Savitribai Phule Pune University

Faculty of Science and Technology

Syllabus for Final Year of Mechanical Engineering

(Course 2015)

Savitribai Phule Pune University

B. E. (Mechanical) (2015 Course) Semester – I

Code	Subject	Teaching Scheme Hrs / week			Examination Scheme					Total Marks	Credits	
		Lecture	Tut	Pract	In Sem	End Sem	TW	PR	OR		Theory	TW/ Pr/OR
402041	Hydraulics and Pneumatics	3	-	2	30	70	25	-	25	150	3	1
402042	CAD CAM Automation	3	-	2	30	70	25	50	-	175	3	1
402043	Dynamics of Machinery	4	-	2	30	70	25	-	25	150	4	1
402044	Elective-I	3	-	2	30	70	25	-	-	125	3	1
402045	Elective-II	3	-	-	30	70	-	-	-	100	3	-
402046	Project-I	-	-	4	-	-	25	-	25	50	-	2
Total		16	-	12	150	350	125	50	75	750	16	6
											22	

B. E. (Mechanical) (2015 Course) Semester – II

Code	Subject	Teaching Scheme Hrs / week			Examination Scheme					Total Marks	Credits	
		Lecture	Tut	Pract	In Sem	End Sem	TW	PR	OR		Theory	TW/ Pr/OR
402047	Energy Engineering	3	-	2	30	70	25	-	25	150	3	1
402048	Mechanical System Design	4	-	2	30 (1.5 Hrs)	70 (3 Hrs)	25	-	50	175	4	1
402049	Elective-III	3	-	2	30	70	25	-	-	125	3	1
402050	Elective-IV	3	-	-	30	70	-	-	-	100	3	-
402051	Project-II	-	-	12	-	-	100	-	100	200	-	6
Total		13	-	18	120	280	175	-	175	750	13	9
											22	

Elective – I		Elective – II	
Code	Subject	Code	Subject
402044 A	Finite Element Analysis	402045 A	Automobile Engineering
402044 B	Computational Fluid Dynamics	402045 B	Operation Research
402044 C	Heating Ventilation and Air Conditioning	402045 C	Energy Audit and Management
		402045 D	Open Elective**

Elective – III		Elective – IV	
402049 A	Tribology	402050 A	Advanced Manufacturing Processes
402049 B	Industrial Engineering	402050 B	Solar & Wind Energy
402049 C	Robotics	402050 C	Product Design and Development
		402050 D	Open Elective**

: Open Elective – Board of studies (BoS) – Mechanical and Automobile Engineering will declare the list of subjects, which can be taken under open electives or any other Electives that are being taught in the current semester, to the same level, as Elective – II and Elective -IV under engineering faculty in the individual college and Industry can define new elective subject with proper syllabus using defined framework of Elective II and Elective IV and ***get it approved from board of studies and other necessary statutory systems in the Savitribai Phule Pune University, Pune, before 30th November* of previous academic year in which the subject to be introduced . Without prior approval from University statutory system, no one can introduce the open elective in curriculum.

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402041 **Course Name : Hydraulics and Pneumatics**

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 03 Hrs Per Week	TH	: 03	Theory	In-Sem : 30	PR : --
Practical	: 02 hrs per week	TW	: 01		End-Sem : 70	OR : 25
						TW : 25

Pre-requisites	: Fluid Mechanics, Manufacturing Processes and Machines, Mechatronics

Course Objectives:

- To study governing laws used in fluid power systems
- To study fluid power applications
- To study working principles of various components
- To study selection of different components
- To study how to design fluid power systems
- To study low cost automation

Course Outcomes:

On completion of the course, students will be able to -

- Understand working principle of components used in hydraulic & pneumatic systems
- Identify various applications of hydraulic & pneumatic systems
- Selection of appropriate components required for hydraulic and pneumatic systems
- Analyse hydraulic and pneumatic systems for industrial/mobile applications
- Design a system according to the requirements
- Develop and apply knowledge to various applications

Course Contents

Unit 1: Basics of Fluid Power and Pumps **6 Hrs**

Fluid power basics, advantages and limitations, fluid power distribution, standard symbols, energy loss in hydraulic systems.

Pumps - types, classification, principle of working and constructional details of vane pumps, gear pumps, radial and axial plunger pumps, screw pumps, power and efficiency calculations, and characteristics curves.

Unit 2: Actuators and Power Unit **6 Hrs**

Linear and rotary actuators- types, construction and characteristics. Cylinder mountings, cushioning of cylinders.

Power units and accessories - types of power units, reservoir assembly, constructional details. Accumulators, Intensifiers, Pressure and Temperature switches /sensors, level sensors.

Unit 3: Fluid Power Control **6 Hrs**

Direction control valves - center positions, methods of actuation, two stage valves, Flow control valves - pressure and temperature compensated. Pressure control valves - pressure reducing valve, sequence valve, unloading valve, brake valve, back pressure valve, counter balance valve, check

valves, prefill valve, servo valves, cartridge valves, proportional valves.

Unit 4: Hydraulic Circuits and Contamination Control **6 Hrs**

Hydraulic circuits: Simple reciprocating, regenerative, speed control (meter in, meter out and bleed off), sequencing, synchronization, traverse and feed, automatic reciprocating, fail safe circuit, counter balance circuit, actuator locking, unloading circuit, motor breaking circuit etc.

Contamination control: Contamination, sources of contamination, suction strainer, filters, filtration, filter ratings.

Unit 5: Pneumatics – Components, Control Valves and Circuits **6 Hrs**

Compressors - Types, principle of working and constructional details. Comparison of pneumatic with hydraulic power transmissions. Types of filters, pressure regulators, lubricators, mufflers, dryers, direction control valves, pneumatic actuators, shuttle valve, two pressure valve, quick exhaust valve and time delay valves, electro-pneumatics. Speed regulating methods, pneumatic circuits, reciprocating, cascading time delay etc. Application of pneumatics in low cost automation and in industrial automation.

Unit 6: System Analysis and Design **6 Hrs**

Calculation of piston velocity, thrust under static and dynamic applications, considering friction, inertia loads, design considerations for cylinders, Design of hydraulic/pneumatic circuits for practical application, selection of different components such as reservoir, control elements, actuators, accumulator, intensifier, filters, pumps. (Students are advised to refer manufacturers' catalogues for design and use simulation tool like Automation Studio for analysis).

Books

Text :

1. Esposito A, Fluid Power with application, Prentice Hall
2. Majumdar S.R, Oil Hydraulic system- Principle and maintenance ,Tata McGraw Hill
3. Majumdar S.R, Pneumatics Systems Principles and Maintenance ,Tata McGraw Hill
4. Stewart H. L, Hydraulics and Pneumatics , Taraporewala Publication

References :

1. Pipenger J.J, Industrial Hydraulics, McGraw Hill
2. Pinches, Industrial Fluid Power, Prentice Hall
3. Yeaple, Fluid Power Design Handbook
4. Andrew A. Parr, Hydraulics and Pneumatics, Elsevier Science and Technology Books
5. ISO - 1219, Fluid Systems and components, Graphic Symbols
6. Standard Manufacturer's Catalogues

Term Work shall consist of following experiments and assignments:

1. Test on Gear/Vane/Piston pump and plotting performance characteristics
2. Following experiments to be done on hydraulic trainer (any 3)
    a) Regenerative circuit
    b) Speed control circuit
    c) Sequencing circuit
    d) Traverse and feed circuit etc.
3. Following experiments to be done on pneumatic trainer (any 3)

a) Automatic reciprocating circuit
b) Speed control circuit
c) Pneumatic circuit involving Shuttle valve/ Quick exhaust valve / Two pressure valve
d) Electro pneumatic circuits

4. Test on pressure relief valve/flow control valve
5. Test on linear /rotary actuator
6. Design of simple hydraulic systems used in practice using manufacturers' catalogue and analysis using software such as Automation Studio.
7. Design of simple pneumatic systems used in practice using manufacturers' catalogue and analysis using software such as Automation Studio.
8. Industrial visit to study Hydraulic / Pneumatic based Automation systems
9. Assignment: Symbols for different components as per standards
10. Assignment: Trouble shooting procedures
11. Assignment: Standard specifications of hydraulic/ pneumatic components using manufacturer's catalogues.

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402042 **Course Name : CAD CAM and Automation**

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 03 Hrs Per Week	TH	: 03	Theory	In-Sem : 30	PR : 50
Practical	: 02 hrs per week	TW	: 01		End-Sem : 70	OR : --
						TW : 25

Pre-requisites	:	Engineering Graphics, Engineering Mathematics, Numerical Methods & Optimization, Computer Aided Machine Drawing, Strength of Materials, Manufacturing Processes

Course Objectives:

- To apply homogeneous transformation matrix for geometrical transformations of 2D/3D CAD entities
- To model mathematically analytical and synthetic curves, surfaces
- To predict performance of simple mechanical components viz. beam, shafts, plates, trusses using FEA (Mathematical and Software treatment)
- To generate CNC program for appropriate manufacturing techniques viz. turning and milling
- To select and apply suitable Rapid Prototyping techniques for engineering applications
- To study role and components of different Automation strategies.

Course Outcomes:

On completion of the course, students will be able to -

- Apply homogeneous transformation matrix for geometrical transformations of 2D CAD entities for basic geometric transformations.
- Use analytical and synthetic curves and surfaces in part modeling.
- Do real times analysis of simple mechanical elements like beams, trusses, etc. and comment on safety of engineering components using analysis software.
- Generate CNC program for Turning / Milling and generate tool path using CAM software.
- Demonstrate understanding of various rapid manufacturing techniques and develop competency in designing and developing products using rapid manufacturing technology.
- Understand the robot systems and their applications in manufacturing industries.

Course Contents

Unit 1: Computer Graphics **6 Hrs**

Transformations (2D & 3D) : Introduction, Formulation, Translation, Shear, Rotation, Scaling and reflection, Homogeneous representation, Concatenated transformation, Mapping of geometric models, Inverse transformations, Introduction to 3D transformation (Theory + Numerical treatment only for 2D – Max 3 vertices)

Projections : Orthographic, Isometric, Perspective projections (Only theory)

Unit 2: Geometric Modeling **6 Hrs**

Curves – Introduction, Analytical curves (Line, circle, ellipse, parabola, hyperbola), Synthetic curves (Hermite Cubic Spline, Bezier, B-Spline Curve) [Numerical on Line, Circle, Ellipse, Hermite Cubic

Spline, Bezier]

Surfaces – Introduction, Surface representation, Analytic surfaces, Synthetic Surfaces, Hermite bicubic, Bezier, B-Spline, Coons patch surface, Applications in freeform surfaces [only Theory]

Solids - Introduction, Geometry and Topology, Solid Representation, Boundary Representation, Euler's equation, Constructive Solid Geometry (CSG), Boolean operation for CSG [only Theory]

Unit 3: Finite Element Analysis (FEA) 6 Hrs

Introduction : Brief History of FEM, Finite Element Terminology (nodes, elements, domain, continuum, Degrees of freedom, loads and constraints), General FEM procedure, Applications of FEM in various fields, meshing, p and h formulation, Advantages and disadvantages of FEM [Only theory]

One Dimensional Problem: Finite element modeling, coordinate and linear shape function, Assembly of Global Stiffness Matrix and Load Vector, Properties of Stiffness Matrix, Finite Element Equations, Temperature Effects. [Theory + Numerical – composite shaft, spring elements in series and parallel]

Trusses : Introduction, 2D Trusses, Assembly of Global Stiffness Matrix [Numerical limited to 4X4 matrix]

Unit 4: Computer Aided Manufacturing (CAM) 6 Hrs

Introduction to Computer Aided Manufacturing (CAM), Coordinate system, Working principal of CNC Lathe, Turning Centers, Milling Machine, Steps in developing CNC part program, Tool and geometric compensations, subroutine and Do loop using canned cycle. [Only theory – 2 hrs]

CNC Lathe part programming (FANUC) : Linear and circular interpolation, Canned cycles for facing, threading, grooving, etc. [Theory + Program]

*CNC Milling part programming (FANUC)***:** Linear and circular interpolation, Pocketing, contouring and drilling cycles. [Theory + Program]

Unit 5: Advanced Manufacturing Method 6 Hrs

Product Life Cycle: Introduction, Need, Components/Elements of PLM, Collaborative Engineering. [Only theory]

Rapid Prototyping : Introduction, classification of RP Processes (SLA, LOM, SLS, FDM, 3D printing), Working principle, features, models & specification of process, application, advantages and disadvantages, Rapid Tooling and STL format, Concept of 4D Rapid Prototyping. [Only theory]

Unit 6: Automation 6 Hrs

Automation : Introduction, Automation strategies, Types of Automation - Hard and Soft Automation, Flexible Manufacturing System – Types, Advantages, Limitations, AGVs and AS/RS [Only theory]

*Group Technology***:** Introduction, Coding Methods, Concepts of Computer Integrated Manufacturing (CIM) and Computer Aided Process Planning (CAPP), Variant & Generative methods of CAPP, advantages of CAPP. [Only theory]

Robotics: RIA definition of Robot, Laws of robotics, Classification of robots, robot anatomy, Point to point and continuous path robotic systems, Joints, End Effectors, Grippers - Mechanical, Magnetic and Pneumatic, Applications. [Only theory]

Books

Text :

1. Ibrahim Zeid and R. Sivasubramanian - CAD/CAM - Theory and Practice Tata McGraw Hill Publishing Co. 2009

2. Chandrupatla T. R. and Belegunda A. D. -Introduction to Finite Elements in Engineering - Prentice Hall India.
3. Nitin S. Gokhale, Practical Finite Element Analysis, Finite To Infinite; First Edition edition, ISBN-10: 8190619500 ISBN-13: 978-8190619509
4. S. K. Sinha, CNC Programming using Fanuc Custom Macro B, McGraw-Hill Professional
5. S. R. Deb, Robotics Technology and Flexible Automation, Tata McGraw Hill.

