Academic Program: PG

Academic Year 2018-19

Syllabus

I & II Semester M.Tech.

(Engineering Analysis & Design)

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002

(An Autonomous Institution recognized by AICTE & Affiliated to VTU, Belagavi)

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SDM College of Engineering & Technology, Dharwad

It is certified that the scheme and syllabus for I &II semester M.Tech. inEngineering Analysis & Design is recommended by Board of Studies of Mechanical Engineering Department and approved by the Academic Council, SDM College of Engineering &Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2018-19 till further revision.

Principal Chairman BoS&HoD

SDM College of Engineering & Technology, Dharwad
Department of Mechanical Engineering
(Our motto: Professional Excellence through Education)

College Vision and Mission

Vision:
To develop competent professionals with human values.

Mission:
1. To have contextually relevant Curricula.
2. To promote effective Teaching Learning Practices supported by Modern Educational Tools and Techniques.
3. To enhance Research Culture.
4. To involve Industrial Expertise for connecting classroom content to real life situations.
5. To inculcate Ethics and impart soft-skills leading to overall Personality Development.

SDMCET- Quality Policy
- In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values
- Competency
- Commitment
- Equity
- Team work and
- Trust

Department Vision and Mission

Vision:

To establish a synergetic Mechanical Engineering program anchored in fundamentals and relevant state of the art technologies, thereby enabling the students to achieve all round development for careers in industry and for higher learning, being responsible to society and environment.

Mission:

1. To establish a curricula & syllabi consisting of robust core courses with emphasis on imparting fundamental principles of mechanical engineering coupled with adaptive and relevant electives catering to the cutting edge technologies.
2. To promote interactive teaching practices using modern educational tools & techniques to attain synergy in teaching, researchand industrial practices.
3. To imbibe industrial expertise for connecting class room learning to real life situation.
4. To impart soft skills and professional ethics enabling students to achieve an all round personality development, making them responsive to societal needs and environmental concerns.

Program Educational Objectives (PEOs)

1. Graduates will be successful in industry, research and higher learning.
2. Graduates will formulate, analyze and solve engineering problems.
3. Graduates will work in teams to address industrial and socially relevant problems / projects.
4. Graduates exhibit awareness and commitment to lifelong learning & practice professional ethics.

Program Outcomes (POs) - PG

1. An ability to independently carry out research / investigation and development work to solve practical problems.
2. An ability to write and present a substantial technical report / document.
3. Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Program Specific Outcomes (PSOs)- PG

1. Student will be able to formulate, analyze, design and critically evaluate automotive &Thermal power systems.
2. Students will be able to apply appropriate techniques, resources & modern engineering tools to solve complex engineering problems related to automotive and thermal systems.

Scheme of Teaching and Examination

I Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration in hours
18PEADC100	Computational Methods in Engineering	4-0-0	4	50	100	3		
18PEADC101	Theoretical Stress Analysis	4-0-0	4	50	100	3		
18PEADEXXX	Elective 1	4-0-0	4	50	100	3		
18PEADEXXX	Elective 2	4-0-0	4	50	100	3		
18PEADEXXX	Elective 3	4-0-0	4	50	100	3		
18PEADL131	Design Engineering Lab – I	0-0-3	2	50			50	3
18PEADL132	**Seminar	0-0-2	1	50				
Total		**20-0-5**	**23**	**350**	**500**		**50**	

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

*SEE fora theory course is conducted for 100 marks and reduced to 50 marks.

**Seminaris to be conducted every week and 2-3 students/week will present topic from emerging are as in Engineering Analysis and Design preferably the contents not studied in their regular courses. Theseminarsh all be evaluated by2faculty members having specialization in Engineering Analysis and Design and alliedareas.

Course Code	Elective Courses
18PEADE125	Advanced Fluid Dynamics
18PEADE126	Finite Element Methods
18PEADE127	Advanced Composite Materials And Mechanics
18PEADE128	Design of Renewable Energy Systems
18PEADE129	Design Optimization
18PEADE130	Design for Manufacture

Scheme of Teaching and Examination
II- Semester

Course code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration in hours
18PEADC200	Automobile System Design	4-0-0	4	50	100	3		
18PEADC201	Computational Fluid Dynamics	4-0-0	4	50	100	3		
18PEADEXXX	Elective4	3-0-2	4	50	100	3		
18PEADEXXX	Elective5	4-0-0	4	50	100	3		
18PEADEXXX	Elective6	3-0-2	4	50	100	3		
18PEADL231	Design Engineering lab -II	0-0-3	2	50			50	3
18PEADL232	** Seminar	0-0-2	1	50				
Total		**18-0-09**	**23**	**350**	**500**		**50**	

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical

***SEE for a theory course is conducted for 100 marks and reduced to 50 marks.

****Seminar is to be conducted every week and 2-3 students/week will present a topic from emerging areas in Engineering Analysis and Design preferably the contents not studied in their regular courses. The seminar shall be evaluated by 2 faculty members having specialization in Engineering Analysis and Design and allied areas.

Course Code	Elective Courses
18PEADE225	Dynamics & Mechanism Design
18PEADE226	Power Plant Design
18PEADE227	Fracture Mechanics
18PEADE228	Heating Ventilation & Air Conditioning (HVAC)
18PEADE229	Advanced Theory of Vibrations
18PEADE230	Advanced Product Design

Detailed Syllabus

I Semester

18PEADC100	Computational Methods in Engineering	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. Formulation of mathematical models to simple physical systems.
2. Establishing numerical solutions based on extensive computational mathematics for the mathematical models developed.
3. Forming the basic algorithms for framing the basis for computer based solutions in modern systems science.

Course Outcomes (COs):

Description of the course outcome: At the end of the course the student will be able to:		Mapping to POs (1-5)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Formulate mathematical models for the simple physical systems and evaluate the errors due to approximations.	3	4	5,1
CO-2	Determine the roots of nonlinear equations and polynomials in Science and Engineering problems.	3	2	5
CO-3	Establish numerical solutions for differentials and integrals functions.	3	2	4
CO-4	Apply the fundamentals of linear algebra for engineering problems.	3	2	4
CO-5	Establish the numerical solutions for ordinary differential equations and partial differential equations.	3	2	4
CO-6	Apply the concepts of optimization for constrained and un-constrained engineering problems.	3	2	5

POs	PO-1	PO-2	PO-3	PO-4	PO-5
Mapping Level	1	2	3	1.25	1

Course content:

1 Mathematical modelling & Error analysis: Mathematical modelling in engineering problem solving, approximations & round-off errors – error definition, accuracy, precision, round-off errors, truncation errors. Use of programing skills and software for engineering computations. **8 Hrs**

2 Roots of equations:
Mathematical background, Solution of non-linear algebraic equations-Bracketing method, graphical method, bisection method, Newton's Rapson method, Secant method. Use of programming skills and software for establishing the numerical solutions for simple problems. **10Hrs**

3 Numerical Differentiation & Integration: Mathematical background, Numerical Differentiation and Numerical Integration: Newton's forward and back ward difference formula. Newton –Cotes and Gauss Quadrature Integration formulae, Integration of Equations, Romberg integration. **9Hrs**

4 Linear algebra Numerical Methods in Linear Algebra: Direct and iterative solution techniques for simultaneous linear algebraic equations – Gauss elimination, Gauss-Jordon, LU Decomposition, QR Method, Jacobi and Gauss-Seidel Method, Eigenvalues and Eigenvectors – Power and inverse power method, householder transformation, physical interpretation of eigenvalues and eigenvectors. - **10 Hrs**

5 Numerical solutions for differential equations: Mathematical basis, need for numerical solutions, Numerical solution of differential equations Ordinary Differential Equations – Euler, Heun's method and Stability criterion, second order, third and fourth order Runge-Kutta methods, Partial Differential Equations – Classification of PDEs, Elliptic equations, Parabolic equations (Transient diffusion equation). **8 Hrs**

6 Optimization – One dimensional unconstrained optimization – Golden section search Newton's method, Constrained optimization- Linear programming, and non-linear constrained optimization. **7Hrs**

Reference Books:

1. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI, 2005.
2. Steven C. Chapra, Raymond P.Canale, Numerical Methods for Engineers, Tata McGraw Hill, 4th Ed, 2002.
3. M K Jain, S.R.K Iyengar, R K. Jain, Numerical methods for Scientific and engineering Computation, New Age International, 2003.
4. Pervez Moin, Fundamentals of Engineering Numerical Analysis, Cambridge, 2010.
5. David C. Lay, Linear Algebra and its applications, 3rd edition, Pearson Education, 2002.
6. Joe D Hoffman, Numerical Methods for Engineers and Scientists, Second Edition, Marcel Dekker (2001)
7. Gilbert Strang, Computational Science and Engineering, Wellesley-Cambridge Press-2007.

