applications of composites.

8 Hours

Unit II

Manufacturing of Composites

Manufacturing of Polymer Matrix Composites: Hand lay-up - Spray technique - Bag molding - Compression molding- Filament winding - Pultrusion - Resin transfer molding (RTM) - Structural reaction injection molding (SRIM). Manufacturing of Metal Matrix Composites: Liquid state process- Liquid infiltration- Vortex method- Squeeze casting techniques. Solid state process- Diffusion bonding- Powder Metallurgy - In situ process. Manufacturing of Ceramic Matrix Composites: Hot pressing- reaction bonding - liquid infiltration- directed oxidation process.

10 Hours

Unit III

Mechanics of Lamina and Laminated Composites

Introduction to lamina and laminate- Characteristics of fiber reinforced lamina: Fundamentals-Orientations of fibers- Elastic properties of lamina- Coefficient of linear thermal expansion- Stress - Strain relationship for thin lamina- Compliance and stiffness Matrices. Laminated Structures: Symmetric laminates- angle ply laminates - Cross ply laminates- Quasi -Isotropic laminates- Inter-laminar Stresses.

8 Hours

Unit IV

Properties of Fiber Reinforced and Metal Matrix Composites

Static Mechanical properties- Tensile - Compressive- Flexural -In plane shear- inter-laminar shear strength- Fatigue- Impact - other properties - Environmental effects - long term properties: creep - stress rupture- fracture behavior and damage tolerance- methods of improving damage tolerance. Properties of metal matrix composites: Wear- corrosive - fracture - fatigue and flexural behaviour of Aluminium, magnesium, titanium and copper alloy composites- testing methods and standards.

10 Hours

Unit V

Design and Failure Analysis

Laminate design considerations- design of beam- tension- compression and torsion member- joint design- Design considerations for metal matrix composites - Failure prediction - failure theories-

Classical Lamination theory- Failure analysis- bending- buckling-fracture - Finite element analysis - microstructural analysis - design and analysis of sandwich structures.

9 Hours

Unit VI$

Research trends in polymer, metal and ceramic matrix composites. Advanced composites - Nano, bio and hybrid composites - Applications

Total: 45 Hours

Reference(s)

1. P.K.Mallick,*Fiber Reinforced Composites: Materials, Manufacturing and Design*, Maneel DekkerInc, 2007.
2. A. K.Kaw, *Mechanics of Composite Materials*, CRC Press, NY, 2006.
3. Krishnan K. Chawla, *Composite Materials- Science and Engineering,* Springer, 2012.
4. F.I. Matthews and R. D. Rawlings, *Composite Materials: Engineering and Science*, Woodhead publishing, 2005.
5. Robert M. Jones, *Mechanics of Composite Materials*, CRC Press, NY, 2015.
6. William D. Callister, *Materials Science And Engineering - An Introduction*, Wiley, 2010
7. http://nptel.iitk.ac.in/courses/Webcourse-contents/IISc-BANG/Composite Materials

15ED58 TRIZ FOR PRODUCT INNOVATION

3 0 0 3

Course Objectives

- To provide knowledge on product development technique through TRIZ.
- To make expertise on the concept of TRIZ and ARIZ algorithms for design.
- To facilitate TRIZ research and development.

Course Outcomes (COs)

The student will be able to

1. Solve inventive or non-routine technical problems within the framework of TRIZ
2. Stimulate interest in the advancement and diffusion of knowledge of the art and science of TRIZ and its application.
3. Build a function model of a system and use it for contradiction identification and resolution

Unit I

Introduction to TRIZ

Introduction to Product Innovation – Relationship between Invention and Innovation – Theories of Innovation, TRIZ – Theory to resolve Inventive Problems, Historical Development – About the Author, Essence of TRIZ. Techniques for Breaking Psychological Inertia.

9 Hours

Unit II

Concept of TRIZ

Ideal final Result – Problem formulation and Functional analysis – Ideality – Contradiction; Physical and Technical – Resolving Contradiction – 39 Contradicting Parameters – Contradiction Matrix – Use of S Curve and Technology Evolution Trends, Quality Function Deployment.

9 Hours

Unit III

Inventive principles and standard solutions

Definition of 40 Inventive Principles – Definition of 76 Standard Solutions – Improving the System with no brittle change (13) – Improving the system by changing the system (23) – System

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Transitions (6) – Detection andMeasurement (17) – strategies for simplification and improvement – Case Studies.

9 Hours

Unit IV
ARIZ Algorithm
ARIZ – The Algorithm for Inventive Problem Solving – ARIZ frame work; Restructuring of the original problem – Removing the Physical Contradiction – Analyzing the Solution – Macro flow Chart of ARIZ– Case Studies

9 Hours

Unit V
Evolution Patterns for System Development
Introduction-Uneven Evolution of Systems**,** Transition to Macro level, Transition to Micro level, Increase of interactions, Expansion and Convolution, Benefits from understanding the patterns of evolution, Application of Evolution Patterns.

9 Hours

Unit VI$
Case Study - Business with TRIZ – Typical obstacles to the adoption of TRIZ - How to introduce TRIZ in your organization.

Total: 45 Hours

Reference(s)

1. Michael A Orloff, *Inventive thinking through TRIZ*, Springer, 2012.
2. Genrich Altshuller,*TRIZ Keys to Technical Innovation*, Technical Innovation Center, 2002.
3. Semyon D and Savransky, *Engineering of Creativity - Introduction to TRIZ Methodology of Inventive Problem Solving*, CRC Press LLC, 2000.
4. Kalevi Rantanen and Ellen Domb, *Simplified TRIZ-New Problem Solving Applications for Engineers and Manufacturing Professionals*, Auerbach Publications 2008.
5. www.triz-journal.com.

15ED59 TRIBOLOGY IN DESIGN

3 0 0 3

Course Objectives
- To impart knowledge on the theory of friction and wear, principle of surface treatment, surface modifications and surface coatings.
- To understand the design and selection procedures of various bearing used in industry.

Course Outcomes (COs)
The student will be able to
1. Demonstrate the influence of surface interaction in friction and wear, failure of bearings, principle of sealing and condition monitoring.
2. Design and select the various bearing used in industry.