References :

1. Ibraim Zeid, Mastering CAD/CAM – Tata McGraw Hill Publishing Co. 2000
2. Segerling L. J. - Applied Finite Elements Analysis, John Wiley and Sons
3. Seshu P. Text book of Finite Element Analysis, PHI Learning Private Ltd. New Delhi, 2010
4. Rao P. N., Introduction to CAD/CAM Tata McGraw Hill Publishing Co.
5. B. S. Pabla, M. Adithan, CNC Machines, New Age International, 1994
6. Groover M.P.-Automation, production systems and computer integrated manufacturing‘ - Prentice Hall of India
7. Ian Gibson, David W. Rosen, Brent Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer
8. Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight, Product Design for Manufacture and Assembly, Third Edition ,CRC Press
9. Antti Saaksvuori, Anselmi Immonen, Product Life Cycle Management -Springer, 1st Edition, 2003

Term Work shall consist of following experiments and assignments:

1. Demonstration of Application Programming Interface (API).
2. Stress and deflection analysis of Beam (FEA).
3. Stress and deflection analysis of 2D truss (FEA).
4. Stress and deflection analysis of any Mechanical Component using FEA software and validate the results by analytical methods (FEA).
5. Tool path generation and simulation for Turning – Grooving and Threading with help of suitable software.
6. Tool path generation and simulation for Milling – Facing, Pocketing, Contouring and drilling, etc. with help of suitable software.
7. Case study on Rapid Prototyping - Exporting STL files from 3D CAD models, structure of STL files, etc.
8. Case study based on modeling and analysis of structural system (Industry Based)
9. Manufacturing of machine component using additive manufacturing or Using CNC simulator software.
10. Assignment on Robot simulation
11. Industrial Visit Report on Automation and Robotics

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402043 **Course Name : Dynamics of Machinery**

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 04 Hrs Per Week	TH	: 04	Theory	In-Sem : 30	PR : --
Practical	: 02 hrs per week	TW	: 01		End-Sem : 70	OR : 25
						TW : 25

Pre-requisites:	Strength of Materials, Engineering Mechanics, Engineering Mathematics and Numerical Methods,

Course Objectives:

- To conversant with balancing problems of machines.
- To understand fundamentals of free and forced vibrations.
- To develop competency in understanding of vibration and noise in Industry.
- To develop analytical competency in solving vibration problems.
- To understand the various techniques of measurement and control of vibration and noise.

Course Outcomes:

On completion of the course, students will be able to -

- Apply balancing technique for static and dynamic balancing of multi cylinder inline and radial engines.
- Estimate natural frequency for single DOF undamped & damped free vibratory systems.
- Determine response to forced vibrations due to harmonic excitation, base excitation and excitation due to unbalance forces.
- Estimate natural frequencies, mode shapes for 2 DOF undamped free longitudinal and torsional vibratory systems.
- Describe vibration measuring instruments for industrial / real life applications along with suitable method for vibration control.
- Explain noise, its measurement & noise reduction techniques for industry and day today life problems.

Course Contents

UNIT 1: Single Degree of Freedom Systems – Free Vibration **10 Hrs**

Fundamentals of Vibration : Elements of a vibratory system, vector representation of S.H.M., degrees of freedom, Introduction to Physical and Mathematical modeling of vibratory systems : Bicycle, Motor bike and Quarter Car. types of vibration, equivalent stiffness and damping, formulation of differential equation of motion (Newton, D'Alembert and energy method)

*Undamped free vibrations***:** Natural frequency for longitudinal, transverse and torsional vibratory systems.

Damped free vibrations: Different types of damping, Viscous damping – over damped, critically damped and under damped systems, initial conditions, logarithmic decrement, Dry friction or coulomb damping - frequency and rate of decay of oscillations.

UNIT 2: Single Degree of Freedom Systems - Forced Vibrations **8 Hrs**

Forced vibrations of longitudinal and torsional systems, Frequency Response to harmonic excitation, excitation due to rotating and reciprocating unbalance, base excitation, magnification factor, Force and Motion transmissibility, Quality Factor. Half power bandwidth method, Critical speed of shaft having single rotor of undamped systems.

UNIT 3: Two Degree of Freedom Systems – Undamped Vibrations **8 Hrs**

Free vibration of spring coupled systems – longitudinal and torsional, torsionally equivalent shafts, natural frequency and mode shapes, Eigen value and Eigen vector by Matrix method, Combined rectilinear and angular motion, Vibrations of Geared systems.

UNIT 4: Balancing **8 Hrs**

Static and dynamic balancing, balancing of rotating masses in single and several planes, primary and secondary balancing of reciprocating masses, balancing in single cylinder engines, balancing in multi-cylinder in-line engines, direct and reverse cranks method -radial and V engines.

UNIT 5: Measurement and Control of Vibration **8 Hrs**

A) *Measurement*: Vibration Measuring Instruments, Accelerometers, Impact hammer, Vibration shakers, Vibration Analyzer, Vibration based condition monitoring, Analysis of Vibration Spectrum, Standards related to measurement of vibration, Human response to vibrations.

B) *Control* : Vibration control methods, passive, semi active (Introduction to Electro-Rheological & Magneto-Rheological dampers) and active vibration control, control of excitation at the source, control of natural frequency, Vibration isolators, Tuned Dynamic Vibration Absorbers, Introduction to Torsional Damper

UNIT 6: Introduction to Noise **6 Hrs**

Fundamentals of noise Sound concepts, Decibel Level, white noise, weighted sound pressure level, Logarithmic addition, subtraction and averaging, sound intensity, noise measurement, sound fields, octave band, sound reflection, absorption and transmission, acoustic material & its characteristics, Noise control at the Source, along the path and at the receiver, pass-by-noise, Reverberation chamber, Anechoic Chamber, Human Exposure to Noise and Noise standards.

Books

Text :

1. S. S. Rao, Mechanical Vibrations, Pearson Education Inc. New Delhi.
2. G. K. Grover, Mechanical Vibrations, New Chand and Bros.,Roorkee
3. Wiiliam J Palm III, Mechanical Vibration, Wiley India Pvt. Ltd, New Delhi
4. Uicker J. John, Jr, Pennock Gordon R, Shigley Joseph E., Theory of Machines and Mechanisms, International Version, OXFORD University Press, New Delhi.
5. M L Munjal, Noise and Vibration Control, Cambridge University Press India

References :

1. Weaver, Vibration Problems in Engineering, 5th Edition Wiley India Pvt. Ltd, New Delhi.
2. Bell, L. H. and Bell, D. H., Industrial Noise Control – Fundamentals and Applications‖, Marcel Dekker Inc.
3. Alok Sinha, Vibration of Mechanical System, Cambridge university Press , India
4. Debabrata Nag, Mechanical Vibrations, Wiley India Pvt. Ltd, New Delhi.
5. Kelly S. G., Mechanical Vibrations, Schaums outlines, Tata McGraw Hill Publishing Co. Ltd., New Delhi.

6. Meirovitch, L., Elements of Mechanical Vibrations‖, McGraw Hill.
7. Ver, Noise and Vibration Control Engineering, Wiley India Pvt. Ltd, New Delhi.
8. Bies, D. and Hansen, C., Engineering Noise Control - Theory and Practice, Taylor and Francis.
9. Shrikant Bhave, Mechanical Vibrations Theory and Practice, Pearson, New Delhi

Term Work shall consist of following experiments and assignments:

A] Compulsory Experiments (Sr. No. 1 to 6)

1. Balancing of wheel / rotor on computerized balancing machine OR Experimental verification of dynamic balancing of rotating masses.
2. To determine the natural frequency of damped vibration of single degree freedom system and to find it‘s damping coefficient.
3. To obtain frequency response curves of single degree freedom system of vibration for different amount of damping.
4. To verify natural frequency of torsional vibration of two rotor system and position of node.
5. To determine natural frequency of transverse vibration of beam using vibration analyzer.
6. Noise measurement and analysis using vibration Analyzer.

B] Any Two Experiments from the following :

1. To determine critical speed of shaft with single rotor.
2. Experimental verification of principle of dynamic vibration absorber.
3. Experiment on shock absorbers and to plot its characteristic curve.
4. A case study (Industrial visit / In-house) based on Conditioning Monitoring and Fault Diagnosis.

C] List of Compulsory Assignment :

1. Simulation (using suitable software) of free response of SDOF damped system to demonstrate different damping conditions by solving differential equation numerically.

OR

2. Simulation (using suitable software) of total response of SDOF damped system to harmonic excitation by solving differential equation numerically.

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402044 A **Course Name : Elective – I**
Finite Element Analysis

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 03 Hrs Per Week	TH	: 03	Theory	In-Sem : 30	PR : --
Practical	: 02 hrs per week	TW	: 01		End-Sem : 70	OR : --
						TW : 25

Pre-requisites	**:** Fluid Mechanics, Heat transfer, Numerical methods, Programming Languages.

Course Objectives:

- To understand the philosophy and general procedure of Finite Element Method as applied to solid mechanics and thermal analysis problems.
- To familiarize students with the displacement-based finite element method for displacement and stress analysis and to introduce related analytical and computer tools.
- It provides a bridge between hand calculations based on mechanics of materials and machine design and numerical solutions for more complex geometries and loading states.
- To study approximate nature of the finite element method and convergence of results are examined.
- It provides some experience with a commercial FEM code and some practical modeling exercises .

Course Outcomes:

On completion of the course, students will be able to -

- Understand the different techniques used to solve mechanical engineering problems.
- Derive and use 1-D and 2-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses.
- Apply mechanics of materials and machine design topics to provide preliminary results used for testing the reasonableness of finite element results.
- Explain the inner workings of a finite element code for linear stress, displacement, temperature and modal analysis.
- Use commercial finite element analysis software to solve complex problems in solid mechanics and heat transfer.
- Interpret the results of finite element analyses and make an assessment of the results in terms of modeling (physics assumptions) errors, discretization (mesh density and refinement toward convergence) errors, and numerical (round-off) errors.

Course Contents

Unit 1: Fundamental Concepts of FEA **6 Hrs**

Introduction: Solution methodologies to solve engineering problems, governing equations, mathematical modelling of field problems in engineering, discrete and continuous models.

Brief history of FEM, Finite Element terminology (nodes, elements, domain, continuum, degrees of

freedom, loads & constraints), general steps involved in FEM, applications of FEM in various fields, advantages and disadvantages of FEM, consistent units system, essential and natural boundary conditions, symmetric boundary conditions.

Introduction to different approaches used in FEA : Direct approach, Variational formulation- Principal of Minimum Potential Energy (PMPE), Galerkin weighted residual method, Principle of Virtual Work, Rayleigh-Ritz method, relation between FEM and Rayleigh-Ritz method

Types of Analysis (Introduction) : Linear static analysis, Non-linear analysis, Dynamic analysis, Linear buckling analysis, Thermal analysis, Fatigue analysis, Crash analysis.

Unit 2: 1D Elements **6 Hrs**

Types of 1D elements, displacement function, global and local coordinate systems, polynomial form of interpolation functions- linear, quadratic and cubic, properties of shape function, primary and secondary variables.

Formulation of elemental stiffness matrix and load vector for bar, truss and beam using any approach, Formulation of load vector due to uniform temperature change (only for bar).

Assembly of global stiffness matrix and load vector, properties of stiffness matrix, half bandwidth, treatment of boundary conditions- elimination approach, stress and reaction forces calculations

Unit 3: 2D Elements **6 Hrs**

Two-Dimensional Stress Analysis: Plane Stress/Strain problems in 2D elasticity, constitutive relations

Constant Strain Triangle(CST), Liner Strain Rectangle (LSR), displacement function, Pascal's triangle, compatibility and completeness requirement, geometric isotropy, convergence requirements, strain filed, stress filed, Formulation of element stiffness matrix and load vector for Plane Stress/Strain problems

Assembly of global stiffness matrix and load vector, Boundary conditions, solving for primary variables (displacement), stress calculations

Unit 4: Isoparametric Elements and Numerical Integration **6 Hrs**

Concept of isoparametric elements, Terms isoparametric, super parametric and subparametric.

Coordinate mapping : Natural coordinates, Area coordinates (for triangular elements), higher order triangular and quadrilateral elements (Lagrangean and serendipity elements), geometry associative mesh, quality checks, mesh refinement- p vs h refinements, Uniqueness of mapping - Jacobian matrix.

Numerical integration: Gauss Quadrature in one and two dimension, Order of Gauss integration, full and reduced integration, sub-modeling, substructuring.

Unit 5: 1D Steady State Heat Transfer Problems **6 Hrs**

Introduction, One dimensional steady-state heat transfer problem- Governing differential equation, Finite Element formulation using Galerkin's approach for composite wall and thin Fin , essential and natural boundary conditions and solving for temperature distribution

Unit 6: Dynamic Analysis **6 Hrs**

Types of dynamic analysis, general dynamic equation of motion, lumped and consistent mass, Mass matrices formulation of bar, truss and beam element.

Undamped-free vibration: Eigenvalue problem, evaluation of eigenvalues and eigenvectors (characteristic polynomial technique).

Books

Text :

1. Daryl L, A First Course in the Finite Element Method,. Logan, 2007.
2. G Lakshmi Narasaiah, Finite Element Analysis, B S Publications, 2008.
3. Y.M.Desai, T.I.Eldho and A.H.Shah, Finite Element Method with Applications in Engineering, Pearson Education, 2011
4. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India, 2002.
5. P., Seshu, Text book of Finite Element Analysis, PHI Learning Private Ltd. , New Delhi, 2010.