18PEADC101	Theoretical Stress Analysis	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objective of this course is to make the student aware of:

1. Analysis of Stress, notation of stress, importance of equilibrium equations, principal stresses boundary conditions in terms of surface forces.
2. Analysis of strain, importance of compatibility equations.
3. Stress-Strain relations, relation between engineering constants, general theorems.
4. Airy's stress function in case of plane stress and plane strain condition, application problems like cantilever beam, simply supported beam, thick cylinder, rotating disc, Differential equations for the bending of thin plates, Energy principles for stress analysis problems.
5. Torsion of circular and non-uniform cross section bars, membrane analogy, tubes.

Course Outcomes (COs):

Description of the course outcome: At the end of the course the student will be able to:		Mapping to POs(1-5)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Visualize the concept stress at a point, derive equations of equilibrium, Solve problems on principal stress, stress transformation	1,3	4	2,5
CO-2	Analyze strain at a point and derive strain compatibility equations, numerical on strain transformation	1,3	4	2,5
CO-3	Derive equations stress strain relations using engineering constants, numerical on stress strain	1,3	4	2,5
CO-4	Derive Governing differential equations for 2-D problems in rectangular and polar co-ordinate system for cantilever beam, bending of thin plates, simply supported beam, Applications of Energy principles in stress analysis	1,3	4	2,5
CO-5	Apply membrane analogy to day today non circular members under torsion, numerical on circular and non-circular sections under torsional load, thin tubes.	-	1,3	2,5

POs	PO1	PO2	PO3	PO4	PO5
Mapping Level	2.8	2.8	2	-	-

Pre requisites: Strength of materials, applied mathematics, material science.

Course contents:

1. **Analysis of Stress**: Definition and notation of stress; differential equations of equilibrium; specification of stress at a point; principal stresses; boundary conditions in terms of surface forces. **6 Hrs**
2. **Analysis of Strain**: Strain components; specification of strain at a point; compatibility equations. **4 Hrs**
3. **Stress-Strain Relations**: Generalized Hooke's law; Generalized Hooke's law in terms of engineering elastic constants; strain energy; general theorems – uniqueness theorem, principle of superposition, saint venants principle. **5Hrs**
4. **Plane stress and plane strain problems**: Governing differential equations; Airy's stress function; 2-D problems in rectangular and polar co-ordinates; Bending of cantilever loaded at the end; bending of simply supported beam by uniform load; Thick cylinder under uniform pressure; Shrink fits; Effect of small circular holes in strained plates; stresses in rotating discs and cylinders; rotating disc of variable thickness; Thermal stresses in thin discs and long cylinders. **14 Hrs**
5. **Torsion**: Torsion of circular and elliptical bars; Membrane analogy, Torsion of thin open sections, torsion of thin tubes. **6 Hrs**
6. **Energy principles**: Principle of potential energy; principle of complimentary energy; the principles of potential and complimentary energy considered as variational principles; Rayleigh-Ritz method; galerkin method; reciprocal theorem and Castiglione's theorems. **9Hrs**
7. **Bending of thin plates:** Differential equation for the bending of thin plates, boundary conditions, bending of simply supported rectangular plates with clamped edges. **8 Hrs**

Reference Books:

1. C.T.Wang "Applied Elasticity" McGraw Hill Book Co. Inc 1953
2. L.S.Srinath "Advanced Solid Mechanics" PHI, 2002
3. S.P.Timoshenko and J.N.Goodier "Theory of Elasticity" 3rd Ed, McGraw Hill, 1970.

18PEADL131	Design Engineering Lab - 1	(0-0-3) 2

Contact Hours: 36

Course Learning Objectives (CLOs): The objective of this course is to make the student aware of:

1. Introduction to Finite Element analysis.
2. Introduction to Thermal and CFD analysis
3. Fabrication and testing of Composite Materials
4. MATLAB coding for finding Stress invariants and control systems.

Course Outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-5)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Ability to analyze the product by use of FEM software	1,5	2,4	3
CO-2	Identifying the advanced materials and fabricate it.	1	2	3, 4, 5
CO-3	Ability to formulate and analyze Thermal and CFD problems	1,4	2,5	3
CO-4	Ability to design, analyze and simulation of simple control systems.	1,4	2	3,5

PO s	PO 1	PO 2	PO 3	PO 4	PO 5
Mapping Level	3	2	1	2.25	1.4

Prerequisites:

1. Finite Element Method, Theory of Elasticity, Ansys, MATLAB
2. Heat Transfer, Advanced Fluid Dynamics, Composite Materials

Course contents:

Experiment #1
Numerically Calculation and MATLAB Simulation
Part A:Invariants, Principal stresses and strains with directions
Part B: Maximum shear stresses and strains and planes, Von- Mises stress

Experiment #2

Stress analysis in Curved beam in 2D
Part A: 2D Photo elastic Investigation.
Part B:Modelling and Numerical Analysis using FEM.

Experiment #3
Stress analysis of rectangular plate with circular hole under i. Uniform Tension and ii. shear
Part A: Modelling of plate geometry under chosen load conditions and study the effect of plate geometry.
Part B: Numerical Analysis using FEA package.

Experiment #4
Single edge notched beam in four point bending.
Part A: Modeling of single edge notched beam in four point bending.
Part B: Numerical Studies using FEA..

Experiment #5
Torsion of Prismatic bar with Rectangular cross-section
Part A: Elastic solutions, MATLAB Simulation
Part B: Finite Element Analysis of any chosen geometry.

Experiment #6
Vibration Characteristics of a Spring Mass Damper System.
Part A: Analytical Solutions.
Part B: MATLAB Simulation.

Experiment #7
Modelling and Simulation of Control Systems using MATLAB.
Experiment #8
Experimental analysis of advanced materials subjected to tension, compression and bending.

Experiment #9
Study of microstructure for advanced materials.

Experiment #10
Thermal analysis:
Part A: Square Plate with Temperature Prescribed on one edge and opposite edge insulated.
Part B: Thermal analysis of a Thick Square Plate with the Top Surface exposed to a Fluid at high temperature, Bottom Surface at room temperature, Lateral Surfaces Insulated

Reference Books:

1. T. R. Chandrupatla and A. D. Belegundu, “Introduction to Finite Elements in Engineering”,Prentice Hall,Ed, 2002.
2. Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant “Experimental Stress Analysis”,Tata McGraw Hill, 1984. “Foundations of fluid mechanics”- S. W. Yuan,SI Unit edition,1988
3. V. P. Singh, DhanpatRai and Company Advanced Mechanics ofsolids, L. S. Srinath“Mechanical Vibrations”, Tata Mc. Graw Hill, 2009.
4. Katsuhiko Ogata “Modern Control Engineering”,5th Edition
5. Derek P. Atherton “Control Engineering: An introduction with the use of Matlab”, Book boonPublishers.
6. Huei-Huang Lee “Finite Element Simulations with ANSYS Workbench 14” , SDCPublication
7. Finite Element Analysis Using Ansys 11.0 Paperback – 2010 by Srinivas, Datti
8. Introduction to Ansys 16.0 Paperback – Import, 2 Feb 2017 by R.B.Choudary
9. Tadeusz Stolarski, Y. Nakasone,S.Yoshimoto “Engineering Analysis with ANSYS Software”,

18PEADL132	Seminar	(0-0-3)1

Contact hours: 36

Course Learning Objectives (CLOs): The objective of this course is to make the student aware of:

1. The latest trends in engineering and research.
2. Presentation skills.
3. Communication skills.
4. Art / techniques of Report preparation.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to Pos (1-5)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Refer to the learning resources, recognize and collect the required information.	2	--	5
CO-2	Describe the usefulness of information and make effective oral presentation using ppt.	2	--	4
CO-3	Compile the information published and prepare a technically sound report.	2	--	-
CO-4	Justify the technical solutions presented and draw the concluding remarks.	2	4	5

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
Mapping Level	-	3	-	1.5	1	

Every student has to present a seminar on thrust areas in Mechanical Engineering suitably selecting the topic in consultation with a guide. The seminar will be evaluated by a faculty committee consisting two members.

18PEADE125	Advanced Fluid Dynamics	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objective of this course is to make the student aware of:

1. Fluid and its properties, laws governing fluid flow and mathematical interpretation.
2. Fluid flow concepts, velocity potential, ideal fluid flow concepts and stream functions.
3. Fluid dynamics continuity equation, Navier stokes equation and application of it.
4. Low Reynolds number flow and viscous flow.
5. Compressible flow, sonic velocity Mach number isentropic flow.