Unit I
Surfaces, Friction and Wear
Topography of Surfaces – Surface features and interaction – Theory of Friction – Adhesive theory of Sliding and Rolling Friction, Friction properties of metallic and non-metallic materials – Friction in extreme conditions – Thermal considerations in sliding friction. Wear, types of wear – Mechanism of wear – Wear resistance materials – friction control and wear prevention.

9 Hours

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Unit II
Elasto and Plasto Hydrodynamic Lubrications
Lubrication, Lubricants and their physical properties, lubricants standards – Additives and selection of Lubricants -Lubrication regimes, Hydrodynamic lubrication – Reynolds Equation – Thermal - Inertia and turbulent effects –Elasto hydrodynamic and plasto hydrodynamic theory-soft and hard EHL- -film shape and thickness within and outside contact zones-Hydro static lubrication – Gas Lubrication.

10 Hours

Unit III
Design of Fluid Film Bearings
Design and performance analysis of thrust and journal bearings – Full, partial, fixed and pivoted journal bearings – Lubricant flow and delivery – Power losses due to thermal effect-Dynamic loads in journal bearings – Special bearings – Hydrostatic Bearing.

8 Hours

Unit IV
Selection of Rolling Element Bearings
Geometry and kinematics - Contact stresses – Hertzian stress equation-Spherical and Cylindrical contacts –Nominal life, static and dynamic capacity, equivalent load, probabilities of survival cubic mean load –Bearing mounting details, preloading of bearings.

9 Hours

Unit V
Seals
Types -mechanical seals, lip seals, packed glands, soft piston seals, mechanical piston rod packing, labyrinth seals and throttling bushes, oil flinger rings and drain grooves -selection of mechanical seals.

9 Hours

Unit VI$
A case study on using solid lubricants in machineries and automotive-Failure investigation of bearing under extreme environment

Total: 45 Hours

Reference(s)
1. B.Bhushan, *Principles and Application of Tribology,* John Wiley & Sons, 2006.
2. A.Cameron, *Basic Lubrication Theory,* Ellis Hardwoods Ltd., UK, 2008.
3. S.K. Basu , S. N. Sengupatha and D. B. Ahuja, *Fundamentals of Tribology,* Prentice Hall of India Pvt. Ltd.,2009
4. J. A. Williams, *Engineering Tribology*, Oxford Univ. Press, 2007.
5. B. C. Majumdar, *Introduction to Tribology in bearings*, S. Chand, 2010.
6. I. M. Hutchings, Tribology, *Friction and Wear of Engineering Material*, Edward Arnold, London, 2005.
7. G. W. Stachowiak and A. W. Batchelor, *Engineering Tribology,* Butterworth-Heinemann publisher, 2013
8. Prasanta Sahoo, *Engineering Tribology,* Prentice-Hall India, New Delhi, 2011.
9. http://www.nptel.ac.in/courses/112102015/

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

15ED60 RELIABILITY ENGINEERING AND TOTAL PRODUCTIVE MAINTENANCE

3 0 0 3

Course Objectives

- To attain knowledge about reliability, failure, design of reliable system and reliability testing.
- To understand the concept of maintenance planning and replacement decision.
- To impart knowledge about Total Productive Maintenance, Reliability centered and Re-engineering maintenance.

Course Outcomes (COs)

The student will be able to

1. Understand the importance of reliability in failure prediction.
2. Design components/products for reliability.
3. Demonstrate the concepts of Total Productive Maintenance, Reliability centered and Re-engineering maintenance.

Unit I

Reliability Engineering

Elements of Probability-Reliability Definition-Measures of Reliability- Factors affecting reliability - Failures-Classification of failures-Failure data Analysis-Availability-Criticality matrix- Event tree analysis-Utilization factor- Distribution of failure and repair times; determination of MTBF and MTTR, Reliability models; system reliability determination.

9 Hours

Unit II

Design for Reliability

Analysis of reliability data-Weibull analysis-Design and manufacture for Reliability-Reliability of parts and components-Design for system reliability- Economics of standby or redundancy in production system-reliability testing-Types

9 Hours

Unit III

Fundamentals of Maintenance

Objectives and functions of Maintenance- Maintenance strategies- Maintenance types, work standards, logistic support, organization for maintenance. Maintenance of electrical, mechanical drives & systems, standard. Maintenance practice & procedures, machine diagnostics, machine condition monitoring and signature analysis. Cost of maintenance

9 Hours

Unit IV

Maintenance planning and replacement decision

Overhaul and repair- meaning and difference- Optimal Overhaul- Repair policies for equipment subject to breakdown. Optimal interval between preventive replacements of equipment subject to break down, group replacement.

9 Hours

Unit V

Modern Maintenance concepts

Reliability Centered Maintenance - Total Productive Maintenance - philosophy and implementation- Signature Analysis- Concept of terotechnology- Reengineering Maintenance process.

9 Hours

Unit VI[$]

Failure an[$]alysis and Recurrence prevention-Spare parts management-Maintenance work Management, cost management and Safety.

Total: 45 Hours

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Reference(s)
1. R. C. Mishra and K.Pathak ,*Maintenance Engineering and Management*, PHI publishers, 2005.
2. Sushil Kumar Srivatsava, *Industrial Maintenance Management*, S Chand and Company, 2005.
3. A. K. Jardine, *Maintenance, Replacement and Reliability*, Pitman Publishing, 2003.
4. Kelly and M J. Harris, *Management of Industrial Maintenance*, Butter worth and Company Limited, 2001.
5. Roy Billington and Ronald N. Allan, *Reliability Evaluation of Engineering Systems*, Springer, 2007.
6. http://www.sciencedirect.com/science/article/pii/S1877705813000854.
7. http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-033-computer-system-engineering-spring-2009/video-lectures/lecture-15/.

15ED61 ADVANCED TOOL DESIGN

3 0 0 3

Course Objectives
- To acquire knowledge on tool design and advanced cutting tool materials.
- To understand the selection procedure of Jigs, fixtures, cutting and forming tools.
- To familiarize in design of press and design of computer numerical control machine tool.

Course Outcomes (COs)
The student will be able to
1. Design a cutting tool for various machining circumstances.
2. Select a suitable Jigs and fixtures for conventional and CNC machines.
3. Design Dies and Press tools for forming applications.