References :

1. Bathe K. J., Finite Element Procedures Prentice, Hall of India (P) Ltd., New Delhi.
2. R. D. Cook, et al., Concepts and Applications of Finite Element Analysis. Wiley, India
3. Kwon Y. W., Bang H., Finite Element Method using MATLAB, CRC Press, 1997
4. Peter Kattan, MATLAB Guides to Finite Elements- An Interactive Approach, Springer, 2008.
5. S. Moaveni, Finite element analysis, theory and application with Ansys, Prentice Hall
6. Erdogan Madenci and Ibrahim Guven, "The Finite Element Method and Applications in Engineering Using Ansys", Springer, 2006.
7. David V. Hutton, Fundamental of Finite Element Analysis, Tata McGraw-Hill
8. Gokhale N. S., et al., Practical Finite Element Analysis, Finite to Infinite, Pune, 2008.

Term Work shall consist of following assignments:

Practical's to be performed: Minimum 7 including

- Any three practical's *from Practical No. 1 to 4** and
- Any three practical *from Practical No. 5 to 9***
- in Open source or Commercial Software

1. Computer program for stress analysis of 1D bar using linear and quadratic elements. Show the variation of stress and strain within the element for linear and quadratic bar element
2. Computer program for stress analysis of 2-D truss subjected to plane forces
3. Computer programs for (i) modal analysis and, (ii) stress analysis for 1-D beam (simply supported or cantilever beams)
4. Computer program for 1-D temperature analysis
5. Static stress concentration factor calculation for a plate with center hole subjected to axial loading in tension using FEA software
6. Modal analysis of any machine component using FEA software.
7. Stress and deflection analysis of any machine component consisting of 3-D elements using FEA software.
8. Elasto-plastic stress analysis of plate using FEA software
9. Coupled Thermal-Structural Analysis using FEA software

*1 Students can write the program in any of the programming language such as FORTRAN, C, C++, MATLAB, Python, VB.

*2 Minimum number of elements considered should be 10 or more.

*3 Validate results of the program with analytical method or commercial FEA software such as Abaqus, ANSYS, Msc-Nastran, Optistruct / Radioss, Comsol-Multiphysics, etc.

**1 Students should do convergence study for all assignment problems.
**2 Use different element types from element library,
**3 If possible use submodel / symmetry option.

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402044 B **Course Name : Elective – I**
Computational Fluid Dynamics

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 03 Hrs Per Week	TH	: 03	Theory	In-Sem : 30	PR : --
Practical	: 02 hrs per week	TW	: 01		End-Sem : 70	OR : --
						TW : 25

Pre-requisites : Fluid Mechanics, Heat transfer, Numerical methods, Programming Languages.

Course Objectives:

- Students should be able to model fluid / heat transfer problems and apply fundamental conservation principles.
- Students should be able to do discretize the governing equations by Finite Difference Method and Finite volume Method.
- Students should be able to develop programming skills by in-house code development for conduction, convection and fluid dynamics problems.
- Students should be able to solve basic convection and diffusion equations and understands the role in fluid flow and heat transfer.
- To prepare the students for research leading to higher studies.
- To prepare the students for career in CAE industry using software tools.

Course Outcomes:

On completion of the course, students will be able to -

- Analyze and model fluid flow and heat transfer problems.
- Generate high quality grids and interpret the correctness of numerical results with physics.
- Conceptualize the programming skills.
- Use a CFD tool effectively for practical problems and research.

Course Contents

Unit 1: Introduction to CFD **6 Hrs**

Introduction to Computational Fluid Dynamics, Derivation and physical interpretation of governing equations (conservation of mass, momentum and energy) in differential form, Concept of substantial derivative, divergence and curl of velocity, Mathematical behavior of Governing Equations and boundary conditions.

Unit 2: Solution to Conduction Equation **6 Hrs**

Introduction to FEA, FDM and FVM, Solution of two dimensional steady and unsteady heat conduction equation using finite volume method (Implicit and Explicit) with Dirichlet, Neumann, Robbin boundary conditions, Stability Criteria.

Unit 3: Solution to Advection Equation **6 Hrs**

Solution of two dimensional steady and unsteady heat advection equation using finite volume method (Implicit and Explicit) with Dirichlet BC, Stability Criteria, Introduction to first order upwind, CD,

second order upwind and QUICK convection schemes.

Unit 4: Solution to Convection-Diffusion Equation **6 Hrs**

Solution of two dimensional steady and unsteady heat convection-diffusion equation for slug flow using finite volume method (Implicit and Explicit), Stability Criteria, 1-D transient convection-diffusion system, Peclet Number

Unit 5: Solution to Navier – Stokes Equation **6 Hrs**

Solution of Navier-Stoke‘s equation for incompressible flow using SIMPLE algorithms for lid driven cavity flow problem, Introduction to external flow simulation.

Unit 6: Introduction to Turbulence Modeling **6 Hrs**

Introduction to turbulence models, Reynolds Averaged Navier-Stokes equations (RANS), One equation model (Derivation) and two equation model.

Books

Text :

1. John D Anderson: Computational Fluid Dynamics- The Basics with Applications, McGraw-Hill
2. Atul Sharma, Introduction to Computational Fluid Dynamics: Development, Application and Analysis, Wiley
3. Suhas V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation
4. A. W. Date, Introduction to Computational Fluid Dynamics, Cambridge Univ. Press, USA.
5. H. Versteeg, and W.Malalasekara, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson.
6. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press.
7. J. Tu, G.-H. Yeoh and C. Liu: Computational Fluid Dynamics: A practical approach, Elsevier.
8. H. Schlichting and K. Gersten, Boundary-Layer Theory, Springer.

References :

1. H. Tennekes and J. L. Lumley, A First Course in Turbulence, MIT Press.
2. David C. Wilcox, Turbulence Modeling for CFD, DCW Industries

Term Work shall consist of following assignments:

Practical’s to be performed: Minimum 7 including

- Any three practical’s with programming language (*from Practical No. 1 to 8*) and
- Any three practical in Open source or Commercial Software (*from Practical No. 9 to 16*)
- Mini project (*Practical No.16*) in Open source or Commercial Software tool
  1. One-dimensional steady state conduction using finite volume method
  2. One-dimensional unsteady state conduction using finite volume method
  3. Two-dimensional steady state conduction using finite volume method
  4. Two-dimensional unsteady state conduction using finite volume method
  5. Two-dimensional advection using finite volume method
  6. One-dimensional conduction convection problem using finite volume method
  7. One-dimensional conduction convection problem using finite volume method
  8. Solution of Navier Stokes equation using SIMPLE algorithm for Lid Driven Cavity flow

problem

9. Numerical simulation and analysis of boundary layer over a flat plate (Blausius Equation)
10. Numerical simulation and analysis of boundary layer for a
11. Developing flow through Pipe
12. Fully developed flow through a pipe
13. CFD Analysis of external flow: Circular Cylinder or Airfoil (NACA 0012)
14. CFD analysis of heat transfer in pin fin.
15. Numerical simulation and analysis of 2D square lid driven cavity. Effect of Reynolds number on the vorticity patterns.
16. Mini project on any practical application. Students should take a problem of their choice and verify the CFD solution with experimental data / research paper. (Mandatory)

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402044 C **Course Name : Elective – I**

Heating, Ventilation, Air Conditioning and Refrigeration Engineering

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 03 Hrs Per Week	TH	: 03	Theory	In-Sem : 30	PR : --
Practical	: 02 hrs per week	TW	: 01		End-Sem : 70	OR : --
						TW : 25

Pre-requisites: Thermodynamics I and II, Refrigeration and Air Conditioning

Course Objectives:

- To understand the recent vapour compression cycle
- To provide the knowledge of analyze thermal design of refrigeration system components
- To understand practical aspects of vapour compression system
- To provide the knowledge of basic concepts of ventilation, infiltration and space distribution techniques
- To inculcate techniques of estimating building envelop load.
- To understand the working non-conventional air-conditioning systems.

Course Outcomes:

On completion of the course, students will be able to -

- Determine the performance parameters of trans-critical & ejector refrigeration systems
- Estimate thermal performance of compressor, evaporator, condenser and cooling tower.
- Describe refrigerant piping design, capacity & safety controls and balancing of vapour compressor system.
- Explain importance of indoor and outdoor design conditions, IAQ, ventilation and air distribution system.
- Estimate heat transmission through building walls using CLTD and decrement factor &time lag methods with energy-efficient and cost-effective measures for building envelope.
- Explain working of types of desiccant, evaporative, thermal storage, radiant cooling, clean room and heat pump air-conditioning systems.

Course Contents

Unit 1: Advanced Vapour Compression Cycles **4 Hrs**

Review of vapour compression cycle, Trans-critical cycle and their types retical treatment) Ejector refrigeration cycle and their types. Presentation of cycle on P-h and T-s chart.

Unit 2: Thermal Design of Refrigeration System Components **8 Hrs**

Compressor : Characteristic curves of reciprocating & Centrifugal compressors, sizing of reciprocating compressor

Evaporator : Standards & Codes, Performance analysis of Dx evaporator,

Condenser: Standards & Codes, air-cooled condenser, shell & tube condenser and evaporative condenser.

Expansion Devices : Standards & Codes, Operating Characteristics, Liquid Charge in the Sensing Bulb , Hunting of Thermostatic Expansion Valve

Cooling Tower: Types & design of cooling towers, cooling tower thermal performance, tower efficiency.

Unit 3: Practical Aspects of Vapour Compression System **6 Hrs**

Refrigerant Piping : Copper Tubing, Piping Design for Reciprocating Refrigeration Systems, Size of Copper Tube, Refrigeration Load, and Pressure Drop, Sizing Procedure, Suction Line, Discharge Line (Hot-Gas Line), Liquid Line

Capacity Controls : Capacity Controls of reciprocating, centrifugal and scroll compressors

Safety Controls: Low-Pressure and High-Pressure Controls. Low-Temperature Control, Frost Control, Oil Pressure Failure Control. Motor Overload Control.

Vapour compression system balance: Performance characteristics of the condensing unit & compressor-capillary tube.

Unit 4: Ventilation and Infiltration **6 Hrs**

Indoor Design Criteria and Thermal Comfort : Basic parameters, factors affecting thermal comforts, Comfort-Discomfort Diagrams, Indoor Temperature, Relative Humidity, and Air Velocity

Indoor Air Quality : Indoor Air Contaminants, Basic Strategies to Improve Indoor Air Quality,

Outdoor Design Conditions : Outdoor Air Requirements for Occupants, The Use of Outdoor Weather Data in Design, Outdoor Weather Characteristics and Their Influence

Ventilation for cooling : Natural ventilation, mechanical ventilation

Space air distribution: Design of air distribution systems, Types of air distribution devices: Airflow patterns inside conditioned space: Stratified mixing flow: Cold air distribution: Displacement flow: *Spot cooling / heating*: Selection of supply air outlets.

Unit 5: Heat Load Estimation in Building Structures **6 Hrs**

Solar radiation, Heat gain through fenestrations, Space load characteristics, cooling load and coil load calculations, Overall heat transmission coefficient, air spaces, sol-air temperature, Decrement factor & time lag method,, Cooling load Temperature Difference method (CLTD) or Equivalent Temperature Differential (ETD), detailed calculation procedure using CLTD method, Total heat balance.

Energy-efficient and cost-effective measures for building envelope**,** Concept of ECBC

Unit 6: Advanced Air-conditioning Systems **6 Hrs**

Desiccant-Based Air Conditioning Systems : Introduction, Sorbents & Desiccants, Dehumidification, Liquid Spray Tower, Solid Packed Tower, Rotary Desiccant Dehumidifiers, Hybrid Cycles, Solid Desiccant Air-Conditioning (Theoretical treatment)

Evaporative-Cooling Air Conditioning Systems, Thermal Storage Air Conditioning Systems, Clean-Room Air Conditioning Systems, Radiant cooling. (Theoretical treatment)

Heat Pump Systems: Heat Pump Cycle, different heats pump Circuits.

Books

Text :

1. Arora R.C., Refrigeration and Air Conditioning, PHI, India
2. Dossat Ray J., Principal of Refrigeration, Pearson, India
3. Arora C P, Refrigeration and Air Conditioning, Tata McGraw Hill

4. Manohar Prasad, Refrigeration and Air-conditioning, Wiley Eastern Limited, 1983

References :

1. Threlkeld J.L., Thermal Environmental Engineering, Prentice Hall Inc. New Delhi
2. ASHRAE Handbook (HVAC Equipments)
3. Stocker W.F. and Jones J.W., Refrigeration and Air-conditioning, McGraw Hill International editions 1982.
4. Roger Legg, Air conditioning systems: Design, Commissioning and maintenance
5. Shan Wang, Handbook of Refrigeration and Air Conditioning, McGrawHill Publications
6. Wilbert Stocker, Industrial Refrigeration, McGrawHill Publications
7. Keith Harold, Absorption chillers and Heat Pumps, McGrawHill publications
8. ASHRAE, Air Conditioning System Design Manual, IInd edition, ASHRAE.

Term Work shall consist of following assignments:

1. Performance Simulation of Central Air-conditioning plant using Newton Raphson Method.
2. Performance analysis of Counter flow or cross flow cooling tower
3. Building heat load simulation using suitable software (Trace 700, Energy plus etc.)
4. Design of cold storage with process layout.

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402045 A **Course Name : Elective – II**
Automobile Engineering

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 03 Hrs Per Week	TH	: 03	Theory	In-Sem : 30	PR : --
Practical	: --	TW	: --		End-Sem : 70	OR : --
						TW : --

Pre-requisites	**:** I. C. Engines, Theory of Machines, Basics of Electrical and Electronics

Course Objectives:

- To make the student conversant with fundamentals of automobile systems.
- To develop competencies in performance analysis of vehicles.
- To make the student conversant with automobile safety, electrical system and vehicle maintenance.
- To understand the emerging trends of electric vehicles, hybrid electric vehicles and solar vehicles. .