Course Outcomes (COs):

Description of the course outcome: At the end of the course the student will be able to:		Mapping to POs(1-5)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Define and Explain the fluid properties, derive the governing equations of fluid flow of 2D and 3D.	3	--	--
CO-2	Analyze viscous flow through circular pipe, between parallel plates, and unsteady flow.	2	--	--
CO-3	Derive equations for velocity and thermal boundary layer thickness and solve related equations and problems, convection	4	--	--
CO-4	Analyze low Reynolds's number flows past cylinder and sphere and solve the problem related lift and drag.	3	--	1
CO-5	Explain integral flow equation, flow measurement using flow meters, pressure probes, hot wire manometer and wind tunnel.	5	--	--

POs	PO 1	PO 2	PO 3	PO 4	PO 5
Mapping Level	1	3	3	3	3

Pre requisites: Basic thermo dynamics, Basic Science, Engineering Mechanics, Fluid mechanics and fluid flow dynamics, Applied Mathematics.

Course contents:

1. **Review of fluid mechanics:** Fluid properties, Continuity equation 2D &3D(Cartesian, cylindrical and spherical co-ordinates derivation and problems) Nevier Stokes equation (3D Cartesian co-ordinates). Elementary inviscid flows; superposition. **10 Hrs**
2. **Viscous flow:** Steady flow Hagen Poseuille problem, plane poiseuille problem, unsteady flow; impulsively started plate. **8 Hrs**
3. **Hydrodynamic & Thermal Boundary Layer theory:** Definitions, Hydrodynamic boundary layer, boundary layer thickness, displacement, momentum & energy thickness, (Derivations and problems) Blasicus equation, von karman integral equation separation of flow thermal boundary layer. **8 Hrs**
4. **Low Reynolds number flow:** Lubrication theory (Reynolds equation), flow past immersed bodies; lift & drag. **6 Hrs**
5. **Integral flow Analysis:** Reynolds transport theorem, continuity, momentum equation Energy equations. **5Hrs**
6. **Flow measuring devices:** Classification, flow meters, notches pressure probes, Hot wire anemometer & Wind tunnels. **8 Hrs**
7. **Special topics:** Natural and forced convection, stability theory and introduction to turbulent flows. **7Hrs**

Reference Books:

1. K Muralidhar& G. Biswas, “Advanced Engineering Fluid Mechanics” 2nd edition, Narosa Publisher, 2013
2. S.W Yuan, “Foundation of fluid mechanics” SI Unit Edition 1988.
3. Dr. R.K.Bansal, “ A text book of Fluid Mechanics and Hydraulic machines” 9th Edition, Laxmi Publications, 2005
4. K L Kumar “Engineering Fluid Mechanics” S Chand & Co Ltd – 2017.

18PEADE126	Finite Element Methods	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The student is expected to learn:

1. To use variational principles for solving problems in solid mechanics.
2. To explain basic procedure of FEM for different types of problems.
3. To formulate different types of problems using different elements using FEM.
4. To solve basic problems on dynamic analysis using FEM.

Course Outcomes (COs):

Description of the course outcome: At the end of the course the student will be able to:		Mapping to POs(1-5)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Solve basic problems in solid mechanics using variational and other principles	-	-	3,4
CO-2	Explain fundamentals of FEM to solve solid mechanics and heat transfer problems.	-	-	1,3,4
CO-3	Develop finite element formulation for bars, trusses and beams.	-	-	3
CO-4	Develop finite element formulation using different 1D, 2D and 3D elements.	3	-	5
CO-5	Solve solid mechanics and heat transfer problems using 1D, 2D and 3D elements.	4	5	-
CO-6	Perform dynamic analysis using finite element method for 1D and 2D problems.	1	5	--

POs	PO1	PO2	PO3	PO4	PO5
Mapping Level	2	-	1.5	1.6	1.6

Pre requisites: Matrix operations and calculus, Strength of Materials, Theory of Elasticity

Course contents:

1. **Introduction to Finite Element Method:** Basic Steps in Finite Element Method to solve mechanical engineering (Solid, Fluid and Heat Transfer) problems: Functional approach and Galerkin approach, Displacement Approach: Admissible Functions, Convergence Criteria: Conforming and Non-Conforming elements, Co C1 and Cn Continuity Elements. Basic Equations, Element Characteristic Equations, Assembly Procedure, Boundary and Constraint Conditions. **10 Hrs**

2. **Solid Mechanics:** One-Dimensional Finite Element Formulations and Analysis – Bars- uniform, varying and stepped cross section-Basic(Linear) and Higher Order Elements Formulations for Axial, Torsional and Temperature Loads with problems. Beams- Basic (Linear) Element Formulation-for uniform, varying and stepped cross section- for different loading and boundary conditions with problems. Trusses, Plane Frames and Space Frame Basic(Linear) Elements Formulations for different boundary condition-Axial, Bending, Torsional, and Temperature Loads with problems. **11Hrs**
3. **Two Dimensional Finite Element Formulations for Solid Mechanics Problems:** Triangular Membrane (TRIA 3, TRIA 6, TRIA 10) Element, Four-Noded Quadrilateral Membrane (QUAD 4, QUAD 8) Element Formulations for in-plane loading with sample problems. Triangular and Quadrilateral Axi-symmetric basic and higher order Elements formulation for axi-symmetric loading only with sample problems Three Dimensional Finite Element Formulations for Solid Mechanics Problems: Finite Element Formulation of Tetrahedral Element (TET 4, TET 10), Hexahedral Element (HEXA 8, HEXA 20), for different loading conditions. Serendipity and Lagrange family Elements. **11Hrs**
4. **Finite Element Formulations for Structural Mechanics Problems:** Basics of plates and shell theories: Classical thin plate Theory,Shear deformation Theory and Thick Plate theory. Finite Element Formulations for triangular and quadrilateral Plate elements. Finite element formulation of flat, curved, cylindrical and conical Shell elements. **10 Hrs**
5. **Dynamic Analysis:** Finite Element Formulation for point/lumped mass and distributed masses system, Finite Element Formulation of one dimensional dynamic analysis: bar, truss, frame and beam element. Finite Element Formulation of Two dimensional dynamic analysis: triangular membrane and axisymmetric element, quadrilatateral membrane and axisymmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame. **10 Hrs**

Reference Books:

1. Rao S. S. “Finite Elements Method in Engineering” 4th Edition, Elsevier, 2006
2. P.Seshu, “Textbook of Finite Element Analysis” PHI, 2004.
3. J.N.Reddy, “Introduction to Finite Element Method” McGraw -Hill, 2006.
4. Bathe K. J. “Finite Element Procedures” Prentice-Hall, 2006.
5. Cook R. D “Finite Element Modeling for Stress Analysis” Wiley,1995
6. T. R. Chandrupatla and A. D. Belegundu, “Introduction to Finite Elements in Engineering”Prentice Hall, 3rd Ed, 2002.
7. Lakshminarayana H. V “Finite Elements Analysis– Procedures in Engineering” UniversitiesPress, 2004.

18PEADE127	Advanced Composite Materials And Mechanics	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): This course will enable students to

1. Learn composite properties including longitudinal and lateral moduli, Poisson‟s ratio, and shear modulus
2. Acquire the knowledge to determine the generalized stiffness and compliance matrix relating in plane stresses to strains for a composite layer assuming plane stiffness
3. Gain knowledge on powder metallurgy application & know what are surface treatments for materials

Course Outcomes (COs):

Description of the course outcome: At the end of the course the student will be able to:		Mapping to POs(1-5)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO 1	Determine composite mechanical properties from constituent fiber and matrix material properties including longitudinal and lateral moduli, Poisson's ratio, and shear modulus.	3, 4	1	--
CO 2	Apply the generalized stiffness and compliance matrix relating in - plane stresses to strains for a composite layer assuming plane stiffness.	3, 4	--	1
CO 3	Model classical laminated plate theory to determine extensional, coupling, and bending stiffness of a composite laminate.	3	5	--
CO 4	Fabricate and detect defect in composite laminates and built up composite structures such as I beams, box beams etc.	3, 4	5	2
CO 5	Apply Concept of Shape Memory, phase transformation mechanism and characterization, properties and applications of Smart Materials.	3, 4	2	--
CO 6	Understand the fundamental mechanisms of Nanomaterials and able use in structural materials for the desired properties.	3, 4	--	5

POs	PO1	PO2	PO3	PO4	PO5
Mapping Level	1.5	1.5	3	3	2

Pre requisites: Engineering Mechanics, Material Science, Applied Mathematics

Course Content:

1. **Introduction to Composite Materials:** Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction. Metal Matrix Composites: Reinforcement materials, Types, Characteristics and selection, Applications. *Macro Mechanics of a Lamina***:** Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems. **13 Hrs**
2. **Micro Mechanical Analysis of a Lamina:** Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems. Experimental Characterisation of Lamina- Elastic Moduli and Strengths. *Failure Criteria:* Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsa-Hill theory, Tsai, Wu tensor theory, Numerical problem, practical recommendations. **14Hrs**
3. **Manufacturing and Testing:** Layup and curing - open and closed mould processing, Hand lay-up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair. NDT tests – Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method.

   Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites. **13 Hrs**

4. Smart Materials: Concept of Shape Memory, crystal structure, phase transformation mechanism and characterization, properties, classification and applications. **6Hrs**
5. Nano composites/materials: Classification, characterization, materials behavior, fabrication and applications. **6 Hrs**

Reference Books:

1. Krishan K. Chawla "Composite Materials, Science &Engg" 2nd edition, Springer publicat1on.
2. ASM Handbook on Metal Casting - Vol .15, 9th edition, ASM publication
3. ASM Handbook on Powder Metallurgy -Vol 17, ASM publications
4. Mick Wilson, KamaliKannangara, "Nanotechnology – Basic Science and Emerging Technologies" Overseas Press India PrivateLimited, First Indian Edition 2005.
5. V.S.R Murthy, A.K.Jena, K.P.Gupta, G.S.Murthy Structure "Properties of Engineering Materials" Tata McGraw Hill.
6. M.M.Schwartz, "Composite Materials Hand book" McGraw Hill.

7. AUTAR K.KAW, “Mechanics of composite materials” Taylor and Francis group.
8. Rober M. Jones, “Mechanics of Composite Materials” Taylor & Francis, 1998.
9. E.PaulDegarmo, J.T.Black, Ronald A Kohser “Materials and Processing in Manufacturing” 8th Edition – Prentice Hall India.
10. K.K.Chawla, “Composite materials – Science &Engineering” Springer.
11. A.K. Sinha, “Powder Metallurgy” 2nd Edition –. DhanpatRai Publications.
    Dr. H.K.Shivanand, “Composite Materials” by. Asian Publication.

18PEADE128	Design of Renewable Energy Systems	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objective of this course is to make the student aware of

1. Need of energy sources and alternative resources
2. Principal or methodology for design and analysis of Renewable Energy Systems
3. Economics & Environmental of energy conversion in renewable energy systems
4. Sustainability of renewable energy systems

Course Outcomes (COs):

Description of the course outcome: At the end of the course the student will be able to:		Mapping to POs(1-5)		
		Substantial Level(3)	Moderate Level(2)	Slight Level(1)
CO -1	Review the need of renewable energy sources for energy requirement	-	3	-
CO -2	Analyze the renewable energy source conversion to different forms of energy	4,5	-	-
CO -3	Design different renewable source use for small to large capacity applications	4,5	-	-
CO- 4	Illustrate the economic viability and sustainability of renewable energy systems	4,5	-	1,2

POs	PO-1	PO-2	PO-3	PO-4	PO-5
Mapping Level	1	1	2	3	3

Course contents:

1. **Factors promoting Renewable Energy sources:** Introduction, Factors affecting the use of renewable energy sources, Energy usage and pattern of India, Global warming and sustainable development. Renewable energy resources, types brief energy conversion methods and use pattern of Renewable energy sources in present context. **7Hrs**

2. **Solar thermal energy systems:** Introduction to solar energy, solar radiation data, methods of conversion, different conversion devices Flat plate collectors, concentrating collectors. Principle of design for thermal and other

forms of conversion.Water heating system for domestic and process industry.Principal of solar drying, design of solar driers. **8 Hrs**

3. **Solar Direct and Indirect conversion:** Direct conversion of solar energy to electrical energy, Performance evaluation of PV cell, modules, Panels and arrays and optimization. Principal of conversion solar energy to electrical by using heat engines. **8 Hrs**

4. **Wind energy systems (WES):** Characteristics of wind, wind power profile, aerodynamics of wind turbines. Basic elements of WES, Siting and sizing of WES, Wind turbine site matching, Applications. **7Hrs**

5. **Biomass energy systems:** Densification, Biomass combustion technology, Thermo-chemical and biochemical conversion to useful energy conversion such as thermal, electrical and mechanical energy. Material, size and types of biogas plants Bio-fuels importance & production. Principal components of Engine Biomass systems **7 Hrs**

6. **Other renewable energy systems & hybridization: Wave, Tidal, OTEC, Geothermal, And Hydrogen.** Principal of conversion and its utilization individually and in hybrid form **8 Hrs**

7. **Economic and environmental aspects of renewable systems.** Economic analysis of renewable sources. Based on the life cycle pollution aspect of renewable systems **7Hrs**

Reference books:

1. ZiyadSalameh, **Renewable Energy System Design**, Academic Press, ELISIEVIR
2. S.P.Sukatme, Solar Energy, TATA McGraw Hill, 1996
3. G.D.Rai, Non-Conventional Energy Sources, Khanna Publishers, New Delhi, Dec 2004.
4. Kreith&Goswami, Solar Energy, Taylor & Francis 1999
5. S. Rao, Dr B.B Parulekar, Energy Technology, 3rd edition, Khanna Publishers, Delhi, 2007

18PEADE129	Design Optimization	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The students are expected to learn:

1. The fundamental concepts of Optimization Techniques.
2. The importance of optimizations in real scenarios.
3. To provide the concepts of various classical and modern methods of for constrained and unconstrained problems in both single and multivariable.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1-5)		
		Substantial level(3)	Moderate level(2)	Slight level(1)
CO-1	Model and formulate optimization problems in standard form and assess the optimality of a solution	3	-	5
CO-2	Solve various constrained and unconstrained problems in single variable as well as multivariable.	3	5	-
CO-3	Construct computer programs to determine the optimal solution for unconstrained and constrained nonlinear optimization problems of multiple variables	3	-	-
CO-4	Apply the methods of optimization in real life situation.	3	-	1,2,
CO-5	Determine the advantages and disadvantages of applying different optimization techniques for a specific problem	3	-	2,
CO-6	Model and analyze multi objective and multidisciplinary optimization problems	3	-	1,2,

POs	PO 1	PO 2	PO 3	PO 4	PO 5
Mapping level	1	1	3	-	1.5

Course Content:

1. **Engineering Design Practice**: Evolution of Design Technology, Introduction to Design and the Design Process, Design versus Analysis, Role of Computers in Design Cycle, Impact of CAE on Design, Numerical Modeling with FEA and Correlation with Physical Tests.
   Applications of Optimization in Engineering Design: Automotive, Aerospace and General Industry Applications, Optimization of Metallic and Composite Structures, Minimization and Maximization Problems, MDO and MOO. **10 Hrs**

2. **Optimum Design Problem Formulation**: Types of Optimization Problems, the Mathematics of Optimization, Design Variables and Design Constraints, Feasible and Infeasible Designs, Equality and Inequality Constraints, Discrete and Continuous Optimization, Linear and Non Linear Optimization.
   Optimization Theory – Fundamental Concepts, Global and Local Minimum, Gradient Vector and Hessian Matrix, Concept of Necessary and Sufficient Conditions, Constrained and Unconstrained Problems, Lagrange Multipliers and Kuhn Tucker Conditions. **12Hrs**

3. **Sensitivity Analysis**, Linear and Non Linear Approximations. Gradient Based Optimization Methods – Dual and Direct.
   Optimization Disciplines: Conceptual Design Optimization and Design Fine Tuning, Combined Optimization, Optimization of Multiple Static and Dynamic Loads, Transient Simulations, Equivalent Static Load Methods. Internal and External Responses, Design Variables in Each Discipline. **10 Hrs**

4. **Manufacturability in Optimization Problems:** Design for Manufacturing, Manufacturing Methods and Rules, Applying ManufacturingConstraints to Optimization Problems.
   Design Interpretation: Unbound Problems, Over Constrained Problems, Problems with No of Multiple Solutions, Active and InactiveConstraints, Constraint Violations and Constraint Screening, Design Move Limits, Local and Global Optimum. **10 Hrs**

5. **Dynamic Programming:** Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming, Initial value problem, Examples. **10 Hrs**

Reference Books:

1. K. V. Mital and C. Mohan “Optimization methods” New age International Publishers, 1999.
2. R.L Fox “Optimization methods for Engg Design” Addison – Wesley, 1971
3. S.S.Rao, “Engineering Optimization: Theory and Practice” John Wiley, 2009
4. JasbirArora, “Introduction to Optimum Design” McGraw Hill, 2011.5.