Unit I
Design of cutting tools
Nomenclature of cutting tools - Orthogonal and oblique cutting - Derivation of force equations- Shear plane angle - Merchant’s theory. Heat development in machining - Effects of various parameters - Measurement methods to determine Chip tool interface temperatures - Action of cutting fluids –Failureof cutting tools - Plastic failure - Brittle fracture - Wear - Machinability

7 Hours

Unit II
Design of Jigs and Fixtures
Principles of Jigs and Fixtures design - Locating principles - Locating elements - Standard parts - Clamping devices - Drill bushes-Different types of Jigs-Plate latch - Channel - Box - Post - Angle plate - Angular post - Turnover - Pot jigs- Automatic drill jigs - Rack & Pinion Operated - Air operated Jigs Components - Fixtures - General principles of boring - Lathe - milling and broaching fixtures - Grinding - Planning and shaping fixtures - Assembly - Inspection and Welding fixtures - Modular fixtures - Design and development of Jigs and fixtures for given components.

10 Hours

Unit III
Design of Molding Dies
Plastic materials, shrinkage, two and three plate mold design, standard mold plates, parting line, core and cavity generation in CAD, runner and gate design, mold cooling, ejection methods, tool materials, runner less molds, microstructure injection molding for MEMs, multi-color injection molding, mold flow analysis using CAE, introduction to thermo setting dies, texturing.

10 Hours

Unit IV
Design of Press Tools
Press working terminology - Presses and Press accessories - Computation of capacities and tonnage requirements - Strip layout-Design and development of various types of cutting - Forming and

drawing dies–Fine blanking - Blank development for Cylindrical and non-cylindrical shells - Compound progressive -Combination dies.

10 Hours

Unit V

Design of CNC Tooling

Introduction -Tooling requirements for Numerical control systems - Fixture design for CNC machine tools- Sub plate and tombstone fixtures-Universal fixtures- Cutting tools- Tool holding methods- Automatic tool changers and tool position - Tool presetting- General explanation of the Brown andSharp machine.

8 Hours

Unit VI$

Case study problems on machine tool applications.

Total: 45 Hours

Reference(s)

1. C. Donaldson, G. H. Lecain and V. C.Goold, *Tool Design*, Tata McGraw- Hill, 2007.
2. Bhattacharya, *Metal Cutting Theory and Practice*, New Central Book Publishers, Calcutta, 2003.
3. B. I. Juneja and G. S. Sekhon, *Fundamentals of Metal cutting and Machine tools*, New Age International (P) Ltd., New Delhi, 2005.
4. R. A .Lindberg, *Process and Materials of Manufacture*, Prentice-Hall of India Pvt. Ltd, New Delhi, 2004.
5. S. F. Krar and F. A. Check, *Technology of Machine Tools*, Tata McGraw-Hill international, 2003.
6. R. C. Wpye, *Injection Mold Design*, East West Press, 2004.
7. http://nptel.ac.in/courses/112105126/35

15ED62/15CC62 GEOMETRIC MODELLING
(Common to CAD/CAM & Engineering Design)

3 0 0 3

Course Objectives

- To impart the knowledge of mathematical representation of curves, surfaces and solids and their relationship with computer graphics.
- To familiarize the mass property calculation and finite element modelling and meshing

Course Outcomes (COs)

The student will be able to

1. Understand the mathematical representation of curves, surfaces and solids and their relationship with computer graphics.
2. Understand the mass property calculation and finite element modelling and meshing.

Unit I

Overview of CAD Systems and Graphics Transformations

Conventional and computer aided design processes, subsystems of CAD-CAD hardware and software, Analytical and graphics packages, CAD workstations. Networking of CAD systems, generative, cognitive and image processing graphics, static and dynamic data graphics. Transport of graphics data. Graphic standards, generation of graphic primitives, display and viewing, transformations customizing graphics software.

10 Hours

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Unit II
Mathematical Representation of curves and Surfaces
Introduction, Wire frame models – surface models – parametric representation of analytic and synthetic surfaces – surface manipulations

8 Hours

Unit III
Mathematical Representation of Solids
Fundamentals of solid modelling – boundary representation (B-Rep) – constructive solid geometry (CSG) – sweep representation – analytical solid modelling – design and engineering applications in wire frame, surface and solid modelling.

9 Hours

Unit IV
Principles of Computer Graphics
Transformation and mapping of geometric models - inversion transformations and mappings – projection of geometric models – design and engineering applications.

9 Hours

Unit V
Mass Property Calculations
Introduction-geometricalpropertyformulation-masspropertyformulation – finite element modelling – mesh generation – design and engineering applications.

9 Hours

Unit VI$
Case study: geometric and finite element modelling of automotiveandsheet metal components-geometric programming for design and cost optimization.

Total: 45 Hours

Reference(s)

1. Ibrahim Zeid, *CAD/CAM Theory and Practice*, McGraw Hill Inc., New Delhi, 2014.
2. P.Radhakrishnan and C.P.Kothandaraman, *Computer Graphics and Design*, DhanpatRai and Sons, 2002.
3. P.Radhakrishnan and S.Subramanyan, *CAD/CAM/CIM*, New Age International, 2016.
4. D. Solomon, *Computer Graphics and Geometric Modelling*, Springer Verlag, 2006.
5. Donald Hearn and M Pauline Baker, *Computer Graphics*, Prentice Hall, 2001.
6. http://nptel.ac.in/courses/112102101/44
7. http://nptel.ac.in/video.php?subjectId=112102101

15ED63 DESIGN OF AUTOMOBILE COMPONENTS

3 0 0 3

Course Objectives

- To understand the fundamentals of automobile components used in different systems.
- To study the design procedures of various automobile components.

Course Outcomes (COs)

The student will be able to

1. Demonstrate the working principles of automobile components.
2. Design of various transmission elements used in automobiles.

Unit I
Introduction
Introduction to design aspects of automobile components. General layout of the automobile, types of chassis layout, various types of frames, constructional details, materials, unitized frame body construction.

9 Hours

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Unit II
Design of Engine Components
Choice of material for various engine components, design of cylinder, design of piston assembly, design of connecting rod, design of crankshaft under bending and twisting, balancing weight calculations, design of valves, valve springs and design of flywheel

9 Hours

Unit III
Design of Clutch and Brakes
Clutches: Introduction **-**design diagrams of clutch, calculation of critical parameters of clutches, design calculation of standard elements of friction clutches Brakes**:** Pressure distribution along shoe length, determining braking torque, design of drum brakes-internally expanding brakes, design of disc brakes.