Course Outcomes:

On completion of the course, students will be able to -

- To compare and select the proper automotive system for the vehicle.
- To analyse the performance of the vehicle.
- To diagnose the faults of automobile vehicles.
- To apply the knowledge of EVs, HEVs and solar vehicles

Course Contents

Unit 1: Introduction and Drive Train **6 Hrs**

Introduction: Current scenario in Indian auto/ancillary industries, vehicle specifications and classification.

Chassis and Frames: Types of chassis layout with reference to power plant locations and drive, various types of frames, constructional details.

Drive Train: Types of transmission system, necessity and selection of clutch, necessity of gear box and different types, fluid flywheel, torque convertor, continuous variable transmission, , overdrive, propeller shaft, final drive and differential.

Unit 2: Axles, Wheels and Tyres, Steering System **6 Hrs**

Axles: Purpose, requirement and types of front and rear axle, loads acting on rear axles.

Wheels and tyres: Wheel construction, alloy wheel, wheel balancing, type of tyres, tyre construction, tyre materials, factors affecting tyre life.

Steering system : Steering mechanism, steering geometry, cornering force, slip angle, scrub radius, steering characteristics, steering linkages and gearbox, power steering, collapsible steering, reversibility of steering, four wheel steering, wheel alignment.

Unit 3: Suspension and Brake System **6 Hrs**

Suspension : Types of suspension linkages, types of suspension springs- leaf, coil, air springs, hydro gas, rubber suspension, interconnected suspension, self levelling suspension (active suspension), shock absorbers (hydraulic and air).

Brake systems: Drum, disc, mechanical, hydraulic, air brakes, vacuum, power assisted brakes, hand brake, ABS, EBD.

Unit 4: Vehicle Performance and Safety **6 Hrs**

Vehicle performance: Parameters, vehicle resistances, traction and tractive effort, power requirement for propulsion, road performance curves (numericals), stability of vehicles, vehicle testing on chassis dynamometer.

Vehicle safety: Types of active and passive safety, vehicle interior and ergonomics, NVH in automobiles.

Unit 5: Electrical System and Vehicle Maintenance **6 Hrs**

Batteries : Principles and construction of lead-acid battery, characteristics of battery, rating capacity and efficiency of batteries, various tests on battery condition, charging methods, introduction to lithium batteries.

Electrical system and accessories : Insulated and earth return systems, positive and negative earth systems, electrical fuel pump, speedometer, fuel, oil and temperature gauges, horn, wiper system, automotive sensors and actuators, electronic control unit/module.

Maintenance: Types of vehicle maintenance, servicing/overhauling of clutch, gear box, propeller shaft, differential, axles, steering system, suspension system, break system, electrical system.

Unit 6: Electric and Hybrid Electric Vehicles **6 Hrs**

Introduction: Concept and environmental importance of EVs, HEVs and solar vehicles.

Electric vehicles: Layout, construction and working.

Hybrid electric vehicles: Types, layout, hybridization factor, plug in hybrid electric vehicles, fuel efficiency analysis.

Challenges and future scope of EVs and HEVs.

Books

Text :

1. K. Newton and W. Seeds, T.K. Garrett, "Motor Vehicle", 13thEdition, Elsevier publications.
2. Hans Hermann Braess, Ulrich Seiffen, "Handbook of Automotive Engineering", SAE Publications.
3. William H. Crouse., "Automotive Mechanics", Tata McGraw Hill Publishing House.
4. Joseph Heitner, "Automotive Mechanics", C.B.S Publishers and Distributors.
5. SAE Manuals and Standards.
6. .N. K. Giri, Automobile Mechanics
7. P. S. Kohali, Automobile Electrical Equipment, Tata McGraw Hill Publishing House.
8. Narang G. B. S, "Automobile Engineering", S. Chand and Company Ltd.

References :

1. Dr. Kirpal Singh, "Automobile Engineering", Volume 1, Standard Publishers distributors.
2. Automobile Mechanics, "Crouse/Anglin", TATA Mcgraw-Hill.
3. R. B. Gupta, Automobile Engineering, Satya Prakashan.

4. Chris Mi, M .Abul Masrur, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, ,Willey.
5. Electric and Hybrid Vehicles, Tom Denton, Routledge.
6. Hybrid Electric Vehicle Technology, Automotive Research and Design, American Technical.
7. Husain, Iqbal, Electric and hybrid vehicles, 2 edition, CRC Press.
8. Ron Hodkinson and John Fenton, Butterworth-Heinemann.Lightweight Electric/ Hybrid Vehicle Design,
9. Ehsani, Yimin Gao, Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Standards media.

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402045 B **Course Name : Elective – II Operation Research**

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 03 Hrs Per Week	TH	: 03	Theory	In-Sem : 30	PR : --
Practical	: --	TW	: --		End-Sem : 70	OR : --
						TW : --

Pre-requisites	Mathematics I, II and III

Course Objectives:

- To familiarize the students with the use of practice oriented mathematical applications for optimization functions in an organization.
- To familiarize the students with various tools of optimization, probability, statistics and simulation, as applicable in particular scenarios in industry for better management of various resources.

Course Outcomes:

On completion of the course, students will be able to -

- Apply LPP and Decision Theory to solve the problems
- Apply the concept of transportation models to optimize available resources.
- Decide optimal strategies in conflicting situations.
- Implement the project management techniques.
- Minimize the process time
- Optimize multi stage decision making problems

Course Contents

Unit 1: Introduction: Operation Research **6 Hrs**

Introduction: Definition, Evolution and Classification of Quantitative Methods and Operations Research Techniques, Methodology, Advantages and Limitations. Linear Programming Problem: Introduction, Formulation of LPP, Solution of LPP by Two Phase Method only. Decision Theory: Meaning and Steps in Decision Making, Types of Management Decisions, Decision under Certainty, under Risk, under Uncertainty, Decision Trees

Unit 2: Transportation & Assignment Model **6 Hrs**

Introduction, Formulation, Basic Method of Solving Transportation Problem, Optimization Methods like UV and Stepping Stone Method, Assignment Problem- Hungarian Method to solve Assignment Problem.

Unit 3: Theory of Games and Linear Programming **6 Hrs**

Theory of Games : Introduction, Minimax and Maximin Principle, Solution of Game with Saddle Point, Solution by Dominance, Solution by Graphical Method, m x n size Game Problem, Iterative method, Introduction to formulation of games using Linear Programming.

Replacement Analysis: Replacement of Items that Deteriorate, Replacement of Items that Fail

Suddenly.

Unit 4: Project Management **6 Hrs**

Network Models: Fulkerson's rule, concept and types of floats, CPM and PERT, Crashing Analysis and Resource Scheduling. Simulation: Introduction, Monte-Carlo Simulation method, Simulation of Inventory and Queuing Problems.

Unit 5: Queuing Theory and Sequencing Models **6 Hrs**

Queuing Theory: Introduction, Basis Structure, Terminology (Kendal's Notations) and Applications. *Queuing Model M/M/1*: /FIFO, M/M/c.

Sequencing models : Solution of sequencing Problem - Processing of n jobs through two machines, Processing of n jobs through three machines, Processing of two jobs through m Machines, Processing of n jobs through m Machines

Unit 6: Integer and Dynamic Programming **6 Hrs**

Integer Programming Introduction to Integer Programming, Cutting plane method and Branch and Bound Method. Dynamic Programming: Introduction, DP Model, Applications of DP Model to shortest route problems. Solution of LPP by Dynamic Programming

Books

Text :

1. Prem Kumar Gupta, D. S. Hira, Problems in Operations Research: Principles and Solutions, S. Chand, 1991
2. J. K. Sharma, Operations Research: Theory and Application, Laxmi pub. India.
3. Operations Research, S. D. Sharma, Kedar Nath Ram Nath-Meerut.
4. L.C.Jhamb,Quantative Techniques Vol. I&II, Everest Publication.
5. Manohar Mahajan, Operation Research, Dhanpatrai Publication

References :

1. Hillier F.S., and Lieberman G.J., Operations Research, Eight Edition, Mc. Tata McGraw Hill, India
2. Ravindran, ―Engineering optimization Methods and Applications‖, 2nd edition, Wiley, India
3. Ravindran, Phillips and Solberg, Operations Research Principles and Practice, Second Edition, Mc. WSE Willey,
4. Operations Research - An introduction, Hamdy A Taha, Pearson Education.

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402045 C **Course Name : Elective – II**

Energy Audit and Management

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 03 Hrs Per Week	TH	: 03	Theory	In-Sem : 30	PR : --
Practical	: --	TW	: --		End-Sem : 70	OR : --
						TW : --

Pre-requisites:	Thermodynamics, Turbo Machines

Course Objectives:

Following concepts to be taught to the students,

- Importance of Energy Management.
- To Carry out Energy Audit.
- Methods to reduce consumption of energy and save cost.
- To improve energy efficiency of overall system.
- Significance of Waste heat recovery and Cogeneration.

Course Outcomes:

On completion of the course, students will be able to -

- Compare energy scenario of India and World.
- Carry out Energy Audit of the Residence / Institute/ Organization.
- Evaluate the project using financial techniques
- Identify and evaluate energy conservation opportunities in Thermal Utilities.
- Identify and evaluate energy conservation opportunities in Electrical Utilities.
- Identify the feasibility of Cogeneration and WHRUse a CFD tool effectively for practical problems and research.

Course Contents

Unit 1: General Aspects of Energy Management **6 Hrs**

Current energy scenario - India and World, Current energy consumption pattern in global and Indian industry, Concept of energy conservation and energy efficiency, Energy and environment, Need of Renewable energy, Principles of Energy management, Energy policy, Energy action planning, Energy security and reliability, Energy reforms.

Unit 2: Energy Audit **6 Hrs**

Need of Energy Audit, Types of energy audit, Components of energy audit, Energy audit methodology, Instruments used in energy audit, Analysis and recommendations of energy audit, Energy audit reporting, Energy audit software, Current Energy Conservation Act.

Unit 3: Energy Economics **6 Hrs**

Costing of Utilities- Determination of cost of steam, natural gas, compressed air and electricity, Financial Analysis Techniques (Numerical) - Simple payback, Time value of money,

Net Present Value(NPV), Return on Investment (ROI), Internal Rate of Return (IRR), Risk and Sensitivity analysis.

Unit 4: Energy Efficiency in Thermal Utilities **6 Hrs**

Energy performance assessment (Numerical) and efficiency improvement of Boilers, Furnaces, Heat exchangers, Cooling tower, DG sets, Fans and blowers, Pumps, Compressors, Compressed air system and HVAC systems. Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system.

Unit 5: Energy efficiency in Electrical Utilities **6 Hrs**

Electricity billing, Electrical load management and maximum demand control, penalties, Power factor improvement and benefits, Selection and location of capacitors. Distribution and transformer losses, Electrical motors- types, efficiency and selection, Speed control, Energy efficient motors, Introduction of Electricity Act 2003,Lamp types and their features, recommended illumination levels, Lighting system performance assessment and efficiency improvement (Numerical)

Unit 6: Cogeneration and Waste Heat Recovery **6 Hrs**

Cogeneration : Need, applications, advantages, classification, Introduction to Trigeneration, Waste heat recovery- Classification, Application, Concept of Pinch analysis, Potential of WHR in Industries, Commercial WHR devices, saving potential. CDM projects and carbon credit calculations.
Case study: Energy Audit of Institute/Department.

Books

References :

1. Handbook of Energy Audit, Albert Thumann P.E. CEM, William J. Younger CEM, The Fairmont Press Inc., 7th Edition.
2. Energy Management Handbook, Wayne C. Turner, The Fairmont Press Inc., 5th Edition, Georgia.
3. Handbook on Energy Audit and Environment management, Abbi Y. A., Jain Shashank, TERI, Press, New Delhi, 2006
4. Energy Performance assessment for equipment and Utility Systems.-Vol. 2,3.4 BEE Govt. of India
5. Boiler Operator‘s Guide Fourth Edition, Anthony L Kohan, McGraw Hill
6. Energy Hand book, Second edition, Von Nostrand Reinhold Company - Robert L. Loftness.
7. www.enrgymanagertraining.com
8. http://www.bee-india.nic.in

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402046 **Course Name : Project – I**

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: --	TH	: --	Theory	In-Sem : --	PR : --
Practical	: 04 hrs per week	TW	: 02		End-Sem : --	OR : 25
						TW : 25

Course Objectives:

- To have ideology of the industrial project.
- Hands on working with tools, tackles and machines
- To carry out literature survey
- To do brain storming for mechanical engineering system

Course Outcomes:

On completion of the course, students will be able to -

- Find out the gap between existing mechanical systems and develop new creative new mechanical system.
- Learn about the literature review
- Get the experience to handle various tools, tackles and machines.

Course Contents

INSTRUCTIONS FOR PROJECT REPORT WRITING (Project Stage I)

It is important that the procedures listed below be carefully followed by all the students of B.E. (Mechanical Engineering).

1. Prepare ***Three Spiral Bound Copies*** of your manuscript.
2. Limit your Project Stage I to *25– 30* pages (preferably)
3. The *footer must include* the following:
   Institute Name, B.E. (Mechanical) Times New Roman 10 pt. and centrally aligned.
4. Page number as second line of footer, Times New Roman 10 pt. centrally aligned.
5. Print the manuscript using
   a) Letter quality computer printing.
   b) The main part of manuscript should be Times New Roman 12 pt. with alignment - justified.
   c) Use 1.5 line spacing.
   d) Entire report shall be of 5- 7 chapters
6. Use the paper size 8.5'' × 11'' or A4 (210 × 197 mm). Please follow the margins given below.