18PEADE130	Design for Manufacture	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objective of this course is to make the student aware of:

1. Identifying major phases of design, effect of material properties on design, material selection process, tolerance analysis, review of tolerance grades through different manufacturing processes.
2. Identifying and analyzing various interchangeable part assembly, group tolerance, and functional datum.
3. Reviewing design considerations in casting, special sand cores, component design, component milling, drilling and finished machining.
4. Identifying and discriminating conventional feature location, tolerance, virtual size concept, position tolerance, functional gauge.
5. Identifying the importance of design of gauges for components checking in assembly.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1-5)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO1	Recognize effect of material properties on design, material selection process, tolerance analysis	1,2	3	5
CO2	Adopt and develop various interchangeable part assembly, group tolerance, and functional datum.	1	-	3
CO3	Review design considerations in casting, special sand cores, component design, component milling, drilling and finished machining	1,2	4	5
CO4	Compile and discriminate conventional feature location, tolerance, virtual size concept, position tolerance, functional gauge	1,2	3,4	5

POs	PO-1	PO-2	PO-3	PO-4	PO-5
Mapping Level	3	3	2	2	1

Course Content:

1. **Effect of Materials And Manufacturing Process On Design**: Major phasesofdesign. Effect of material properties on design Effect of manufacturing processes on design. Material selection process- cost per unit property, Weighted properties and limits on properties methods.
   Tolerance Analysis: Process capability, mean, varience, skewness, kurtosis, Process capability metrics, Cp, Cpk, Cost aspects, Feature tolerances, Geometries tolerances, Geometric tolerances, Surface finish, Review of relationship between attainable tolerance grades and different machiningprocess.Cumulativeeffectoftolerance – Surefitlawandtruncatednormallaw. **13Hrs**

2. **Selective Assembly:** Interchangeable part manufacture and selective assembly, Deciding the number of groups -Model-1: Group tolerance of mating parts equal, Model total and group tolerances of shaft equal. Control of axial play-Introducing secondary machining operations, laminated shims, examples.
   Datum Features: Functional datum, Datum for manufacturing, changing the datum. Examples. **12 Hrs**

3. **Design Considerations**: Design of components with casting consideration. Pattern,Mould, and Parting line. Cored holes and machined holes. Identifying the possibleand probable parting line. Casting requiring special sand cores. Designing to obviatesand cores.
   Component Design: Component design with machining considerations link design for turning components-milling, Drilling and other related process esincluding finish- machining operations. **13 Hrs**

4. **True positional theory**: Comparison between coordinate and convention method offeature location. Tolerance and true position tolerancing virtual size concept, Floating and fixed fasteners. Projected tolerance zone. Assembly with gasket, zero position tolerance. Functional gauges, Paper layout gauging. **8Hrs**

5. **Design of Gauges**: Design of gauges for checking components in assemble with emphasis on various types of limit gauges for both hole and shaft.**6 Hrs**

Reference Books:

1. Harry Peck, “Designing for Manufacturing”, Pitman Publications, 1983.
2. Dieter, “Machine Design” - McGraw-Hill Higher Education, -2008
3. R.K. Jain, "Engineering Metrology", Khanna Publishers, 1986
4. Geoffrey Boothroyd “Product design for manufacture and assembly”, Peterdewhurst, Winston Knight, Merceldekker. Inc. CRC Press, Third Edition
5. “Material selection and Design” Vol. 20 - ASM Hand book.

II Semester

18PEADC200	Automobile System Design	(4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs): The objective of this course is to make the student aware of:

1. The stages involved in automobile system design.
2. Industrial practices in design of various systems of an automobile.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1-5)		
		Substantial Level(3)	Moderate Level(2)	Slight Level(1)
CO-1	Define and explain basic parts of automobile and understand basic fuel injection principles.	1	3	2,5
CO-2	Design the different engine parts like piston, crankshaft, cylinder head, camshaft,etc	1,4	5	2,3
CO-3	Design of springs and combustion chamber	1,4	5	2,3
CO-4	Explain different transmission and suspension parts of automobile,	1	3	2,4,5
CO-5	Understand different cooling and emission principles in automotive.	-	1,2	3,4,5

POs	PO 1	PO 2	PO 3	PO 4	PO 5
Mapping Level	2.8	1.2	1.4	2	1.4

Course contents:

1. **Body Shapes:** Aerodynamic Shapes, drag forces for small family cars. Fuel Injection: Spray formation, direct injection for single cylinder engines (both SI & CI) and energy audit. **12 Hrs**

2. **Design of I.C. Engine I**: Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines. **9Hrs**

3. **Design of I.C. Engine II**: Design of crankshaft, camshaft, connecting rod, piston & piston rings for small family cars (max up to 3 cylinders). **10 Hrs**

4. **Transmission System**: Design of transmission systems – gearbox (max of 4-speeds), differential. Suspension System: Vibration fundamentals, vibration

analysis (single & two degree of freedom, vibration due to engine unbalance, application to vehicle suspension. **11Hrs**

5. **Cooling System**: Heat exchangers, application to design of cooling system (water cooled). Emission Control: Common emission control systems, measurement of missions, exhaust gas emission testing. **10 Hrs**

Reference Books:

1. Turns- Introduction to combustion
2. N.K.Giri “Automobile Mechanic” Khanna Publications, 1994
3. Maleev “I.C. Engines” McGraw Hill book company, 1976
4. Heldt P.M. “Diesel engine design” Chilton company New York.
5. V.M. Faires&Wingreen “Problems on design of machine elements” McMillan Company., 1965
6. John Heywood “Design of I.C.Engines” TMH
7. A .Kolchin& V. Demidov “Design of Automotive Engines”, MIR Publishers, Moscow
8. Newton steeds &Garratte“The motor vehicle” , Iliffee& sons Ltd., London
9. Edward F Obert “I.C. Engines”, International text book company.

18PEADC201	Computational Fluid Dynamics	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): This course will enable students to

1. To understand fundamentals of computational fluid dynamics to solve fluid flow and heat transfer problems.
2. To understand dimensionless form of governing equations of fluid flow and heat transfer.
3. Explain FDM and FVM.
4. Solve linear algebraic equations in CFD using numerical methods.
5. Solve fluid flow and heat transfer problems using commercial CFD codes.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to Pos (1-5)		
		Substantial Level(3)	**Moderate Level(2)**	**Slight Level(1)**
CO-1	Explain the fundamentals of CFD applied to fluid flow and heat transfer and also discuss on partial differential equations and mathematical flow models used in CFD.	3	---	---
CO -2	To examine fluid flow and heat transfer problems by using Finite Difference method and also error propagation.	1,3	---	---
CO-3	Explain Finite Volume method and analyze fluid flow and heat transfer problems by using Finite Volume method.	1,3	---	---
CO-4	Explain the implicit, explicit, ADI methods and solve the problems using implicit/explicit or ADI method.	3	---	----
CO-5	Explain the essentials of numerical method for CFD.	3	---	---
CO-6	Investigate the fluid flow and heat transfer problems by using theoretical approach and also by using commercial CFD software.	5,3	4	1,2

POs	PO 1	PO 2	PO 3	PO 4	PO 5
Mapping Level	2.3	1	3	2	3

Pre requisites: Fluid mechanics, Partial differential equations, Numerical Methods, Heat transfer**.**

Course Content:

1. **Introduction and Basic Concepts:** Need of CFD as a design and research tool, applications and advantages of CFD, Governing equations (Only discussion on continuity, momentum and energy equations),Dimensionless form of equations; Simplified mathematical models; Hyperbolic, Parabolic & Elliptic systems; Properties of numerical solutions (Consistency, Stability, Conservation, Convergence and Accuracy). Grid generation: structured grids, unstructured grids. **10 Hrs**
2. **Finite Difference Methods**: A differential to algebraic formulation for governing Partial Differential Equations and Boundary conditions, application of FDM to CFD, error propagation. Solution of One-dimensional heat conduction steady state and unsteady state, Two-dimensional steady state heat conduction using FDM. **10 Hrs**
3. **Finite volume method:** Surface & volume integrals; Interpolation & differentiation; Boundary conditions; Central difference and upwind schemes applied to 1-D situation involving convection and diffusion terms, Solution of One-dimensional heat conduction steady state and unsteady stateusing FVM. Calculation of flow field: staggered grid, SIMPLE algorithm. Implicit & Explicit Schemes, Alternate Direction Implicit (ADI) method. **14 Hrs**
4. **Essentials of Numerical Methods for CFD;** Iterative solution of linear algebraic equations for a flow property, iterative methods, applications of iterative methods to CFD, Tridiagonal Systems, under relaxation. **9Hrs**
5. **Use of commercial software**: Solution of 2D and 3D fluid flow and Heat transfer problems using commercial software. **9Hrs**

Reference Books:

1. T. J. Chung "Computational Fluid Dynamics" Cambridge Univ. Press, 2002.
2. Farlow "Partial Differential Equations for Scientists and Engineers" John Wiley, 1982.
3. J.H. Ferziger& M. Peric "Computational Methods for Fluid Dynamics", 3rd edition -, Springer, 2002.
4. G.D. Smith, Numerical Solutions of Partial Differential Equations, Finite Difference methods, 3rd ed., -, Oxford University Press. 1986.
5. Suhas V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, Washington, D. C., 1980.
6. H. Versteeg, W. Malalasekra, An Introduction to Computational Fluid Dynamics, 2^{nd} ed., Pearson Education Ltd. 1995.
7. John D. Anderson, Jr., Computational Fluid Dynamics: The basics with applications, McGraw Hill Education (India) Private Limited, New Delhi.1995.
8. Atul Sharma, Introduction to Computational Fluid Dynamics: Development, Applications and Analysis, Ane Books Pvt Ltd, New Delhi. 2017.
9. C. Hirsch, Numerical Computation of Internal & External Flows: The fundamentals of Computational Fluid Dynamics, Elsevier India PvtLtd New Delhi.2012.
10. K. Muralidhar, T. Sundararajan, Computational Fluid Flow and Heat Transfer, 2^{nd} ed., Narosa Publishing House, New Delhi. 1995.