10 Hours

Unit IV
Design of Transmission Systems
Determining main parameters of transmission, differential, axle shafts, gear box, design of universal joint and propeller shaft, location determination of universal joint and propeller shaft.

8 Hours

Unit V
Suspension, Steering and Automotive Electronic Systems
Oscillation and smoothness of ride, fundamentals of designing and calculating steering control linkage, steering gears, hydraulic booster. Sensorsin automobiles, engine management system

9 Hours

Unit VI$
Case studies on failure analysis of crankshaft, Gear box and manual change gear box.

Total: 45 Hours

Reference(s)
1. P. Lukin, G. Gasparyants and V. Rodionov, *Automobile Chassis Design and Calculations*, Mir Publishers, Moscow, 2005.
2. Heinz Heisier, *Vehicle and Engine Technology*, SAE, New York, 2007.
3. T. D. Gillespie, *Fundamentals of Vehicle Dynamics*, SAE Inc., New York, 2006.
4. A.E. Schwaller, *Motor Automotive Technology*, Delman Publishers, New York, 2008.
5. W. Steed, *Mechanics of Road Vehicles*, IIiffe Books Ltd., London- 2005.
6. J. G. Giles, Steering, *Suspension and Tyres*, IIiffe Book Co., London- 2004.
7. Julian Happian-Smith**,** *Anintroduction to Modern Vehicle Design*, Society of Automotive Engineers Inc, 2002.
8. http://saeindia.org/

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

15ED64/15CC64 DESIGN OPTIMIZATION OF MECHANICAL SYSTEMS
(Common to CAD/CAM & Engineering Design)

3 0 0 3

Course Objectives

- To acquire concepts of design optimization, and model the engineering problem mathematically.
- To impart knowledge on various optimization methods for obtaining approximate structural design solutions.
- To familiarize the selecting algorithms for solving multi-objective and non-traditional optimization problems.

Course Outcomes (COs)

The student will be able to

1. Formulate the mathematical models of real world problems.
2. Understand the various traditional optimization theories applied to solve structural problems.
3. Solve the engineering problems using suitable optimization techniques.

Unit I
Introduction
Introduction to optimum design - Principles of optimization - Conventional versus Optimal design process - Problem formulation - Classification of Engineering optimization problem

6 Hours

Unit II
Single Variable Optimization Techniques
Optimality Criteria - Bracketing Methods: Exhaustive search method - Bounding phase method - Region Elimination Methods: Interval halving method - Fibonacci search method - Golden section search method - Gradient based Methods: Newton - Raphson method - Bisection method - Cubic search method

9 Hours

Unit III
Multi Variable and Constrained Optimization Techniques
Unconstrained optimization techniques: Direct search Method: Simplex search methods - Hooke-Jeeve's pattern search method - Powell's conjugate direction method - Gradient based method: Cauchy's method - Newton's method - Conjugate gradient method. Constrained optimization techniques: Kuhn - Tucker conditions - Penalty Function methods - Solution by the method of Lagrangian multiplier.

12 Hours

Unit IV
Design of Experiments and Modelling
Introduction- ANOVA- Factorial Design, Fractional factorial Design, Regression Approach- Two, and multi variable Design, Orthogonal Array Design, Response Surface Methods- Simple Problems

9 Hours

Unit V
Non Traditional Optimization
Introduction to non-traditional optimization - Genetic Algorithm - Bee Colony Algorithm - Particle Swarm Optimization (PSO) and Neural Networks in optimization, Simple Applications

9 Hours

Unit VI$
Case studies: Using any modelling software.

Total: 45 Hours

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Reference(s)

1. S. S. Rao, *Engineering Optimization: Theory and Practice*, Wiley- Interscience, 2009.
2. K. Deb, *Optimization for Engineering Design Algorithms and Examples*, Prentice Hall of India Pvt. 2010.
3. Jasbir S. Arora, *Introduction to Optimum Design*, McGraw Hill International, 2011.
4. Panos Y. Papalambros and Douglass J. Wilde, *Principles of Optimal Design: Modelling and Computation*, Cambridge University Press, 2000.
5. R. PanneerSelvam, *Design and Analysis of Experiments*, PHI Learning Private Limited, 2012.
6. Ashok D. Belegundu, R. Tirupathi and Chandrupatla, *Optimization Concepts and Applications in Engineering*, Pearson Education, 2014.
7. G. V. Reklaitis, A. Ravindram and K. M. Ragsdell, *Engineering Optimization - Methods & Application*, Wiley, 2006.
8. http://nptel.ac.in/courses/111105039/.

15ED65 PRODUCT RELIABILITY

3 0 0 3

Course Objectives

- To impart knowledge on reliability mathematics and its models.
- To familiarize the concept ofproficiency on product maintainability and software reliability.
- To understand the techniques for predicting reliability in industries.

Course Outcomes (COs)

The students will be able to

1. Apply knowledge of failure modes and effect analysis.
2. Apply the concept of accelerated testing.
3. Solve maintenance and serviceability related issues.

Unit I
Introduction

Definitions, stage gate approach, reliability mathematics, reliability models, parametric and catastrophic methods, reliability predictive modelling.

9 Hours

Unit II
Failure Modes and Effect Analysis

Goal and vision, concepts and types of FMEA evaluations, Fault tree model. Implementation of FMEA technique to identify the modes of failures.

9 Hours

Unit III
Evaluating Product Risk

Test design by failure modes and aging stresses. Aging due to cyclic force, Miner's rule. Evaluating the product risk on the basis on market approach

8 Hours

Unit IV
Concepts in Accelerated Testing

Time acceleration factor, influence of acceleration factor in test planning, application to acceleration test, high temperature operating life acceleration model, temperature humidity bias acceleration model, temperature cycle acceleration model, vibration accelerator model, failure free accelerated test planning. Accelerated reliability growth.

10 Hours

Unit V
Product Maintainability and Introduction to Software Reliability
Maintainability concepts and analysis measures of maintainability, design for serviceability, supportability and maintainability preventive maintenance scheduling. Software reliability - Definitions, waterfall lifecycle, techniques to improve software reliability, software reliability models

9 Hours

Unit VI$
Poka yoke- Design of experiments- Error proofing & Statistical analysis- Field data analysis and evaluation -Reliability validation.