Margin Location	Paper 8.5'' × 11''	Paper A4 (210 × 197 mm)
Top	1''	25.4 mm
Left	1.5''	37 mm
Bottom	1.25''	32 mm
Right	1''	25.4 mm

7. All paragraphs will be *1.5 lines spaced with a one blank line between each paragraph*. Each paragraph will begin with *without any indentation*.
8. *Section titles* should be bold with *14 pt.* typed in all capital letters and should be left aligned.
9. *Sub-Section headings* should be aligning at the left with *12 pt.* bold and Title Case (the first letter of each word is to be capitalized).
10. Illustrations (charts, drawings, photographs, figures) are to be in the text. Use only illustrations really pertinent to the text. Illustrations must be sharp, clear, black and white. Illustrations downloaded from internet are not acceptable.
    a) Illustrations should not be more than two per page. One could be ideal
    b) Figure No. and Title at bottom with 12 pt.
    c) Table No. and Title at top with 12 pt.
    d) Legends below the title in 10 pt.
    e) Leave proper margin in all sides
    f) Illustrations as far as possible should not be photo copied.
11. Photographs if any should be of glossy prints
12. Please use SI system of units only.
13. Please number the pages on the front side, centrally below the footer
14. References should be either in order as they appear in the thesis or in alphabetical order by last name of first author
15. Symbols and notations if any should be included in nomenclature section only
16. Following will be the order of report
    i. Cover page and Front page (*as per the specimen on separate sheet*)
    ii. Certificate from the Institute (*as per the specimen on separate sheet*)
    iii. Acknowledgements
    iv. Contents
    v. List of Figures
    vi. List of Tables
    vii. Nomenclature
    viii. Abstract (A brief abstract of the report not more than 150 words. The heading of abstract i.e. word "Abstract" should be bold, Times New Roman, 12 pt. and should be typed at the center. The contents of abstract should be typed on new line without space between heading and contents. Try to include one or two sentences each on motive, method, key-results and conclusions in Abstract

    1. Introduction (2-3 pages) (TNR – 14 Bold)
        1.1 Problem statement (TNR – 12)
        1.2 Objectives
        1.3 Scope
        1.4 Methodology
        1.5 Organization of Dissertation

    2. Literature Review (12-16 pages)
    Discuss the work done so far by researchers in the domain area and their significant conclusions. No derivations, figures, tables, graphs are expected.

    3. This chapter shall be based on your own simulation work (Analytical/ Numerical/FEM/CFD) (8 - 12 pages)

    4. Experimental Validation - This chapter shall be based on your own experimental work

(2 - 3 pages)

5. Concluding Remarks and Scope for the Future Work (1 - 2 pages)
(IF above Chapters 3, 4, 5 not completed please mention the plan for the same and time period for completion and detail activity chart).
References ANNEXURE (if any) (Put all mathematical derivations, Simulation program as Annexure)

17. All section headings and subheadings should be numbered. For sections use numbers 1, 2, 3, …. and for subheadings 1.1, 1.2, …. etc and section subheadings 2.1.1, 2.1.2, …. etc.
18. References should be given in the body of the text and well spread. No verbatim copy or excessive text from only one or two references. If figures and tables are taken from any reference then indicate source / citatation of it. Please follow the following procedure for references

Reference Books :
Collier, G. J. and Thome, J. R., Convective boiling and condensation, 3rd ed., Oxford University Press, UK, 1996, pp. 110 – 112.

Papers from Journal or Transactions :
Jung, D. S. and Radermacher, R., Transport properties and surface tension of pure and mixed refrigerants, *ASHRAE Trans*, 1991, 97 (1), pp. 90 – 98.
Bansal, P. K., Rupasinghe, A. S. and Jain, A. S., An empirical correction for sizing capillary tubes, *Int. Journal of Refrigeration*, 1996, 19 (8), pp.497 – 505.

Papers from Conference Proceedings :
Colbourne, D. and Ritter, T. J., *Quantitative assessment of flammable refrigerants in room air conditioners*, Proc. of the Sixteenth International Compressor Engineering Conference and Ninth International Refrigeration and Air Conditioning Conference, Purdue University, West Lafayette, Indiana, USA, 2002, pp. 34 – 40.

Reports, Handbooks etc. :
United Nations Environmental Programme, Report of the Refrigeration, Air Conditioning and Heat Pumps, Technical Option Committee, 2002, Assessment - 2002.
ASHRAE Handbook: Refrigeration, 1994 (Chapter 44)

Patent :
Patent no, Country (in parenthesis), date of application, title, year.

Internet :
www.(Site) [Give full length URL] *accessed on date*

A Project Stage-I Report on
(TNR, 16pt, centrally aligned)

Title of the Project Report

(TNR, 27pt, Bold, Centrally Aligned, Title Case)

By
(TNR, 16pt, Centrally Aligned)

Mr. Student's 1 Name
(TNR, 16pt, Centrally Aligned)

Mr. Student's 2 Name
(TNR, 16pt, Centrally Aligned)

Mr. Student's 3 Name
(TNR, 16pt, Centrally Aligned)

Mr. Student's 4 Name
(TNR, 16pt, Centrally Aligned)

Guide
Guide's Name
(TNR, 16pt, Centrally Aligned)

Institute Logo

Department of Mechanical Engineering
Name of the Institute
[2018-19]

(TNR, 22pt, Title Case Centrally Aligned)

Name of the Institute

Institute Logo

C E R T I F I C A T E

This is to certify that ***Mr. (Name of the Student)***, has successfully completed the Project Stage – I entitled "(***Title of the Project)*** " under my supervision, in the partial fulfillment of Bachelor of Engineering - Mechanical Engineering of University of Pune.

Date:

Place:

Guide's Name
Guide

Internal Examiner

HoD Name
Head of the Department

Principal Name
Principal

Seal

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402047 **Course Name : Energy Engineering**

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 03 Hrs Per Week	TH	: 03	Theory	In-Sem : 30	PR : --
Practical	: 02 hrs per week	TW	: 01		End-Sem : 70	OR : 25
						TW : 25

Pre-requisites: Thermodynamics I and II and Heat Transfer

Course Objectives:

- To study the power generation scenario, the components of thermal power plant, improved Rankin cycle, Cogeneration cycle
- To understand details of steam condensing plant, analysis of condenser, the an environmental impacts of thermal power plant, method to reduce various pollution from thermal power plant
- To study layout, component details of hydroelectric power plant, hydrology and elements , types of nuclear power plant
- To understand components; layout of diesel power plant , components; different cycles ; methods to improve thermal efficiency of gas power plant
- To study the working principle , construction of power generation from non-conventional sources of energy
- To learn the different instrumentation in power plant and basics of economics of power generation.

Course Outcomes:

On completion of the course, students will be able to -

- Describe the power generation scenario, the layout components of thermal power plant and analyze the improved Rankin cycle, Cogeneration cycle
- Analyze the steam condensers, recognize the an environmental impacts of thermal power plant and method to control the same
- Recognize the layout, component details of hydroelectric power plant and nuclear power plant
- Realize the details of diesel power plant, gas power plant and analyze gas turbine power cycle
- Emphasize the fundaments of non-conventional power plants
- Describe the different power plant electrical instruments and basic principles of economics of power generation.

Course Contents

Unit 1: Introduction and Thermal Power Plant **6 Hrs**

A) *Power Generation* : global scenario, present status of power generation in India, in Maharashtra, Role of private and governmental organizations, load shedding, carbon credits, pitfalls in power reforms, concept of cascade efficiency.

B) *Thermal Power Plant* : General layout of modern thermal power plant with different circuits, site selection criteria, classification of coal, coal blending, coal beneficiation, selection of coal for thermal

power plant, slurry type fuels, pulverized fuel handling systems, fuel burning methods, FBC systems, high pressure boilers, ash handling system, Rankine cycle with reheat and regeneration (Numerical Treatment), steam power plants with process heating (Numerical Treatment)

Unit 2: Steam Condenser and Environmental Impacts of Thermal Power Plant **6 Hrs**

A) *Steam Condenser* : Necessity of steam condenser, elements of steam condensing plant, classification, cooling water requirements, condenser efficiency, vacuum efficiency (Numerical Treatment), cooling towers, air leakage and its effects on condenser performance, air pumps (Numerical Treatment for Air Pump capacity)

B) *Environmental impact of thermal power plants* : Different pollutants from thermal power plants, their effects on human health and vegetation, methods to control pollutants such as particulate matter; oxides of sulphur; oxides of nitrogen, dust handling systems, ESP, scrubbers, water pollution, thermal pollution, noise pollution from TPP and its control

Unit 3: Hydroelectric and Nuclear Power Plant **6 Hrs**

A) *Hydroelectric Power Plant* : site selection, classification of HEPP (based on head, nature of load, water quantity), criteria for turbine selection, dams, spillways, surge tank and forebay, advantages and disadvantages of HEPP, hydrograph ,flow duration curve ,mass curve, (Numerical Treatment) environmental impacts of HEPP

B) *Nuclear Power Plants* : elements of NPP, types of nuclear reactor (PWR, BWR, CANDU, GCR, LMCR, OMCR, fast breeder, fusion), material for nuclear fuel, cladding, coolants, control rod and shielding, nuclear waste disposal, environmental impacts of NPP

Unit 4: Diesel and Gas Turbine Power plant **6 Hrs**

A) *Diesel Power Plants* : applications, components of DPP, different systems of DPP, plant layout, performance of DPP (Numerical Treatment) advantages & disadvantages of diesel power plant, environmental impacts of DPP

B) *Gas Turbine Power Plant* : general layout of GTPP, components of GTPP, open, closed & semi-closed cycle gas turbine plant, Brayton cycle analysis for thermal efficiency, work ratio, maximum & optimum pressure ratio, methods to improve thermal efficiency of GTPP: inter-cooling; reheating & regeneration cycle (numerical treatment), gas and steam turbine combined cycle plant, environmental impacts of GTPP

Unit 5: Non-Conventional Power Plants **6 Hrs**

*Solar Power Plant based on***:** flat plate collector, solar ponds, parabolic solar collector, heliostat, solar chimney, SPV cell based plants: working principal, solar photovoltaic systems, applications

*Geothermal Plant***:** superheated steam system, flash type, binary cycle plant.

*Tidal Power Plant***:** components, single basin, double basin systems.

*OTEC Plant***:** principal of working, Claude cycle, Anderson Cycle.

MHD Power Generation : Principal of working, Open Cycle MHD generator, closed cycle MHD generators.

Fuel cell : alkaline, acidic, proton-exchange membrane

Wind Power Plant : wind availability, wind mills and subsystems, classification of wind turbines, operating characteristics, wind solar hybrid power plants, challenges in commercialization of non-conventional power plants, environmental impacts of NCPP

Unit 6: Instrumentation and Economics of Power Plant **6 Hrs**

A) *Power Plant Instruments* : layout of electrical equipment, generator, exciter, generator cooling, short circuits & limiting methods, switch gear, circuit breaker, power transformers, methods of earthling, protective devices & control system used in power plants, measurement of high voltage, current and power, control room

B) *Economics of Power Generation* : cost of electric energy, fixed and operating cost [methods to determine depreciation cost] (Numerical Treatment), selection and type of generation, selection of generation equipment , load curves, performance and operation characteristics of power plants, load division, all terms related to fluctuating load plant (Numerical Treatment)

Books

Text :

1. Domkundwar & Arora, Power Plant Engineering, Dhanpat Rai & Sons, New Delhi
2. Domkundwar & Domkundwar- Solar Energy and Non-Conventional Sources of Energy, Dhanpat Rai& Sons, New Delhi.
3. R.K.Rajput, Power Plant Engineering‖, Laxmi Publications New Delhi.
4. D.K.Chavan & G.K.Phatak, Power Plant Engineering‖, Standard Book House, New Delhi.

References :

1. E.I.Wakil, Power Plant Engineering‖, McGraw Hill Publications New Delhi
2. P.K.Nag, Power Plant Engineering‖, McGraw Hill Publications New Delhi.
3. R.Yadav , Steam and Gas Turbines‖ ,Central Publishing House, Allahabad.
4. G.D.Rai, Non-Conventional Energy Sources, Khanna Publishers,Delhi
5. S.P.Sukhatme, Solar Energy‖ Tata McGraw-Hill Publications, New Delhi
6. G R Nagpal Power Plant Engineering , Khanna Publication

Term Work shall consist of following assignments:

IMP Notes for Term Work:

- Any Eight Experiment should be conducted (*from Experiment No. 1 to 10*) and
- *Experiment No 1, 2, 7,* and *8* are compulsory
- *Experiment No: 3 - 9* can be performed using suitable simulation software

1. Visit to Thermal Power plant /Co-generation Power plant.
2. Visit to HEPP/GTPP/Non-Conventional Power Plants.
3. Study of Fluidized Bed Combustion system.
4. Study of High Pressure Boilers
5. Study of Steam Turbine Systems –governing systems, protective devices, lubricating systems, glands and sealing systems.
6. Study of Co-generation Plants
7. Trial on Steam Power Plant or with help of suitable software to determine
    a) Plant Efficiency, Rankine Efficiency Vs Load
    b) Specific Steam consumption Vs Load
    c) Rate of Energy Input Vs Load
    d) Heat Rate and Incremental heat Rate Vs Load
8. Trial on Diesel Power Plant or with help of suitable software to determine
    a) Plant Efficiency Vs Load

b) Total fuel consumption Vs Load
c) Rate of Energy Input Vs Load
d) Heat Rate and Incremental heat Rate Vs Load

9. Study of Power Plant Instruments.
10. Study of Different Tariff Methods

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402048 **Course Name : Mechanical System Design**

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 04 Hrs Per Week	TH	: 04	Theory	In-Sem : 30	PR : --
Practical	: 02 hrs per week	TW	: 01		End-Sem : 70	OR : 25
						TW : 50

Pre-requisites:	Engineering Mechanics, Manufacturing Process, Strength of Materials, Machine design, Engineering Mathematics, Theory of Machines, Dynamics of Machinery, and IC Engines.