18PEADL231	Design Engineering lab – 2	(0-0-3)2

Contact Hours: 36

Course Learning Objectives (CLOs): The objective of this course is to make student aware of:

1. Introduction to Finite Element analysis.
2. Introduction to Complex models and Dynamic analysis
3. Fabrication and testing of Composite Materials
4. Design of mechanisms and synthesize different models.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1-5)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Ability to analyze the product by use of FEM software	1,5	2,4	3
CO-2	Identifying the advanced materials and fabricate it.	1	2	3, 4, 5
CO-3	Ability to formulate and analyze Complex models for dynamic analysis	1,4	2,5	3
CO-4	Ability to design, analyze and simulation of Mechanisms	1,4	2	3,5

PO s	PO 1	PO 2	PO 3	PO 4	PO 5
Mapping Level	3	2	1	2.25	1.4

Course contents:

Experiment #1

Structural Analysis

Part A: FE modeling of a stiffened Panel using a commercial preprocessor.

Part B: Buckling, Bending and Modal analysis of stiffened Panels.

Experiment #2

Design Optimization

Part A: Shape Optimization

Part B: Topology Optimization

Experiment #3

Thermal Stress Analysis

Part A: A Thick Walled Cylinder with specified Temperature at inner and outer Surfaces.
Part B: A Thick Walled Cylinder filled with a Fluid at high temperature and Outer Surface exposed to atmosphere.

Experiment #4
CFD Analysis
Part A: CFD Analysis of aerodynamic blade
Part B: Laminar Flow Analyses in a 2-D Duct

Experiment #5
Fracture toughness measurement for advanced materials using experimental and numerical approach.

Experiment #6
Simulation of crank rocker mechanism, crank-crank mechanism, crank rocker mechanism, rocker-rocker mechanism using software

Experiment #7
Static force analysis – four bar mechanism, slider crank mechanism (Analytical And Numerical)

Experiment #8
Natural frequency determination for suspension system using analytically and numerically.

Experiment #9
Dynamic analysis:
Part A: Harmonic Analysis of Cantilever beam
Part B: Dynamic analysis of bar subjected to forcing function

Experiment #10
Corner anglebracket analysis using finite element analysis.

Reference Books:

1. T. R. Chandrupatla and A. D. Belegundu, “Introduction to Finite Elements in Engineering”,
2. Prentice Hall,Ed, 2002.
3. Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant “Experimental Stress Analysis”,
4. Tata McGraw Hill, 1984. “Foundations of fluid mechanics”- S. W. Yuan,SI Unit edition,1988
5. V. P. Singh, DhanpatRai and Company Advanced Mechanics ofsolids, L. S. Srinath

6. “Mechanical Vibrations”, Tata Mc. Graw Hill, 2009.
7. Katsuhiko Ogata “Modern Control Engineering”,5th Edition
8. Derek P. Atherton “Control Engineering: An introduction with the use of Matlab”, BookboonPublishers.
9. Huei-Huang Lee “Finite Element Simulations with ANSYS Workbench 14” , SDCPublication
10. Finite Element Analysis Using Ansys 11.0 Paperback – 2010 by Srinivas, Datti
11. Introduction to Ansys 16.0 Paperback – Import, 2 Feb 2017 by R.B.Choudary
12. Tadeusz Stolarski, Y. Nakasone,S.Yoshimoto “Engineering Analysis with ANSYS Software”.

18PEADL232	Seminar	(0-0-3)2

Contact Hours: 36

Course Learning Objectives (CLOs): The objective of this course is to make the student aware of:

1. The latest trends in engineering and research.
2. Presentation skills.
3. Communication skills.
4. Art / techniques of Report preparation.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to Pos (1-5)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Refer to the learning resources, recognize and collect the required information.	2	--	5
CO-2	Describe the usefulness of information and make effective oral presentation using ppt.	2	--	4
CO-3	Compile the information published and prepare a technically sound report.	2	--	-
CO-4	Justify the technical solutions presented and draw the concluding remarks.	2	4	5

POs	PO 1	PO 2	PO 3	PO 4	PO 5
Mapping Level	-	3	-	1.5	1

Every student has to present a seminar on thrust areas in Mechanical Engineering suitably selecting the topic in consultation with a guide. The seminar will be evaluated by a faculty committee consist two members.

18PEADE225	Dynamics & Mechanism Design Simulation	(3-0-2) 4

Contact Hours: 52

Course Learning Objectives (CLOs): This course will enable students to

1. Learn the basic concepts of motion dynamics.
2. Design and analyze the mechanisms.
3. Familiarize about complex mechanisms.
4. Devise a mechanism using software.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1-5)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Analyse the planar mechanisms by Grashoff's law and introduction about complex mechanisms.	5	1	-
CO-2	Explain the terms associated with the principles of dynamics.	-	-	1
CO-3	Derive the mathematical models of mechanical systems using Lagrange's equation and Hamilton's principle.	3	-	-
CO-4	Calculate precision positions by using Chebychev spacing for function generation and path generation.	-	3	-
CO-5	Synthesize four bar and slider crank mechanisms by using Freudenstein's and Bloch's equations analytically and crank rocker mechanisms by graphical method.	1	2,5	-
CO-6	Study the spatial mechanisms and usage of software	-	-	4

POs	PO 1	PO 2	PO 3	PO 4	PO 5
Mapping Level	2	2	2.5	1	2.5

Pre requisites: Mechanical Vibrations, Kinematics and Dynamics of Machines.

Course Content:

1. **Geometry of Motion:** Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoffs law, Equivalent mechanisms, Unique mechanisms, complex mechanisms – low and high degree complexity mechanisms. **6 Hrs**
2. **Generalized Principles of Dynamics:** Fundamental laws of motion, Generalized coordinates, Configuration space, Constraints, Virtual work, principle of virtual work, Energy and momentum, Work and kinetic energy, Equilibrium and stability, Kinetic energy of a system, Angular momentum,

Generalized momentum. Lagrange's Equation: Lagrange's equation from D'Alembert's principles, Examples, Hamiltons equations, Hamiltons principle, Lagrange's, equation from Hamiltons principle, Derivation of Hamiltons equations, Examples. **13 Hrs**

3. **Synethesis:**Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebychev spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle Motion Generation: Poles and relative poles, Location of poles and relative poles, polode, Curvature, Inflection circle. **08 Hrs**
4. **Graphical Methods of Dimensional Synthesis:** Two position synthesis of crank and rocker mechanisms, Three position synthesis, Four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages. Ana1ytical Methods of Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis. **10 Hrs**
5. **Spatial Mechanisms:**Introduction,Position analysis problem. **3 Hrs**

6. Dynamic Simulation Laboratory

Software used: MSC-ADAMS (Adams-View)

1. Modeling of crank-rocker, double lever and crank-crank mechanisms using Grashoffs law.
2. Kinematic analysis of slider crank mechanism.- 1 exercise
3. Kinematic analysis of four bar mechanism.- 1 exercise.
4. Static force analysis of slider crank mechanism – 2 exercises.
5. Static force analysis of four bar mechanism – 1 exercise.
6. Dynamic force analysis of slider crank mechanism – 1 exercise.
7. Dynamic force analysis of four bar mechanism – 1 exercise.
8. Modeling of single DOF spring mass system.
9. Modeling of multi DOF spring mass system.

References Books:

1. J.E.Shigley, "Theory of Machines and Mechanism" -McGraw-Hill, 1995
2. A.G.Ambekar, "Mechanism and Machine Theory", PHI, 2007.
3. Ghosh and Mallick, "Theory of Mechanism and Mechanism" East West press2007.
4. David H. Myszka , "Machines and Mechanisms", Pearson Education, 2005.
5. K.J.Waldron&G.L.Kinzel, "Kinematics, Dynamics and Design of Machinery", Wiley India, 2007.
6. Greenwood, "Classical Dynamics", Prentice Hall of India, 1988.
7. Rattan S S -Theory of Machines; 2nd Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2006.
8. Adams multi body dynamics tutorials.
9. Dynamic simulation lab manual.