Total: 45 Hours

Reference(s)
1. V N A Naikan, *Reliability Engineering and Life Testing*, PHI Learning Private Limited, 2009.
2. D N Prabhakar Murthy and Marvin Rausand, *Product Reliability*, Springer-Verlag London Limited, 2008.
3. Dana Crowe and Alec Feinberg, *Design for Reliability*, CRC Press, 2001.
4. John W Priest and Jose M Sanchez, *Product Development and Design for Manufacturing – A Collaborative Approach to Producibility and Reliability*, Second Edition, Marcel Dekker, 2001.
5. Michael Pecht, *Product Reliability, Maintainability and Supportability Handbook*, CRC Press, 2009.
6. http://nptel.ac.in/courses/112101005.

15ED66 PRODUCTIONS AND OPERATIONS MANAGEMENT

3 0 0 3

Course Objectives
- To impart knowledge on forecasting facility location and plant layout.
- To produce expertise in aggregate planning, manufacturing planning and controlling.
- To understand the procedure for allocating the resources and computer integration in manufacturing and its operations.

Course Outcomes (COs)
The students will be able to
1. Demonstrate the project management principles and importance of facility layouts.
2. Understand production control, principles of just-in-time systems and forecasting techniques.
3. Implement the concept of flexible manufacturing system in production industries.

Unit - I
Forecasting Facility Location and Layout
Introduction, measures of forecast. Accuracy, forecasting methods, time series smoothing, regression models, exponential smoothing, seasonal forecasting, cyclic forecasting. Location factors, location evaluation methods. Different types of layouts for operations and production. Arrangement of facilities within departments.

8 Hours

Unit II
Aggregate Planning, Master Production Scheduling and Inventory Analysis
Approaches to aggregate planning, graphical, empirical and optimization. Development of a master production schedule, materials requirement planning (MRP-I) and manufacturing resource planning (MRP-II). Definitions, ABC inventory system, EOQ models for purchased parts, inventory order

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

policies, EMQ models for manufactured parts, lot sizing techniques. Inventory models under uncertainty.

10 Hours

Unit III

Work Measurement, Scheduling and Controlling

Labour standards and work measurement, historical experience, time studies, predetermined time standards. Objectives in scheduling, major steps involved, information system linkages in production planning and control, production control in repetitive, batch and job shop manufacturing environment.

9 Hours

Unit IV

Just In Time Manufacturing and Project Planning

Introduction elements of JIT, uniform production rate, pull versus push method, KANBAN system, small lot size, quick, inexpensive set-up, and continuous improvement. Optimized production technology. Evolution of network planning techniques, critical path method (CPM), project evaluation and review technique (PERT). Network stochastic consideration. Project monitoring. Line of balance.

9 Hours

Unit V

Scheduling with Resource Constraints

Allocation of units for a single resource, allocation of multiple resources, resource balancing. Line balancing, Helgeson Brine approach, region approach. Stochastic mixed product line balancing. Flexible manufacturing system, concepts, advantages and limitation, computer integration in manufacturing and operations. Electronic data interchange.

9 Hours

Unit VI$

Recent advancements in production management systems, Evolution of operations management: past, present and future – case studies.

Total: 45 Hours

Reference(s)

1. Bedworth D David, James E Bailey, *Integrated Production Control systems: Management, Analysis, Design*, John Wiley and Sons, New York, 2007.
2. Dilworth B James, *Operations Management, Design, Planning and Control for Manufacturing and Services*, McGraw Hill, Inc., New Delhi, 2006.
3. Jay Heizer and Barry Render, *Operations Management*, Eighth Edition, and Pearson Education, 2005.
4. Vollman T E, *Manufacturing Planning and Control Systems*, Galgotia Publication (P) Ltd., New Delhi, 2004.
5. P.Rama Murthy, *Production and Operations Management*, New Age International Publishers, New Delhi, India, 2005.
6. ErkanBayraktar, M.C. Jothishankar, EkremTatoglu, Teresa Wu, *Evolution of operations management: past, present and future, Management Research News*, 30 (11), pp. 843-871, 2007.
7. http://nptel.ac.in/courses/112102106/1.

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

15ED67 MECHANICS OF FRACTURE

3 0 0 3

Course Objectives

- To impart knowledge on mechanics of cracked components of different modes by which these components fail under static load and fatigue load conditions.
- To understand fracture mechanics, failure analysis tools and formulate fracture toughness of materials, this leads to safe design.

Course Outcomes (COs)

The students will be able to

1. Select material based on behavior in crack under static and fatigue load conditions.
2. Demonstrate fracture mechanics, failure analysis tools, toughness of materials, this leads to safe design.

Unit I

Elements of Solid Mechanics

Introduction – elementary Solid mechanics –the geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation-limit analysis

9 Hours

Unit II

Stationary Crack under Static Loading

Two dimensional elastic fields-Analytical solutions yielding near a crack front-Irwins approximation-plastic zone size-Dugdale model-J integral and its relation to crack opening displacement.

9 Hours

Unit III

Energy Balance and Crack Growth

Griffth analysis-Linear Fracture Mechanics-Geometric Model of a Crack-Complex variable method in elasticity-Crack opening displacement-Dynamic energy balance-crack arrest.

9 Hours

Unit IV

Fatigue Crack Growth Curve

Empirical relation describing crack growth by Fatigue-Life calculations for a given in load amplitude-effects of changing the load spectrum-Effects of Environment

9 Hours

Unit V

Elements of Applied Fracture Mechanics

Examples of crack-growth Analysis for cyclic loading-leak before break- crack initiation under large scale yielding-Thickness as a Design parameter-crack instability in Thermal or Residual-stress fields

9 Hours

Unit VI$

Case study: Evaluating Stress Intensity Factors - Experimental Method-Fatigue-Crack Propagation under Variable-Amplitude Load Fluctuation.

Total: 45 Hours

Reference(s)

1. R. J. Sanford, *Principles of Fracture Mechanics*, Pearson Education, Inc. Upper Saddle River, 2003.
2. David Broek, *Elementary Engineering Fracture Mechanics*, Fifthoff and Noerdhoff International Publisher, 2005.
3. KareHellan, *Introduction to Fracture Mechanics*, McGraw Hill Book Company, 2003.
4. Preshant Kumar, *Elements of Fracture Mechanics*, Wheeler Publishing, 2004.
5. T L. Anderson, *Fracture Mechanics: Fundamentals and Applications*, CRC Press, 2005.