Course Objectives:

- To develop competency for system visualization and design.
- To enable student to design cylinders and pressure vessels and to use IS code.
- To enable student select materials and to design internal engine components.
- To introduce student to optimum design and use optimization methods to design mechanical components.
- To enable student to design machine tool gearbox.
- To enable student to design material handling systems.
- Ability to apply the statistical considerations in design and analyze the defects and failure modes in components

Course Outcomes:

On completion of the course, students will be able to -

- Understand the difference between component level design and system level design.
- Design various mechanical systems like pressure vessels, machine tool gear boxes, material handling systems, etc. for the specifications stated/formulated.
- Learn optimum design principles and apply it to mechanical components.
- Handle system level projects from concept to product.

Course Contents

Unit 1: Design of Machine Tool Gear Box **8 Hrs**

Introduction to machine tool gearboxes, design and its applications, basic considerations in design of drives, determination of variable speed range, graphical representation of speed and structure diagram, ray diagram, selection of optimum ray diagram, gearing diagram, deviation diagram.
(Note: Full design problem to be restricted up to 2 Stages only)

Unit 2: Statistical Consideration in Design **8 Hrs**

Frequency distribution-Histogram and frequency polygon, normal distribution - units of central tendency and dispersion- standard deviation - population combinations - design for natural tolerances - design for assembly - statistical analysis of tolerances, mechanical reliability and factor of safety.

Unit 3: Design of Belt Conveyor System for Material Handling **8 Hrs**

System concept, basic principles, objectives of material handling system, unit load and

containerization.

Belt conveyors, Flat belt and troughed belt conveyors, capacity of conveyor, rubber covered and fabric ply belts, belt tensions, conveyor pulleys, belt idlers, tension take-up systems, power requirement of horizontal belt conveyors for frictional resistance of idler and pulleys.

Unit 4: Design of Cylinders and Pressure Vessels **8 Hrs**

Design of Cylinders: Thin and thick cylinders, Lame's equation, Clavarino's and Bernie's equations, design of hydraulic and pneumatic cylinders, auto-frettage and compound cylinders,(No Derivation) gasketed joints in cylindrical vessels (No derivation).

Design of Pressure vessel : Modes of failures in pressure vessels, unfired pressure vessels, classification of pressure vessels as per I. 2825 - categories and types of welded joints, weld joint efficiency, stresses induced in pressure vessels, materials for pressure vessel, thickness of cylindrical shells and design of end closures as per code, nozzles and openings in pressure vessels, reinforcement of openings in shell and end closures - area compensation method, types of vessel supports (theoretical treatment only).

Unit 5: Design of I.C. Engine Components **8 Hrs**

Introduction to selection of material for I. C. engine components, Design of cylinder and cylinder head, construction of cylinder liners, design of piston and piston-pins, piston rings, design of connecting rod. Design of crank-shaft and crank-pin, (Theoretical treatment only).

Unit 6: Optimum Design **8 Hrs**

Objectives of optimum design, adequate and optimum design, Johnson's Method of optimum design, primary design equations, subsidiary design equations and limit equations, optimum design with normal specifications of simple machine elements- tension bar, transmission shaft and helical spring, Pressure vessel Introduction to redundant specifications (Theoretical treatment).

Books

Text :

1. Bhandari V.B. ―Design of Machine Elements‖, Tata McGraw Hill Pub. Co. Ltd.
2. Juvinal R.C, Fundamentals of Machine Components Design, Wiley, India

References :

1. Design Data- P.S.G. College of Technology, Coimbatore.
2. Bhandari, V. B. Machine Design data book, Tata McGraw Hill Publication Co. Ltd.
3. I.S. 2825: Code for unfired pressure vessels.
4. Shigley J. E. and Mischke C.R., ―Mechanical Engineering Design‖, McGraw Hill Pub. Co
5. M. F. Spotts, –Mechanical Design Analysis‖, Prentice Hall Inc.
6. Black P.H. and O. Eugene Adams, –Machine Design‖ McGraw Hill Book Co. Inc.
7. Johnson R.C., ―Mechanical Design Synthesis with Optimization Applications‖, Von Nostrand Reynold Pub.
8. S.K. Basu and D. K. Pal, –Design of Machine Tools, Oxford and IBH Pub Co.
9. Rudenko,‖Material Handling Equipment‖, M.I.R. publishers, Moscow
10. P. Kannaiah ,‖Design of Transmission systems‖, SCIETCH Publications Pvt Ltd.
11. Pandy, N. C. and Shah, C. S., Elements of Machine Design, Charotar Publishing House.
12. Mulani, I. G., ―Belt Conveyors‖
13. Singiresu S. Rao, Engineering Optimization: Theory and Practice, John Wiley & Sons.

14. M.V. Joshi, Process Equipment Design, Mc-Millan.

Term Work shall consist of following assignments:

1. One Design Project:

The design project shall consist of two imperial size sheets (Preferably drawn with 3D/2D CAD software) - one involving assembly drawing with a part list and overall dimensions and the other sheet involving drawings of individual components, manufacturing tolerances, surface finish symbols and geometric tolerances must be specified so as to make it working drawing. A design report giving all necessary calculations of the design of components and assembly should be submitted. Projects shall be in the form of design of mechanical systems including pressure vessel, conveyor system, multi speed gear box, I.C engine, etc.

Each Student shall complete any one of the following assignments.

1. Design of Flywheel.
2. Design for Manufacture, Assembly and safe.
3. Application of Composite Material for different mechanical components.
4. Case study of one patent/ copyright/trademark from the product design point of view.
5. Design of Human Powered system.

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402049 A **Course Name : Elective – III Tribology**

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 03 Hrs Per Week	TH	: 03	Theory	In-Sem : 30	PR : --
Practical	: 02 hrs per week	TW	: 01		End-Sem : 70	OR : --
						TW : 25

Pre-requisites	**:** Physics, Chemistry, Mathematics, Fluid Mechanics, Theory of Machine and Machine Design

Course Objectives:

- To provide the knowledge and importance of Tribology in Design, friction, wear and lubrication aspects of machine components.
- To select proper grade lubricant for specific application.
- To understand the principles of lubrication, lubrication regimes, theories of hydrodynamic and the advanced lubrication techniques.
- To introduce the concept of surface engineering and its importance in tribology.
- To understand the behavior of Tribological components.

Course Outcomes:

On completion of the course, students will be able to -

- The course will enable the students to know the importance of Tribology in Industry.
- The course will enable the students to know the basic concepts of Friction, Wear, Lubrications and their measurements.
- This course will help students to know the performance of different types of bearings and analytical analysis thereof.
- This course will help students to apply the principles of surface engineering for different applications of tribology.

Course Contents

Unit 1: Introduction to Tribology **6 Hrs**

Importance of Tribology in Design, Tribology in Industry, Economic Considerations, Lubrication- Definition, Lubricant properties, Viscosity, its measurements- Numerical, basic modes of lubrication, types of lubricants, Standard Grades of lubricants, selection of lubricants, commonly used lubricants and Hazards, Recycling of used oil, Disposal of used oil, bearing materials, bearing construction, oil seals and gaskets.

Unit 2: Friction and Wear **5 Hrs**

Introduction, Laws of friction, kinds of friction, causes of friction, area of contact, friction measurement, theories of friction.

Types of wear, various factors affecting wear, measurement of wear, wear between solids and flowing liquids, theories of wear

Unit 3: Hydrodynamic Lubrication **7 Hrs**

Theory of hydrodynamic lubrication, mechanism of pressure development in an oil film. Two dimensional Reynolds equation, Petroff's equation, pressure distribution in journal bearings - long & short, Load Carrying capacity, Somerfield number and its importance- Numerical. Introduction to Hydrodynamic Thrust Bearing

Unit 4: Hydrostatic Lubrication **5 Hrs**

Introduction to hydrostatic lubrication, hydrostatic step bearing, load carrying capacity and oil flow through the hydrostatic step bearing- Numerical.

Hydrostatic squeeze film : basic concept, circular and rectangular plate approaching a plane- Numerical

Unit 5: Elasto-hydrodynamic lubrication and Gas Lubrication **5 Hrs**

Elasto - hydrodynamic lubrication: Basic concept, Elasto-hydrodynamic lubrication between two contacting bodies, different regimes in EHL contacts.

Gas lubrication: Introduction, merits and demerits, applications, externally pressurized gas bearings, porous gas bearings, and Dynamic characteristics of gas lubricated bearing.

Unit 6: Surface Engineering **8 Hrs**

Concept and scope of Surface engineering, surface topography, apparent and real area of contact, tribological behavior of asperities contact- contact stress, surface roughness and hydrodynamic action- Numerical, surface coating-plating, fusion process, vapor phase processes, selection of coating for wear and corrosion resistance. Behavior of tribological components- selection of bearings, plain bearings, gears, wire ropes, seals and packings, conveyor belts, other tribological measures.

Books

Text :

1. Basu S.K., Sengupta S. N. and Ahuja B.B. "Fundamentals of Tribology" PHI Learning, Ltd. India.
2. Majumdar B. C. "Introduction to Tribology and Bearings", S. Chand and Company Ltd., New Delhi.

References :

1. Bharat Bhushan, "Principles and Applications of Tribology", John Wiley and Sons.
2. Sahu P., "Engineering Tribology", PHI Learning, Ltd. India
3. Fuller D.D. "Theory and Practice of Lubrication for Engineers". John Wiley and Sons.
4. Neale M. J. "Tribology hand Book", Butterworths. London.
5. Orlov P., "Fundamentals of Machine Design", Vol. IV, MIR Publication.
6. Cameron A. "Basic Lubrication Theory", Wiley Eastern Ltd.
7. 'Hailing J., "Principles of Tribology", McMillan Press Ltd., 1975.
8. Ghosh M.K., Mujumdar B.C. and Sarangi M., "Theory of lubrication", Tata McGraw Hill Education Pvt. Ltd., New Delhi.

Term Work shall consist of following assignments:

A] *Any one case study of the following*

1. Friction in sliding/ rolling contact bearing.
2. Wear of cutting tool.
3. Surface Coating.
4. Sliding/ rolling contact bearing Performance

B] Assignment based on the Tribological design of the system like I C Engine, Machine Tool, Rolling Mill.

OR

Industrial Visit: Students should visit the industry to study the lubrication systems or to study the techniques of surface coating.

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402049 B **Course Name : Elective – III Industrial Engineering**

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 03 Hrs Per Week	TH	: 03	Theory	In-Sem : 30	PR : --
Practical	: 02 hrs per week	TW	: 01		End-Sem : 70	OR : --
						TW : 25

Pre-requisites: NIL

Course Objectives:

- To introduce the concepts, principles and framework of contents of Industrial Engineering.
- To acquaint the students with various productivity enhancement techniques.
- To acquaint the students with different aspects of Production Planning and Control and Facility Design.
- To introduce the concepts of various cost accounting and financial management practices as applied in industries.
- To acquaint the students with different aspects of Human Resource activities and Industrial Safety rules.
- To acquaint students with different aspect of simulation modeling for various industrial engineering\applications.

Course Outcomes:

On completion of the course, students will be able to -

- Apply the Industrial Engineering concept
- Understand, analyze and implement different concepts involved in method study.
- Design and Develop different aspects of work system and facilities.
- Understand and Apply Industrial safety standards, financial management practices.
- Undertake project work based on modeling & simulation area.

Course Contents

Unit 1: Introduction to Industrial Engineering and Productivity **6 Hrs**

Definition and Role of Industrial Engineering, Types of production systems and organization structure, Functions of management.

Measurement of productivity: Factors affecting the productivity, Productivity Models and Index (Numerical), Productivity improvement techniques.

Note: *Productivity improvement techniques viz. 5S, Kaizen, TPS, KANBAN, JIT, etc. shall be discussed at the end of this* Unit.

Unit 2: Method Study **6 Hrs**

Work Study: Definition, objective and scope of work-study, Human factors in work-study.

*Method Study***:** Definition, objective and scope of method study, work content, activity recording and exam aids.

*Charts to record movements***:** Operation process charts, flow process charts, travel chart, two-handed chart and multiple activity charts. Principles of motion economy, classification of movements, SIMO chart, and micro motion study.

Definition and installation of the improved method, brief concept about synthetic motion studies.

Introduction to Value Engineering and Value Analysis.

Unit 3: Work Measurements **6 Hrs**

*Work Measurements***:** Definition, objectives and uses, Work measurement techniques.

*Work Sampling***:** Need, confidence levels, sample size determinations, random observation, conducting study with the simple problems.

*Time Study***:** Definition, time study equipment, selection of job, steps in time study. Breaking jobs into elements, recording information, Rating and standard rating, standard performance, scales of rating, factors affecting rate of working, allowances and standard time determination.

*Introduction to PMTS and MTM***:** (Numerical), Introduction to MOST.

Unit 4: Production Planning and Control **6 Hrs**

Introduction: Types of production systems, Need and functions of PPC, Aggregate production planning.

Capacity Planning, ERP: Modules, Master Production Schedule, MRP and MRP-II.

Forecasting Techniques: Causal and time series models, moving average, exponential smoothing, trend and seasonality (Numerical), Demand Control strategies (MTO, MTA, MTS).

Introduction to Supply Chain Management: Basic terminologies.

Unit 5: Facility Design **6 Hrs**

Plant Location : Need and factors influencing plant location,

Plant Layout: Objectives, principles, types of plant layouts, Introduction to Assembly Line Balancing and Layout parameters to evaluate.