18PEADE226	Power Plant Design	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The students are expected to learn:

1. Thermal Power Plant Operation, basic thermodynamic cycles, modern boilers ,and power plant economics cost of generation and revenue per year.
2. Design of surface condensers, chimney and cooling towers in thermal power plants, knowledge of other accessories, numerical on surface condenser, chimney and cooling tower design.
3. Analyze combined cycle power plant and evaluation of the performance of combined cycle power plant.
4. Highlight the need of cogeneration and its benefits in terms of improved thermodynamic efficiency and revenue thorough case studies available in the literature
5. Environmental and safety aspects of power plant operation.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping POs (1-5)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Calculate thermodynamic efficiency of Rankine cycle and load factors of a power plant. and cost of power generation.	1, 3	--	--
CO -2	Explain boiler inspection methods, and evaluate rating and sizing problems related to surface condensers, cooling tower and chimney	1	3	--
CO-3	Calculate thermodynamic efficiency of combined cycle power plant and explain various possibilities of combined cycle power plant	1	3	--
CO-4	Evaluate the thermodynamic efficiency of cogeneration plants and explain topping and bottoming cycle cogeneration plants with case studies	1	3	2
CO-5	Explain environmental and safety aspects of power plants.	3	--	--

POs	PO 1	PO 2	PO 3	PO 4	PO 5
Mapping Level	3	2	3	--	--

Pre requisites: Basic and applied thermodynamics, heat transfer, engineering economics

Course contents:

1. **Thermal Plant**: Review of thermodynamics; vapor power cycles; regeneration; reheat cycles; furnace design; heat transfer; design estimation of net plant heat rate. Power plant economic-cost of generation per kwh. Effect of load factor on cost per kwh. **10 Hrs**

2. **Boilers and Steam Turbine**: Modern boilers and their features, Boiler Inspection Methods. Classification; design of multi stage power plant turbine, Mollier chart, velocity diagrams; governing; instrumentation; lubrication; estimation of specific steam consumption. **09Hrs**

3. **Design of surface condensers and cooling towers:** Requirements of modern surface condensers, classification of condensers. estimation of size; feed water heaters; mechanical and natural draft cooling towers, use of psychometric chart for evaluation of performance of cooling towers; cooling water treatment different methods. **12 Hrs**

4. **Combined cycle power plant** (STAG): Gas and steam power plant, Nuclear based combined cycle power plant Performance of combined cycle power plants. **08 Hrs**

5. **Cogeneration technology and systems** ; Topping cycle and bottoming cycle plants cogeneration applied to various industry viz. sugar petrochemical, textile, paper etc. enhancement of plant efficiency, reduction in costs due to cogeneration, case studies. **7Hrs**
6. **Environmental aspects in power plant & pollution control.** Introduction; Air pollution and control strategieswater pollution and control strategies. Safety features in power plant **6 Hrs**

Reference books:

1. Power Plant Engg. Domkundwar& Arora, DhanpatRai& Sons
2. P.K.Nag, Power plant engineering, 2nd Ed. Tata McGraw Hill, 2002
3. E.E.Khalil , Power design, 2 nd edition, Gorden and Breach Scince publishers Switzerland 1990
4. Principles of energy conversion, Culp Jr. McGraw Hill
5. Power Plant Engg. R.J.Rajput, Laxmi Publications New Delhi
6. Power plant technology, El Wakel M.M McGraw Hill 621.016 E52
7. Steam Turbine Cycles, K.J.Salisbury
8. Steam Turbine Theory & Practice, W.S.Keerton

18PEADE227	Fracture Mechanics	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The students are expected to learn:

1. About fracture mechanics provides a methodology for prediction, prevention and control of fracture in materials, components and structures.
2. The background for damage tolerant design.
3. To quantify toughness as materials resistance to crack propagation.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1 - 5)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO 1	Mechanics of fracture and stress-concentration/intensity concepts and Classify the different mechanisms/modes of fracture and apply the governing equations of linear elastic fracture mechanics to analyze the stresses and displacements around crack tips.	1	--	--
CO 2	Apply Griffith's energy balance concepts to determine fracture energy for various crack geometry and loading conditions and analyze initiation and growth of cracks in structures using nonlinear fracture parameters such as J-integral and CTOD to avoid failure under service loading	1,	3, 4	--
CO 3	Apply the various models for initiation and growth of a crack subjected to Mode-I and Mode-II and mix mode loading within the scope of LEFM	1,	3, 4	--
CO 4	Apply LEFM and EPFM testing methods for evaluating the fracture toughness of materials and its limitations in accordance with ASTM Standards.	1, 2, 3	--	5
CO 5	Predict the lifetime of structures susceptible to gradual crack growth through an empirical law and know some commonly used nondestructive test methods with merits and demerits.	1, 4	2	--

POs	PO-1	PO-2	PO-3	PO-4	PO-5
Mapping Level	3	2.5	2	2	1

Course Content:

1. **Introduction:** History and overview, Fundamental concepts, Fracture mechanics in Metals, Ductile fracture, Cleavage, The Ductile-Brittle transition, Inter-granular fracture, Modes of Fracture Failure **5Hrs**
   Stress Intensity Factor: Introduction, Stress analysis of cracks, The stress Intensity Factor, Effect of Finite size, Principle of superposition, Weight Functions, Relationship between K and G, Crack tip plasticity, Plane stress versus plane strain, K as a failure criterion, effective crack length, effect of plate thickness. **8 Hrs**
2. **Energy Release Rate:** Introduction, The Griffith energy balance, The energy release rate, Instability and the R-Curve, Thin plate vs Thick plate, Critical Energy release rate. **6 Hrs**
   Elastic Plastic Fracture Mechanics: Crack tip opening displacement, The J Contour Integral, Relationships between J and CTOD, Crack growth resistance curves, J-controlled fracture, Crack tip constraint under large scale yielding, HRR field. **8 Hrs**
3. **Fatigue Crack Propagation** Similitude in fatigue, Empirical fatigue crack growth equations, Crack Closure, Variable amplitude loading and retardation, Growth of short cracks, Micro-mechanisms of fatigue, Experimental measurement of fatigue crack growth, Damage Tolerance. **8 Hrs**
   Mixed Mode fracture: A simple Elliptical Model, Maximum Tensile Stress Criterion, Strain Energy Density Criterion, Maximum Energy Release Rate Criterion, Experimental Verifications; **5Hrs**
4. **Fracture Toughness testing of metals:** General Considerations, K_{IC} testing, K-R Curve testing, J testing of metals, CTOD testing, Dynamic and crack arrest toughness, Fracture testing of weldments. **6 Hrs**
5. **Crack Detection through Non-Destructive Testing:**Introduction, Examination through Human Sense, Liquid Penetration Inspection, Ultrasonic Testing, Radiographic Imaging and Magnetic Particle Inspection. **6 Hrs**

Reference Books:

1. Karen Hellan, “Introduction to fracture mechanics”, McGraw Hill, 2nd Edition
2. S.A. Meguid, “Engineering fracture mechanics” Elsevier Applied Science, 1989
3. Jayatilaka, “Fracture of Engineering Brittle Materials”, Applied Science Publishers, 1979
4. Rolfe and Barsom, “Fracture and Fatigue Control in Structures”, Prentice Hall, 1977
5. Knott, “Fundamentals of fracture mechanisms”, Butterworths, 1973
6. David Broek, “Elementary Engineering Fracture Mechanics”, Springer Netherlands,2011
7. Anderson, “Fracture Mechanics-Fundamental and Application”, T.L CRC press1998.

18PEADE228	Heating Ventilation and Air Conditioning	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): This course will enable students to

1. Explain basic terms and concepts used in HVAC industry and also make them to identify the parameters involved in Psychometric chart.
2. Identify the various units of Air-Conditioning.
3. To understand HVAC system design.
4. Understand house hold and nonconventional Air-Conditioning.
5. To understand acoustic control in Air-Conditioning.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to Pos (1-5)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Apply the basic thermodynamic principles on Air conditioning systems	1	---	---
CO -2	Analyze the operating principles mainly the thermodynamic and thermal insulation aspects of different components of Air conditioning system.	1	3	---
CO-3	Evaluate load prediction for a given space using the principles of Heating Ventilation and Air Conditioning (HVAC).	1	3	---
CO-4	Specify different components of a given air conditioning plant with suitable matching operating characteristics	1	3	----
CO-5	Analyzing heating, ventilation and Air-conditioning in building and also assess indoor air quality.	1	3	---
CO-6	Explain the need for noise control and acoustic control in air-conditioned units.	1	-	-

POs	PO 1	PO 2	PO 3	PO 4	PO 5
Mapping Level	3	-	2	-	-

Pre requisites: Thermodynamics, Heat Transfer,

Course Content:

1. Psychometry and psychometric properties, psychometric relations, psychometric chart, psychometric processes, requirements of comfort air

conditioning, comfort chart, Indoor air quality , thermal comfort, air contaminants. **12 Hrs**