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

6. TribikramKundu, *Fundamentals of Fracture Mechanics*, CRC Press, Boca Raton, 2008.
7. Dietmar Gross and Thomas Seelig, *Fracture Mechanics with an Introduction to Micromechanics*, Springer-the Netherlands, 2006.
8. U. Zerbst, *Review on fracture and crack propagation in weldments – A fracture mechanics perspective*, Engineering Fracture Mechanics, Volume 132, pp 200–276, 2014.
9. http://nptel.ac.in/courses/112106065.

15ED68 MODELLING AND SIMULATION OF DYNAMIC SYSTEMS

3 0 0 3

Course Objectives

- To understand the development of mathematical model of dynamic systems.
- To study the analyses procedure of the modeled systems in time and frequency domain.
- To understand the various design procedure of a controller used in dynamic system.

Course Outcomes (COs)

The students will be able to

1. Develop the Model and simulate the response of dynamic systems.
2. Analyze the response of system in time and frequency domain.
3. Design controller for dynamic system to meet the specific requirement of system.

Unit I

Mathematical model of control system

Introduction – Terminology, types and example in control system – Mathematical model of mechanical and electrical system – Transfer function approach – Electrical analogy of mechanical system – Block Diagram approach – Signal flow graph – Thermal system.

9 Hours

Unit II

Time Response Analysis

Time response – Test Signal- order of a system – First order system – response of second order system – Time domain Specification – Steady state error – Static error Constant – Generalized Error coefficient.

9 Hours

Unit III

Frequency Response Analysis

Frequency domain specification – Frequency response plot – Bode plot – Polar Plot – correlation between time and frequency response.

9 Hours

Unit IV

Concept of stability and root locus

Impulse response and stability – Location of pole on s plane – Routh Hurwitz criterion – Nyquist stability criterion – Relative stability – Gain Margin and Phase margin – Root locus.

9 Hours

Unit V

Control system Design

Introduction to design using compensator – Lag compensator – Lead compensator – Lag- lead compensator – PI PD and PID controller – feedback compensation.

9 Hours

Unit – VI[$]

Demonstration of modelling of Hydraulic & Pneumatic system – response of P, PI, PD and PID controller – component system.

Total: 45 Hours

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Reference(s)

1. J.Nagrath and M.Gopal, *Control System Engineering*, New Age International Publishers, 5th Edition, 2007.
2. N.S. Nise, *Control Systems Engineering*, 4th ed., Wiley International Edition, 2004.
3. Benjamin.C.Kuo, *Automatic control systems*, Prentice Hall of India, 7th Edition, 2001.
4. Richard M. Murray, Karl Johan Astrom, Stephen P. Boyd, R. W. Brockett, G. Stein, *Future Directions in Control in an Information-rich World*, IEEE Control Systems Magazine, 23:2, pp. 20–33, April 2003.
5. Karl JohanAstrom, Tore Hagglund, *The future of PID control*, Control Engineering Practice, 9, pp. 1163–1175, 2001.
6. http://nptel.ac.in/courses/108102044/

15ED69/15CC68 ADDITIVE MANUFACTURING TECHNIQUES
(Common to CAD/CAM & Engineering Design)

3 0 0 3

Course Objectives

- To provide an exhaustive knowledge of various Rapid Prototyping Techniques (RPT).
- To make familiar about materials and process parameters in prototype development.
- To educate the emerging trends and applications of Additive Manufacturing (AM) technology.

Course Outcomes (COs)

The student will be able to

1. Develop three-dimensional models for rapid prototyping machines.
2. Create new file conversion technique/file formats for rapid prototype systems.
3. Select the suitable additive manufacturing process for respective applications.

Unit I

Introduction

Needs - Impact of Rapid Prototyping (RP) and Tooling on Product Development- RP 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 - RP Benefits-Classification of RP systems.

9 Hours

Unit II

Liquid Based and Solid Based Rapid Prototyping Systems

Stereolithography Apparatus (SLA): Principle, Part building processes, Photo polymerization of SL resins, Part quality, Recoating issues, Materials.

Solid Ground Curing (SGC), Fused Deposition Modelling (FDM) and Laminated Object Manufacturing (LOM): Working Principle - Process parameters and Materials.

10 Hours

Unit III

Powder Based and Other Rapid Prototyping Systems

Selective Laser Sintering (SLS): Principle, Process Variables, Indirect and direct SLS - Powder structures, Materials, Post processing, Surface deviation and Accuracy. Three dimensional Printing (3DP): Principle, Physics of 3DP, Types, Process capabilities, Solid, Liquid and Powder based 3DP systems. Direct Metal Deposition (DMD), Ballistic Particle Manufacturing (BPM), Electron Beam Melting (EBM) and Laser Engineered Net Shaping (LENS): Working Principle.

10 Hours

Unit IV

Materials Properties

Role of materials - Viscous flow – Photo-polymerization - Sintering - Infiltration - Materials for AM Processes - Mechanical Properties of AM Parts - Material properties, Colour, Dimensional accuracy, Stability, Surface finish, Machinability, Environmental resistance, Operational properties of products developed.

9 Hours

Unit V
Applications of Rapid Prototyping
Introduction to rapid tooling - Direct and indirect method - Application of Rapid prototyping in Medical field, Manufacturing, Automotive industries, Aerospace and Electronics and Retail industries. Software for RP - STL file creation from CAD model using Magics, Mimics, Streamics.

7 Hours

Unit VI$
Case studies: Rapid Manufacturing in industrial applications. Articles on developments in Additive Manufacturing.

Total: 45 Hours

Reference(s)
1. D. T.Pham and S. S.Dimov, *Rapid manufacturing*, Springer-Verlag, London, 2001.
2. I. Gibson, D. W. Rosen, and B. Stucker, *Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing*, Springer, 2010.
3. C. K. Chua, K. F. Leong and C. S. Lim, *Rapid prototyping: Principles and applications*, Cambridge University Press, 2010.
4. L.W. Liou, F.W. Liou, Rapid Prototyping and Engineering applications: A tool box for prototype development, CRC Press, 2013.
5. A. K. Kamrani, E. A. Nasr, *Rapid Prototyping: Theory and practice*, Springer, 2006.
6. N. Hopkinson, R. J. M. Hague, P. M. Dickens, *Rapid Manufacturing - An Industrial Revolution for Digital Age*, John Wiley & Sons Limited, 2006.