Material Handling: Objectives, relation with plant layout, principles. Types and purpose of different material handling equipment, Selection of material handling equipment.

Inventory control and Management: Types of inventories, Need of inventories, terminology, costs, Inventory Models: Basic production models, (with and without shortage and discount), ABC, VED Analysis.

Unit 6: Engineering Economy, Human Resource and Industrial Safety **6 Hrs**

Introduction to Costing: Elements of Cost, Break-Even Analysis (Numerical).

Introduction to Debit and Credit Note, Financial Statements (Profit and loss account and Balance Sheet), Techniques for Evaluation of capital investments.

Human Resource Development: Functions: Manpower Planning, Recruitment, Selection, Training. Concept of KRA (Key Result Areas), Performance Appraisal (Self, Superior, Peer, 3600).

Industrial Safety: Safety Organization, Safety Program

Books

Text :

1. M Mahajan, Industrial Engineering and Production Management, Dhanpat Rai and Co.
2. O. P. Khanna, Industrial engineering and management, Dhanpat Rai publication
3. Martend Telsang, Industrial Engineering, S. Chand Publication.
4. Banga and Sharma, Industrial Organization& Engineering Economics, Khanna publication.

References :

1. Introduction to Work Study by ILO, ISBN 978-81-204-1718-2, Oxford & IBHPublishing Company, New Delhi, Second Indian Adaptation, 2008.
2. H. B. Maynard, K Jell, Maynard's Industrial Engineering Hand Book, McGraw Hill Education.
3. Askin, Design and Analysis of Lean Production System, Wiley, India
4. Zandin K.B., Most Work Measurement Systems, ISBN 0824709535, CRCPress,2002
5. Martin Murry, SAP ERP: Functionality and Technical Configuration, SAP Press; 3rdNew edition (2010).
6. Barnes, Motion and time Study design and Measurement of Work, Wiley India
7. Raid Al-Aomar, Adwerd J Williams, Onur M. Uigen 'Process Simulation using WITNESS', Wiley

Term Work shall consist of following assignments:

- Minimum of *8 Experiments* are compulsory from the following list of Experiments.
- Assignment number *1, 2, 3, 8* and *12* are compulsory.
- It is advisable that, students shall collect data by visiting suitable industry to complete following assignments (*Per batch of Max. 20 students*)
- For completing above assignments *any suitable simulation software* like WITNESS can be used

1. Case study based Assignment on Method Study.
2. Hands on Assignment on application of Work Measurement technique(s).
3. Assignment on simulation of Routing & Scheduling Model
4. Assignment on **s**imulation of Manufacturing System **/** Service System Operations for demand forecasting of the given product using any two methods.
5. Assignment on simulation determination of EOQ and plot the graphs.
6. Assignment on analysis of Manufacturing / Service Operation for Capacity Planning.
7. Case study based assignment on supply chain model.
8. Assignment on analysis of (selected) plant layout modeling and simulation for bottleneck / line balancing.
9. Assignment on analysis of material handling system - modeling simulation for the selected plant layout.
10. Case study based assignment on identification of Key Result Areas for performance appraisal for selected company (3600 feedback).
11. Case study based assignment on cost-revenue model analysis.
12. Assignment on industrial safety audit of selected work environment.

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402049 C **Course Name : Elective – III Robotics**

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 03 Hrs Per Week	TH	: 03	Theory	In-Sem : 30	PR : --
Practical	: 02 hrs per week	TW	: 01		End-Sem : 70	OR : --
						TW : 25

Pre-requisites:	Engineering Mechanics, TOM, Mechatronics, Basics of Electrical and Electronics Engineering, Control system.

Course Objectives:

- To get acquainted with basic components of robotic systems.
- To study various gripper mechanisms and sensors and understand role of suitable control system.
- To understand statistics & kinematics of robots
- To develop competency in obtaining desired motion of the robot.
- To study various programming methods in robotics.
- To understand need of modern techniques in robotics.

Course Outcomes:

On completion of the course, students will be able to -

- Identify different type of robot configuration with relevant terminology.
- Select suitable sensors, actuators and drives for robotic systems.
- Understand kinematics in robotic systems.
- Design robot with desired motion with suitable trajectory planning.
- Select appropriate robot programming for given application.
- Understand need of IoT, machine learning, simulation in robotics.

Course Contents

Unit 1: **6 Hrs**

Introduction: Basic Concepts, laws of Robotics, Robot anatomy, Classification, structure of robots, point to point and continuous path robotic systems. Robot performance- resolution, accuracy, repeatability, dexterity, compliance, RCC device, Applications.

Robot Grippers: Types of Grippers, Design of gripper, Force analysis for various basic gripper systems including Mechanical, Hydraulic and Pneumatic systems.

Unit 2: **6 Hrs**

Robotic Sensors: Characteristics of sensing devices, Classification, Selection and applications of sensors. Types of Sensors, Need for sensors and vision system in the working and control of a robot. GPS, IMU, Vision, PVDF Tactile (construction, working and selection)

Drives and Control Systems : Types and selection of Drives, Actuators and transmission systems, Types of Controllers, closed loop control, second order linear systems and their control, control law of partitioning, trajectory-following control, modeling and control of a single joint, force control.

Unit 3: **6 Hrs**

Kinematics : Transformation matrices and their arithmetic, link and joint description, Denavit–Hartenberg parameters, frame assignment to links, direct kinematics, kinematics redundancy, kinematics calibration, inverse kinematics of two joints, solvability, algebraic and geometrical methods.

*Velocities and Static Forces in Manipulators***:** Motion of the manipulator links, Jacobians, singularities, static forces, Jacobian in force domain.

Unit 4: **6 Hrs**

Introduction to Dynamics, Trajectory generations, Motion planning and control: Joint and Cartesian space trajectory planning and generation, potential field method for motion planning Manipulator Mechanism Design, Force control and hybrid position/force control

Unit 5: **6 Hrs**

Machine Vision System: Vision System Devices, Image acquisition, Masking, Sampling and quantization, Image Processing Techniques, Masking, Sampling and quantization, Noise reduction methods, Edge detection, Segmentation.

Robot Programming : Methods of robot programming, lead through programming, motion interpolation, branching capabilities, WAIT, SIGNAL and DELAY commands, subroutines, Programming Languages: Robot language structure, Introduction to various types such as RAIL and VAL II

Unit 6: **6 Hrs**

*Artificial Intelligence***:** Introduction, Need and Application, Problem solving through forward and backward search.

Introduction to Internet of Things (Industrial control, Smart Social Network), Industry 4.0, Machine learning

Simulation : Need of simulation, tools, types and techniques of simulation

Books

Text :

1. S. R. Deb, Robotics Technology and Flexible Automation, Tata McGraw Hill.

References :

1. Groover M.P.-Automation, production systems and computer integrated manufacturing‘ - Prentice Hall of India
2. S B Niku, Introduction to Robotics, Analysis, Control, Applications, 2nd Edition, Wiley Publication, 2015.
3. John Craig, Introduction to Robotics, Mechanics and Control, 3rd Edition, Pearson Education, 2009
4. Mathia, Robotics for Electronics Manufacturing, Cambridge Uni. Press, India
5. A Ghosal, Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2013.
6. R K Mittal & I J Nagrath, Robotics and Control, McGraw Hill Publication, 2015.

7. K Astrom & T Hagglund, PID Controllers: Theory, Design and Tuning, 2nd Edition, The Instrumentation, Systems, and Automation Society, 1995.
8. Asfahl, Robots and Manufacturing Automation, Wiley, India, 2012
9. S. K. Saha, Introduction to Robotics, TMH International
10. Ganesh Hegde, Industrial Robotics, Laxmi publication
11. www.roboanalyzer.com

Term Work shall consist of following assignments:

*The term work shall consist of detailed report on **any five** of the following practical, essentially with one demonstration, one gripper design and an industrial visit.*

1. Simulation of Cartesian / Cylindrical/Spherical robot.
2. Simulation of Articulated / SCARA robot.
3. Virtual modeling for kinematic and dynamic verification any one robotic structure using suitable software.
4. Design, modeling and analysis of two different types of gripper.
5. Program for linear and non-linear path.
6. Report on industrial application of robot /Industrial visit.

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402050 A **Course Name : Elective – IV**

Advanced Manufacturing Processes

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 03 Hrs Per Week	TH	: 03	Theory	In-Sem : 30	PR : --
Practical	: --	TW	: --		End-Sem : 70	OR : --
						TW : --

Pre-requisites:	Basic Engineering Science - Physics, Chemistry, Material Science, Engineering Metallurgy, Manufacturing processes

Course Objectives:

- To analyze and identify applications of special forming processes
- To analyze and identify applications of advanced joining processes
- To understand and analyze the basic mechanisms of hybrid non-conventional machining techniques
- To understand various applications and methods of micro and nano fabrication techniques
- To understand advanced Additive Manufacturing (AM) technology for innovations in product development
- To understand various material characterization techniques.

Course Outcomes:

On completion of the course, students will be able to -

- Classify and analyze special forming processes
- Analyze and identify applicability of advanced joining processes
- Understand and analyze the basic mechanisms of hybrid non-conventional machining techniques
- Select appropriate micro and nano fabrication techniques for engineering applications
- Understand and apply various additive manufacturing technology for product development
- Understand material characterization techniques to analyze effects of chemical composition, composition variation, crystal structure, etc.

Course Contents

Unit 1: Special Forming Processes **6 Hrs**

Principle, Machines, Process variables, characteristics, advantages, limitations and application of High Energy Rate Forming process (HERF), High Velocity Forming (HVF), Explosive forming, Magnetic pulse forming, Electro hydraulic forming, Metal spinning, Flow forming, Stretch forming, Incremental sheet metal forming, Petro-forge forming, Micro forming, Micro coining, Micro extrusion, Micro bending/laser bending, fine blanking.

Unit 2: Advanced Joining Processes **6 Hrs**

Friction stir welding, Electron Beam welding, Laser beam welding, Ultrasonic welding, Under water welding, Cryogenic welding, Thermal spray coatings, Welding of plastics and composites, Explosive joining, Adhesive bonding

Unit 3: Hybrid Non-conventional Machining Techniques **6 Hrs**

Introduction to hybrid processes, Abrasive flow finishing, Magnetic abrasive finishing, Abrasive water-jet machining, Wire electric discharge machining, Electrochemical grinding (ECG), Electrochemical Deburring (ECD), Shaped tube electrolytic machining (STEM), Electro-jet Machining (EJM), Electrolytic In-process dressing (ELPD), Ultrasonic assisted EDM, Rotary EDM, Electrochemical discharge Machining (ECDM), Laser surface treatments.

Unit 4: Micro Machining and Nano Fabrication Techniques **6 Hrs**

Introduction, need of micro and nano machining, Machine/setup, Process parameters, Mechanism of material removal, Applications, Advances of the Diamond Turn machining, Ultrasonic micro-machining, Focused Ion Beam Machining, Lithography, photochemical machining, Challenges in micro and nano fabrication techniques.

Unit 5: Additive Manufacturing Processes **6 Hrs**

Introduction and principle of the additive manufacturing process; Generalized additive manufacturing process chain; Classification of additive manufacturing processes and its principle, process steps and materials;

Post-processing of parts manufactured by Additive Manufacturing (AM) processes, Software issues in AM, Design For Additive Manufacturing (DFAM), Applications of Additive Manufacturing in Medical and Aerospace technologies

Unit 6: Material Characterization Techniques **6 Hrs**

Introduction : Material Characterization

Microscopy : Electron Microscopes, Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Scanning Tunneling Microscope (STM), Atomic Force Microscope (AFM), Field Ion Microscope (FIM);

Spectroscopy : Energy-dispersive X-ray spectroscopy (EDX), X-Ray Diffraction (XRD), X-Ray Photoelectron Spectroscopy (XPS), Nuclear Magnetic Resonance Spectroscopy (NMR), Electron Backscatter Diffraction (EBSD)

Books

Text :

1. V. K. Jain, "Advanced Machining Processes", Allied Publishers Pvt. Ltd.
2. M. P Groover., Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 6th Edition, Wiley 2015
3. A. Ghosh, A. K. Mallik, Manufacturing Science, Affiliated East-West Press Pvt. Ltd., New Delhi

References :

1. ASM: Metal Handbook, Volume 6, "Welding, Brazing and Soldering", Metal Park, Ohio.
2. ASM: Metal Handbook, Volume 14, "Forming", Metal Park, Ohio.
3. R. Balasubramaniam, RamaGopal V. Sarepaka, SathyanSubbiah, Diamond Turn Machining: Theory and Practice, CRC Press, ISBN 9781138748323 - CAT# K32643
4. V. K. Jain, Micro manufacturing Processes, CRC Press ISBN-13: 978-1138076426 ISBN-

10: 1138076422
5. Ian Gibson, David Rosen, B.Stucker, Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, And Direct Digital Manufacturing, New York, NY : Springer, 2015.
6. Sam Zhang, Lin Li, Ashok Kumar, Materials characterization techniques. Boca Raton: CRC Press. ISBN 1420042947
7. Douglas B. Murphy, Fundamentals of light microscopy and electronic imaging, 2001, Wiley-Liss, Inc. USA
8. Schwartz, A. J., Kumar, M., Adams, B. L., and Field, D. P., eds., 2009, Electron Backscatter Diffraction in Materials Science, Springer US.

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402050 B **Course Name : Elective – IV**

Solar and Wind Energy

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 03 Hrs Per Week	TH	: 03	Theory	In-Sem : 30	PR : --
Practical	: --	TW	: --		End-Sem : 70	OR : --
						TW : --

Pre-requisites	: Basic Mechanical Engineering, Basic Electrical and Electronics Engineering and Heat Transfer

Course Objectives:

- To understand fundamentals of solar and wind energies.
- To understand constructions, working principle and design procedure of solar and wind power plants.
- To apply basic engineering principle to design a simple solar and wind power system.