2. Components and selection of Air conditioning units. Heat exchanger types, Insulation requirements and evaluation, insulating materials for air condition units. Selection of ducts, fans and blowers.Selection of working fluid and their characteristics. **8 Hrs**
3. Load and energy calculation : Cooling load calculations and design of air conditioning system: Different heat sources, Conduction heat load, Radiation load of the Sun, occupants load, equipment load, infiltration air load, miscellaneous heat sources, fresh air load, design of air conditioning system, bypass factor consideration, effective sensible heat factor, cooling coils and dehumidifying air washers. **10 Hrs**
4. HVAC design: space air diffusion, duct design, Pipe sizing , insulation for mechanical systems. **6 Hrs**
5. Building Envelope; Heat transfer , indoor air quality , air moisture controlling in building, heat transfer due to windows , wall and roof . **7Hrs**
6. Nonconventional air conditioning; evaporative cooling, evaluation of performance of evaporative cooler. **5Hrs**
7. Noise level and acoustic control, Automatic controls in air conditioning units. **4 Hrs**

Reference Books:

1. Arora, C.P., Refrigeration and Air Conditioning, 2nd ed., Tata McGraw-Hill, 2004.
2. Stoeker, W.F. and Jones, J.W., Refrigeration and Air Conditioning, 2nd ed., Tata McGrawHill, 1982.
3. Krieder J.F Curtiss P.S. Rable A “Heating cooling of buildngs “ McgrawHill, NewYark 2002
4. ASHRAE Handbook - Fundamentals, American Society of Heating, Refrigerating and Air - Conditioning Engineers Inc., Atlanta, USA, 2009.
5. Croome, D.J. and Roberts, B.M., Air conditioning and ventilation of buildings, Pergamon.

18PEADE229	ADVANCED THEORY OF VIBRATIONS	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

The objective of this course is to make the students aware of

1. How to use the theoretical principles of vibration, and vibration analysis techniques, for the practical solution of vibration problems in engineering design practices.
2. Understand the importance of vibrations in mechanical design of machine parts that operate in vibratory conditions.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1-5)		
		Substantial Level(3)	Moderate Level(2)	Slight Level(1)
CO -1	Apply Newton's equation of motion and energy methods to model basic vibrating mechanical systems and solve for the natural frequencies of undamped, damped, forced and Transient vibrating single degree of freedom systems	1,3,4	5	--
CO -2	Design of shock isolators, active vibration-control systems and vibration absorbers for given specification and understand vibration measurements and its applications	1,3,4	5	--
CO -3	Apply experimental modal analysis and machine-condition monitoring techniques to determine the system characteristics and diagnosis and Investigate free-vibration solutions of string, bar, shaft and beam.	1,3,4	5	2
CO- 4	Understand Random phenomena of vibration using Time averaging, Frequency response function, Probability distribution, Power spectrum, power spectral density and Fourier transforms.	1,3,4	--	--

POs	PO-1	PO-2	PO-3	PO-4	PO-5
Mapping Level	3	1	3	3	2

Course Content:

1. **Single degree of freedom systems: Review of** free and forced vibration with or without damping, transmissibility. **Multi degree of freedom systems**: Two degree of freedom system, undamped vibration absorbers, generalized coordinates and coordinate coupling, orthogonality principle. **Transient Vibration of single Degree-of freedom systems:** Impulse excitation, Arbitrary excitation, Laplace transform formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation. **14 Hrs**

2. **Vibration Control:** Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, shock isolation, Dynamic vibration absorbers, Vibration dampers. **Vibration Measurement and applications:** Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis. **12Hrs**

3. **Continuous Systems:** Vibrating string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams**. Modal analysis and Condition Monitoring:** Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis. **16 Hrs**

4. **Random Vibrations :** Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms, FTs and response. **10 Hrs**

Reference Books

1. Theory of Vibration with Application, - William T. Thomson, Marie Dillon Dahleh,Chandramouli Padmanabhan , 5th edition Pearson Education
2. S. Graham Kelly , "Fundamentals of Mechanical Vibration" - McGraw-Hill, 2000
3. S. S. Rao , "Mechanical Vibrations", Pearson Education, 4th edition.
4. Mechanical Vibration by G.K. Grover. Nem Chand & Bros. 2009
5. S. Graham Kelly , "Mechanical Vibrations", Schaum's Outlines, Tata McGraw Hill,2007.
6. C Sujatha , "Vibraitons and Acoustics – Measurements and signal analysis", Tata McGraw Hill, 2010.

18PEADE230	Advanced Product Design	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objective of this course is to make student aware of:

1) The elements of Product design and the various stages in Product development.
2) The basics and application of ergonomics in Product development.
3) The importance of visual communication, free hand sketches and drawings in the initial stages of Product design.
4) The significance of form, color, display, controls, textures, patters and graphics in the development of a Product.
5) The role of Product detailing, material considerations during Product development.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-5)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO1	Explain the basic stages, elements in Product design and development.	--	1,2,3	--
CO2	Explain in depth the role of ergonomics and human factors in the development of a Product.	1,2,3	--	4,5
CO3	Recognize the applications, advantages and working of visual communication, free hand sketches and drawings in the initial stages of Product design.	--	1,2,3	--
CO4	Define and describe the significance of form, color, display, controls, textures, patters and graphics in the development of a Product.	--	1,2,3	4,5
CO5	Assess in depth the idea regarding Product detailing, choosing of materials for Product development process.	--	1,2,3	--

POs	PO-1	PO-2	PO-3	PO-4	PO-5
Mapping Level	2.2	2.2	2.2	1	1

Course contents:

1. **Elements of design**: Introduction to basic elements and concepts of visual design: line, texture, colour, form balance, proportion, size, shape mass, unity and variery. Spatial relationship and compositions in 2 and 3 dimensional space, 2 dimensional radii manipulation and form transition. Graphic composition and layout. Use of grids. **5Hrs**
2. **Product design - I**: Factors influencing the context and the products. Assessing relevance of available products with respect to the context. Problem areas and the limitations. Familiarization studies and programming for detailed investigation of context. Developing questionnaires, interviewing user and selecting suitable techniques to study use behavior and reactions, interviewing and observing user and photographic studies of products in use. Market demands and manufacturing constraints. Data analysis role of creativity in understanding of latent needs. **8 Hrs**
3. **Applied ergonomics**: Gross human anatomy, anthropometry, static and dynamic, muscles and work physiology, static and dynamic, muscles and work physiology, static and dynamic work including maximum capacity, bio-mechanics. Environmental condition including thermal, illumination, noise and vibration. Biological transducers and nervous system including their limitation. Controls and display psycho physiological aspect of design. Research techniques in ergonomic data generation interpretation and application of statistical methods. Case analysis. **6 Hrs**
4. **Visual communication**: Geometry of elements in products and its application in object drawing. Product presentation in various media like pencil, ink and colour, presenting thoughts and ideas in, design through sketches, perspective and exploded views. Presentation of product design concepts through simplified graphics presentation. **6 Hrs**
5. **Product design – II**: Role of creativity in problem solving study of inhibitions, conformity and vertical thinking, brain storming, synectics to develop creative attitude and open mind. Detailed discussion on stages in design process. Complimentary nature of systematic and creative thinking in various stages of design process. Methodology for visual analysis of products. Principles of value analysis, use and definition of function. **10 Hrs**
6. **Analysis and organization of control & displays**: Function of control and display elements dials, knobs, push buttons, handles and electronic displays. Investigations and study of visual, functional and ergonomic requirements of control and display elements. Legibility of display elements, character of different typefaces and their readability. Printing and transfer techniques. Product graphics, study of different textures and patterns. Area, volume and proportion. Order and system. **4 Hrs**
7. **Studies in form**: Exploration and study of formal elements to develop visual awareness, imagination and creative insight. Form elements in the context of product design, 2 & 3 dimensional radii manipulation; joints, grooves and openings, 2 & 3 dimensional form transition, introduction to colour and colour as elements of design. Colour classification and dimensions of colour: hue, value and chroma relationships. Colour dynamics and interaction of colours.

Colour meaning and traditions. Phychological use of colours. Colour in nature. Colour and form relationships. **7 Hrs**

8. **Product detailing**: Detailing in plastic products, while using manufacturing processes, F.R.P moulding detailing for fabricated products in sheet metal, steel lubes and angles, aluminium sheets and extruded sections, detailing while using fabric materials, form and other cushions, leather and cloth in combination with materials like wood and metal. **6 Hrs**

Reference Books:

1. Baldwin E.N and niebelB.W "Designing for production" Edwin Homewood Illinois, 1975.
2. Jones, J.C "Design methods, seeds of human futures" John Wiley, New york 1978.
3. Hollins, B and pugh s "Successful product design "Butterworths, London, 1990
4. BrallaJ.G "Handbook of product design for manufacture" McGraw Hill, New York 1988.