15ED70 ENGINEERING OPTIMIZATION

3 0 0 3

Course Objectives
- To acquire concepts of design optimization, and model the engineering problem mathematically.
- To impart knowledge on various optimization methods for obtaining approximate structural design solutions.
- To familiarize the selecting algorithms for solving multi-objective and non-traditional optimization problems.

Course Outcomes (COs)
The student will be able to
1. Formulate the mathematical models of real world problems.
2. Understand the various traditional optimization theories applied to solve structural problems.
3. Solve the engineering problems using suitable optimization techniques.

Unit I
Introduction
Introduction to optimum design - Principles of optimization - Conventional versus Optimal design process - Problem formulation - Classification of Engineering optimization problem

6 Hours

Unit II
Single Variable Optimization Techniques
Optimality Criteria - Bracketing Methods: Exhaustive search method - Bounding phase method - Region Elimination Methods: Interval halving method - Fibonacci search method - Golden section search method - Gradient based Methods: Newton - Raphson method - Bisection method - Cubic search method

9 Hours

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Unit III
Multi Variable and Constrained Optimization Techniques
Unconstrained optimization techniques: Direct search Method: Simplex search methods - Hooke-Jeeve’s pattern search method - Powell’s conjugate direction method - Gradient based method: Cauchy’s method - Newton’s method - Conjugate gradient method. Constrained optimization techniques: Kuhn - Tucker conditions - Penalty Function methods - Solution by the method of Lagrangian multiplier.

12 Hours

Unit IV
Design of Experiments and Modelling
Introduction- ANOVA- Factorial Design, Fractional factorial Design, Regression Approach- Two, and multi variable Design, Orthogonal Array Design, Response Surface Methods- Simple Problems

9 Hours

Unit V
Non Traditional Optimization
Introduction to non-traditional optimization - Genetic Algorithm - Bee Colony Algorithm - Particle Swarm Optimization (PSO) and Neural Networks in optimization, Simple Applications

9 Hours

Unit VI$
Case studies: Using any modelling software.

Total: 45 Hours

Reference(s)
1. S. S. Rao, *Engineering Optimization: Theory and Practice*, Wiley- Interscience, 2009.
2. K. Deb, *Optimization for Engineering Design Algorithms and Examples*, Prentice Hall of India Pvt. 2010.
3. Jasbir S. Arora, *Introduction to Optimum Design*, McGraw Hill International, 2011.
4. Panos Y. Papalambros and Douglass J. Wilde, *Principles of Optimal Design: Modelling and Computation*, Cambridge University Press, 2000.
5. R. PanneerSelvam, *Design and Analysis of Experiments*, PHI Learning Private Limited, 2012.
6. Ashok D. Belegundu, R. Tirupathi and Chandrupatla, *Optimization Concepts and Applications in Engineering*, Pearson Education, 2014.
7. G. V. Reklaitis, A. Ravindram and K. M. Ragsdell, *Engineering Optimization - Methods & Application*, Wiley, 2006.
8. http://nptel.ac.in/courses/111105039/.

15ED71 TRIZ FOR PRODUCT INNOVATION

3 0 0 3

Course Objectives
- To provide knowledge on product development technique through TRIZ.
- To make expertise on the concept of TRIZ and ARIZ algorithms for design.
- To facilitate TRIZ research and development.

Course Outcomes (COs)
The student will be able to
1. Solve inventive or non-routine technical problems within the framework of TRIZ
2. Stimulate interest in the advancement and diffusion of knowledge of the art and science of TRIZ and its application.
3. Build a function model of a system and use it for contradiction identification and resolution

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

Unit I
Introduction to TRIZ
Introduction to Product Innovation – Relationship between Invention and Innovation – Theories of Innovation, TRIZ – Theory to resolve Inventive Problems, Historical Development – About the Author, Essence of TRIZ. Techniques for Breaking Psychological Inertia.

9 Hours

Unit II
Concept of TRIZ
Ideal final Result – Problem formulation and Functional analysis – Ideality – Contradiction; Physical and Technical – Resolving Contradiction – 39 Contradicting Parameters – Contradiction Matrix – Use of S Curve and Technology Evolution Trends, Quality Function Deployment.

9 Hours

Unit III
Inventive principles and standard solutions
Definition of 40 Inventive Principles – Definition of 76 Standard Solutions – Improving the System with no or little change (13) – Improving the system by changing the system (23) – System Transitions (6) – Detection and Measurement (17) – strategies for simplification and improvement – Case Studies.

9 Hours

Unit IV
ARIZ Algorithm
ARIZ – The Algorithm for Inventive Problem Solving – ARIZ frame work; Restructuring of the original problem – Removing the Physical Contradiction – Analyzing the Solution – Macro flow Chart of ARIZ– Case Studies

9 Hours

Unit V
Evolution Patterns for System Development
Introduction-Uneven Evolution of Systems**,** Transition to Macro level, Transition to Micro level, Increase of interactions, Expansion and Convolution, Benefits from understanding the patterns of evolution, Application of Evolution Patterns.

9 Hours

Unit VI[$]
Case Study - Business with TRIZ – Typical obstacles to the adoption of TRIZ - How to introduce TRIZ in your organization.

Total: 45 Hours

Reference(s)
1. Michael A Orloff, *Inventive thinking through TRIZ*, Springer, 2012.
2. GenrichAltshuller,*TRIZ Keys to Technical Innovation*, Technical Innovation Center, 2002.
3. Semyon D and Savransky, *Engineering of Creativity - Introduction to TRIZ Methodology of Inventive Problem Solving*, CRC Press LLC, 2000.
4. KaleviRantanen and Ellen Domb, *Simplified TRIZ-New Problem Solving Applications for Engineers and Manufacturing Professionals,* Auerbach Publications 2008.
5. www.triz-journal.com.

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

15ED72 COMPOSITE MATERIALS AND MECHANICS

3 0 0 3

Course Objectives

- To understand the fundamental concepts of various composite materials and its behavior.
- To acquire knowledge about various techniques involved in the manufacturing of Polymer, Metal and Ceramic Matrix Composites.
- To learn the procedures involved in the design and failure analysis of various composites.

Course Outcomes (COs)

The student will be able to

1. Demonstrate the manufacturing techniques of Polymer, Metal and Ceramic Matrix Composites.
2. Design a suitable composite by adopting the standard design and failure analysis procedures.
3. Select suitable composite materials for specific engineering applications.