Course Outcomes:

On completion of the course, students will be able to -

- Design of solar food drier for domestic purpose referring existing system
- Design of parabolic dish solar cooker for domestic purpose referring existing system
- Design of solar photovoltaic system for domestic purpose referring existing system
- Design miniature wind mill for domestic purpose referring existing system

Course Contents

Unit 1: Solar Energy Principles **6 Hrs**

Present solar energy scenario, world energy futures, governing bodies (self-study), solar radiations and its measurements, solar constant, solar radiation geometry, solar radiation data, estimation of average solar radiation, solar radiation on tilted surface.

Unit 2: Solar Thermal Systems and Applications **8 Hrs**

Types of Solar thermal collector, flat plate collector analysis, Evacuated tube collectors (ETC) analysis, its design and application, solar air heaters and its types, solar distillation.

Solar Concentrating collectors: types- line and point concentrator, theory of Concentrating collectors, parabolic trough collector, parabolic dish collector, solar tower, concentrated Fresnel linear receiver (CFLR).

Unit 3: Solar Photovoltaic and Applications **6 Hrs**

Forming the PN junction solar cells & its applications, Structure of a solar cell, types of modules, PV array, solar cell equation, Fill factor and maximum power, Grid aspects of solar power, equipment used in solar photovoltaic plants, Power Conditioning Equipment-inverters, Regulators, Other Devices; System Analysis-Design Procedure, Design Constraints, Other Considerations.

Unit 4: Case Study on Solar Energy Applications **6 Hrs**

Case study 1: Design of solar food drier for domestic purpose referring existing system
Case study 2: Design of parabolic dish solar cooker for domestic purpose referring existing system
Case study 3: Design of solar photovoltaic system for domestic purpose referring existing system

Unit 5: Wind Energy **8 Hrs**

Principle of wind energy conversion; Basic components of wind energy conversion systems; various types and their constructional features; design considerations of horizontal and vertical axis wind machines: analysis of aerodynamic forces acting on wind mill blades and estimation of power output; wind data and site selection considerations, wind energy potential and installation in India.

Unit 6: Case Study on Wind Mill Design **2 Hrs**

Case study on designing miniature wind mill for domestic purpose referring existing system.

Books

Text :

1. G. D. Rai, 'Non-Conventional Energy Sources', Khanna Publisher
2. S. P. Sukhatme, 'Solar Energy: Principles of thermal collections and storage', McGraw Hill
3. Tiwari G N. 'Solar Energy: Fundamentals, design, modeling and Applications', Narosa, 2002

References :

1. Mukund R. Patel, 'Wind And Solar Power Systems: Design, Analysis and Operation, Second Edition', CRC Press
2. Kreith And Kreider, Solar Energy Handbook, McGraw Hill
3. Ray Hunter, 'Wind Energy Conversion: From Theory to Practice', John Wiley and Son Ltd
4. Gary L Johnson, 'Wind Energy Systems', Prentice-Hall Inc., New Jersey
5. Martin O L Hansen, 'Aerodynamics of Wind Turbines', James & James/Earthscan.
6. Goswami D Y, Kreith F, Kreider J F, 'Principles of Solar Engineering', Taylor & Francis
7. Robert Gasch, 'Wind Power Plant Fundamentals, Design, Construction And Operations', Springer
8. C S Solanki, 'Solar Photovoltaic: Fundamentals, Technology And Applications', PHI Learning

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402050 C **Course Name : Elective – IV**

Product Design and Development

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: 03 Hrs Per Week	TH	: 03	Theory	In-Sem : 30	PR : --
Practical	: --	TW	: --		End-Sem : 70	OR : --
						TW : --

Pre-requisites	**:** Basic Engineering Science - Physics, Chemistry, Material Science, Engineering Metallurgy, Manufacturing processes

Course Objectives:

To explain student's significance of

- Product design and Product development process
- Customer needs, satisfaction and commercialization of product
- Forward & Reverse Engineering and its role in designing a product
- Design Aspects (DFA, DFMEA, Design for Reliability and Safety)
- Product Life Cycle Management and Product Data Management

Course Outcomes:

On completion of the course, students will be able to -

- Understand essential factors for product design
- Design product as per customer needs and satisfaction
- Understand Processes and concepts during product development
- Understand methods and processes of Forward and Reverse engineering
- Carry various design processes as DFA, DFMEA, design for safety
- Understand the product life cycle and product data management

Course Contents

Unit 1: Introduction to Product Design and Development **6 Hrs**

Definition of product design, Essential Factors for product design, Modern approaches to product design, standardization, simplification and specialization in product design product development, product development versus product design, modern product development process, product testing and validation.

Unit 2: Product Development –Technical and Business Concerns **6 Hrs**

Mission Statement and Technical Questioning, Technology Forecasting and S Curve, Customer Needs and Satisfaction, Customer Needs - Types and Models, tools for Gathering Customer Needs, Customer Population and Market Segmentation.

Unit 3: Product Development from Concept to Product Function **6 Hrs**

Product information gathering, brainstorming and lateral thinking, morphological analysis of product, generating concepts, concept selection - design evaluation, estimation of technical feasibility, concept selection process, Pugh's concept, selection charts, concept scoring, process of concept embodiment,

system modeling, functional modeling and decomposition, fast method, subtract and operate procedure, Simulation driven design.

Unit 4: Reverse Engineering **6 Hrs**

Product Teardown Process, Tear Down Methods, Force Flow Diagrams, Measurement and Experimentation, Applications of Product Teardown, Benchmarking Approach and Detailed Procedure, Tools Used in Benchmarking Indented Assembly Cost Analysis, Function -Form Diagrams, Trend Analysis, Setting Product Specifications, Introduction to Product Portfolio and Architecture.

Unit 5: Design for X **6 Hrs**

Design for manufacture, Design for assembly, Design for robustness, Design for safety, Design for reliability, Design for environment, Design for piece part production, manufacturing cost analysis. Local, Regional and Global issues, basic life cycle assessment - basic method, weighed sum assessment method (Numerical), Design Failure mode effect analysis.

Unit 6: Product Life Cycle Management and Product Data Management **6 Hrs**

Introduction, Concept of Product Life Cycle management, Components/Elements of PLM, Customer Involvement, Product Data and Product Workflow, The Link Between Product Data and Product Workflow, Different Phases of Product Life Cycle and corresponding technology.

Books

Text :

1. K. Chitale; R.C. Gupta, Product Design and Manufacturing, Prentice Hall India.
2. Dieter George E., Engineering Design McGraw Hill Pub. Company, 2000.

References :

1. Kevin Otto and Kristin Wood, Product Design: Techniques in Reverse Engineering and New Product Development, Pearson Education Inc.
2. Grieves, Michael, Product Lifecycle Management McGraw Hill
3. Bralla, James G., Handbook of Product Design for Manufacturing, McGraw Hill Pub.
4. Karl Ulrich, product design and development, TMH.

Savitribai Phule Pune University
Final Year of Mechanical Engineering (2015 Course)

Course Code : 402051 **Course Name : Project – II**

Teaching Scheme:		Credits		Examination Scheme:		
Theory	: --	TH	: --	Theory	In-Sem : --	PR : --
Practical	: 12 hrs per week	TW	: 06		End-Sem : --	OR : 100
						TW : 100

Course Contents

INSTRUCTIONS FOR PROJECT REPORT WRITING

It is important that the procedures listed below be carefully followed by all the students of B.E. (Mechanical Engineering).

1. Prepare ***Three Hard Bound Copies*** of your manuscript.
2. Limit your Dissertation report to *80– 120* pages (preferably)
3. The *footer must include* the following:
   Institute Name, B.E. (Mechanical) Times New Roman 10 pt. and centrally aligned.
4. Page number as second line of footer, Times New Roman 10 pt. centrally aligned.
5. Print the manuscript using
   a) Letter quality computer printing.
   b) The main part of manuscript should be Times New Roman 12 pt. with alignment - justified.
   c) Use 1.5 line spacing.
   d) Entire report shall be of 5- 7 chapters
6. Use the paper size 8.5'' × 11'' or A4 (210 × 197 mm). Please follow the margins given below.

Margin Location	Paper 8.5'' × 11''	Paper A4 (210 × 197 mm)
Top	1''	25.4 mm
Left	1.5''	37 mm
Bottom	1.25''	32 mm
Right	1''	25.4mm

7. All paragraphs will be 1.5 lines spaced with a one blank line between each paragraph. Each paragraph will begin with without any indentation.
8. Section titles should be bold with 14 pt. typed in all capital letters and should be left aligned.
9. Sub-Section headings should be aligning at the left with 12 pt. bold and Title Case (the first letter of each word is to be capitalized).
10. Illustrations (charts, drawings, photographs, figures) are to be in the text. Use only illustrations really pertinent to the text. Illustrations must be sharp, clear, black and white. Illustrations downloaded from internet are not acceptable.
    a) Illustrations should not be more than two per page. One could be ideal
    b) Figure No. and Title at bottom with 12 pt.
    c) Table No. and Title at top with 12 pt.
    d) Legends below the title in 10 pt.
    e) Leave proper margin in all sides

f) Illustrations as far as possible should not be photo copied.

11. Photographs if any should be of glossy prints
12. Please use SI system of units only.
13. Please number the pages on the front side, centrally below the footer
14. References should be either in order as they appear in the thesis or in alphabetical order by last name of first author
15. Symbols and notations if any should be included in nomenclature section only
16. Following will be the order of report
    i. Cover page and Front page (*as per the specimen on separate sheet*)
    ii. Certificate from the Institute (*as per the specimen on separate sheet*)
    iii. Acknowledgements
    iv. Contents
    v. List of Figures
    vi. List of Tables
    vii. Nomenclature
    viii. Abstract (A brief abstract of the report not more than 150 words. The heading of abstract i.e. word "Abstract" should be bold, Times New Roman, 12 pt and should be typed at the center. The contents of abstract should be typed on new line without space between heading and contents. Try to include one or two sentences each on motive, method, key-results and conclusions in Abstract

    1. Introduction (2-3 pages) (TNR – 14 Bold)
        1.1 Problem statement (TNR – 12)
        1.2 Objectives
        1.3 Scope
        1.4 Methodology
        1.5 Organization of Dissertation

    2. Literature Review (20-30 pages)
    Discuss the work done so far by researchers in the domain area and their significant conclusions. No derivations, figures, tables, graphs are expected.

    3. This chapter shall be based on your own simulation work (Analytical/ Numerical/FEM/CFD) (15- 20 pages)

    4. Experimental Validation - This chapter shall be based on your own experimental work (15-20 pages)

    5. Concluding Remarks and Scope for the Future Work (2-3 pages)
    References ANNEXURE (if any) (Put all mathematical derivations, Simulation program as Annexure)
17. All section headings and subheadings should be numbered. For sections use numbers 1, 2, 3, … and for subheadings 1.1, 1.2, …. etc and section subheadings 2.1.1, 2.1.2, …. etc.
18. References should be given in the body of the text and well spread. No verbatim copy or excessive text from only one or two references. If figures and tables are taken from any reference then indicate source / citation of it. Please follow the following procedure for references

<u>Reference Books</u> :

Collier, G. J. and Thome, J. R., Convective boiling and condensation, 3rd ed., Oxford

University Press, UK, 1996, pp. 110 – 112.

Papers from Journal or Transactions :
Jung, D. S. and Radermacher, R., Transport properties and surface tension of pure and mixed refrigerants, *ASHRAE Trans*, 1991, 97 (1), pp. 90 – 98.
Bansal, P. K., Rupasinghe, A. S. and Jain, A. S., An empirical correction for sizing capillary tubes, *Int. Journal of Refrigeration*, 1996, 19 (8), pp.497 – 505.

Papers from Conference Proceedings :
Colbourne, D. and Ritter, T. J., *Quantitative assessment of flammable refrigerants in room air conditioners*, Proc. of the Sixteenth International Compressor Engineering Conference and Ninth International Refrigeration and Air Conditioning Conference, Purdue University, West Lafayette, Indiana, USA, 2002, pp. 34 – 40.

Reports, Handbooks etc. :
United Nations Environmental Programme, Report of the Refrigeration, Air Conditioning and Heat Pumps, Technical Option Committee, 2002, Assessment - 2002.
ASHRAE Handbook: Refrigeration, 1994 (Chapter 44)

Patent :
Patent no, Country (in parenthesis), date of application, title, year.

Internet :
www.(Site) [Give full length URL] *accessed on date*

A Project Report on
(TNR, 16pt, centrally aligned)

Title of the Project Report

(TNR, 27pt, Bold, Centrally Aligned, Title Case)

By
(TNR, 16pt, Centrally Aligned)

Mr. Student's 1 Name
(TNR, 16pt, Centrally Aligned)

Mr. Student's 2 Name
(TNR, 16pt, Centrally Aligned)

Mr. Student's 3 Name
(TNR, 16pt, Centrally Aligned)

Mr. Student's 4 Name
(TNR, 16pt, Centrally Aligned)

Guide
Guide's Name
(TNR, 16pt, Centrally Aligned)

Institute Logo

Department of Mechanical Engineering
Name of the Institute

[2018-19]

(TNR, 22pt, Title Case Centrally Aligned)

Name of the Institute

Institute Logo

C E R T I F I C A T E

This is to certify that ***Mr. (Name of the Student)***, has successfully completed the Project Stage – I entitled "(***Title of the Project)***" under my supervision, in the partial fulfillment of Bachelor of Engineering - Mechanical Engineering of University of Pune.

Date:

Place:

Guide's Name
Guide

Internal Examiner

HoD Name
Head of the Department

Principal Name
Principal

External Examiner

Seal