Unit I
Introduction to Composite Materials

Definition- Classifications - Matrix materials- Polymers-metals-ceramics- properties- Reinforcements-particles- whiskers - Fibers: glass- ceramic- aramid and carbon fibers -fabrication and properties. Metal Matrix Composites: classifications- particle reinforced- dispersed strengthened- fiber reinforced composites - rule of mixture- matrix/reinforcement interface- wettability- advantages -limitations and applications of composites.

8 Hours

Unit II
Manufacturing of Composites

Manufacturing of Polymer Matrix Composites: Hand lay-up - Spray technique - Bag molding - Compression molding- Filament winding - Pultrusion - Resin transfer molding (RTM) - Structural reaction injection molding (SRIM). Manufacturing of Metal Matrix Composites: Liquid state process- Liquid infiltration- Vortex method- Squeeze casting techniques. Solid state process- Diffusion bonding- Powder Metallurgy - In situ process. Manufacturing of Ceramic Matrix Composites: Hot pressing- reaction bonding - liquid infiltration- directed oxidation process.

10 Hours

Unit III
Mechanics of Lamina and Laminated Composites

Introduction to lamina and laminate- Characteristics of fiber reinforced lamina: Fundamentals- Orientations of fibers- Elastic properties of lamina- Coefficient of linear thermal expansion- Stress - Strain relationship for thin lamina- Compliance and stiffness Matrices. Laminated Structures: Symmetric laminates- angle ply laminates - Cross ply laminates- Quasi -Isotropic laminates- Inter-laminar Stresses.

8 Hours

Unit IV
Properties of Fiber Reinforced and Metal Matrix Composites

Static Mechanical properties- Tensile - Compressive- Flexural -In plane shear- inter-laminar shear strength- Fatigue- Impact - other properties - Environmental effects - long term properties: creep - stress rupture- fracture behavior and damage tolerance- methods of improving damage tolerance. Properties of metal matrix composites: Wear- corrosive - fracture - fatigue and flexural behaviour of Aluminium, magnesium, titanium and copper alloy composites- testing methods and standards.

10 Hours

Unit V
Design and Failure Analysis

Laminate design considerations- design of beam- tension- compression and torsion member- joint design- Design considerations for metal matrix composites - Failure prediction - failure theories-

Classical Lamination theory- Failure analysis- bending- buckling-fracture - Finite element analysis - microstructural analysis - design and analysis of sandwich structures.

9 Hours

Unit VI$

Research trends in polymer, metal and ceramic matrix composites. Advanced composites - Nano, bio and hybrid composites - Applications

Total: 45 Hours

Reference(s)

1. P.K.Mallick, *Fiber Reinforced Composites: Materials, Manufacturing and Design*, Maneel Dekker Inc, 2007.
2. A. K.Kaw, *Mechanics of Composite Materials*, CRC Press, NY, 2006.
3. Krishnan K. Chawla, *Composite Materials- Science and Engineering*, Springer, 2012.
4. F.I. Matthews and R. D. Rawlings, *Composite Materials: Engineering and Science*, Wood head publishing, 2005.
5. Robert M. Jones, *Mechanics of Composite Materials*, CRC Press, NY, 2015.
6. William D. Callister, *Materials Science And Engineering - An Introduction*, Wiley, 2010.
7. http://nptel.iitk.ac.in/courses/Webcourse-contents/IISc-BANG/Composite Materials.

$ Includes Self Study topics of all 5 units and considered for Continuous Assessment only.

15EDXA VALUE ENGINEERING

1 0 0 1

Course Objectives (CO)

- To study the fundamental concepts of value engineering.
- To understand the applications of versatility of value engineering.

Course Outcomes (COs)

The student will be able to

1. Demonstrate the various principles of value engineering.
2. Apply versatility of value engineering in engineering field.

Value Engineering Techniques: concepts, advantages, applications, problem recognition, and role in productivity, criteria for comparison, element of choice. Selecting products and operation for value engineering action, value engineering programmes, determining and evaluating function(s) assigning rupee equivalents, developing alternate means to required functions, decision making for optimum alternative, use of decision matrix, queuing theory and Monte Carlo method make or buy, measuring profits, reporting results, Follow up, Use of advanced technique like Function Analysis System. Versatility of Value Engineering: Value engineering operation in maintenance and repair activities. Value engineering in non-hardware projects. Initiating a value engineering programme, introduction, training plan, career development for value engineering specialities.

Total: 20 Hours

Reference(s)

1. Alphonse Dell'Isola, *Value Engineering: Practical Applications for Design, Construction, Maintenance & Operations*, R S Means Co., 2000.
2. Del L. Younker, *Value Engineering analysis and methodology*, Marcel Dekker Inc., New York, 2004.

15EDXB CONCEPTS OF ENGINEERING DESIGN

1 0 0 1

Course Objectives

- To impart knowledge on materials selection and manufacturing processes integrated with Engineering Design.
- To understand the need for component design.

Course Outcomes (COs)

Students will be able to

1. Select materials and integrate the manufacturing processes with Engineering Design.
2. Apply economic principles for a component design.

Importance of design- The design process-Considerations of Good Design –Designing to codes and standards - Identification of customer needs- customer requirements- Quality Function Deployment- Product Design Specifications- Human Factors in Design – Ergonomics and Aesthetics. Societal consideration - Contracts – Product liability – Protecting intellectual property – Legal and ethical domains – Codes of ethics– Ethical conflicts – Environment responsible design-future trends in interaction of engineering with society. Conceptual decomposition-Generating design concepts-Axiomatic Design – Evaluation methods-Embodiment Design-Product Architecture- Configuration Design- Parametric Design. Role of models in design-Mathematical Modelling – Material Selection Process – Economics – Cost Vs Performance – Weighted property Index – Value Analysis – Role of Processing in Design – Classification of Manufacturing Process.

Total: 20 Hours

Reference(s)

1. T. Karl Ulrich and Steven D. Eppinger, *Product Design and Development*, McGraw Hill Edition, 2000.
2. E. Dieter, George, *Engineering Design –A materials and processing Approach*, McGraw Hill, International Edition, Singapore, 2000.
3. Michael Ashby, Hugh Shercliff and David Cebon, *Materials Engineering, Science, Processing and Design*, Butterworth Heinemann, 2007.