Savitribai Phule Pune University

Structure and Syllabus

FOR

B.E. Mechanical Engineering
2012 Course

UNDER FACULTY OF ENGINEERING

EFFECTIVE FROM June 2015

B. E. (Mechanical) Semester – I

(w. e. f. Academic year 2015 - 16)

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme(Marks)					
		Lect.	Tut	Practical	In-Sem	End-Sem	TW	PR+	OR+	Total
402041	Refrigeration and Air Conditioning	3	--	2	30	70	25	--	50	175
402042	CAD/ CAM Automation	3	--	2	30	70	--	50	--	150
402043	Dynamics of Machinery	4	--	2	30	70	25	--	50	175
402044	Elective – I	3	--	--	30	70	--	--	--	100
402045	Elective –II	3	--	--	30	70	--	--	--	100
402046	Project –I	--	2	--	--	--	50*	--	--	50
Total of Semester – I		16	2	6	150	350	100	50	100	750

B. E. (Mechanical) Semester – II

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme(Marks)					
		Lect.	Tut	Practical	In-Sem	End-Sem	TW	PR+	OR+	Total
402047	Power Plant Engineering	4	--	2	30	70	25	--	50	175
402048	Mechanical System Design	4	--	2	30	70	--	--	50	150
402049	Elective-III	4	--	--	30	70	--	--	--	100
402050	Elective- IV	4	--	2	30	70	25	--	--	125
402051	Project – II	--	6	--	--	--	150	--	50	200
Total of Semester – II		16	6	6	120	280	200	--	150	750

+ For all Oral/Practical heads: Examination will be based on term work and Theory Subject

* Assessment should be carried out by panel of examiners from same Institute

	Elective-I			Elective-II	
Code	Subject		Code	Subject	
402044 A	Energy Audit Management		402045 A	Gas Turbine Propulsion	
402044 B	Tribology		402045 B	Product Design and Development	
402044 C	Reliability Engineering		402045 C	Operation Research	
402044 D	Machine Tool Design		402045 D	Advanced Manufacturing Processes	
	Elective-III			Elective-IV	
Code	Subject		Code	Subject	
402049 A	Refrigeration and Air Conditioning Equipment Design		402050 A	Computational Fluid Dynamics	
402049 B	Robotics		402050 B	Finite Element Analysis	
402049 C	Industrial Engineering		402050 C	Design of Pumps, Blowers and Compressors	
402049 D	Open Elective **				

**: Open Elective – Board of studies (BoS) - Mechanical 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 – III under engineering faculty or individual college and Industry can define new elective with proper syllabus using defined framework of Elective III and GET IT APPROVED FROM BOARD OF STUDIES AND OTHER NECESSARY STATUTORY SYSTEMS IN THE SAVITRIBAI PHULE PUNE UNIVERSITY (Formally UNIVERSITY OF PUNE) BEFORE 30th NOVEMBER. Without approval from University statutory system, no one can introduce the open elective in curriculum.

(402041) Refrigeration and Air Conditioning

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402041	Refrigeration and Air Conditioning	3	---	2	30 (1 hr)	70 (2 ½ hrs)	25	---	50	175

Prerequisite: Basic Thermodynamics- Laws of thermodynamics, Ideal gas processes, Thermodynamic cycles, Properties of pure substance, Mollier Charts, Fluid properties, Fluid dynamics, Modes of heat transfer, Governing Equations in Heat Transfer, Extended Surfaces, Condensation and Boiling, Heat Exchangers.

Course Objectives
- Learning the fundamental principles and different methods of refrigeration and air conditioning.
- Study of various refrigeration cycles and evaluate performance using Mollier charts and/ or refrigerant property tables.
- Comparative study of different refrigerants with respect to properties, applications and environmental issues.
- Understand the basic air conditioning processes on psychrometric charts, calculate cooling load for its applications in comfort and industrial air conditioning.
- Study of the various equipment-operating principles, operating and safety controls employed in refrigeration air conditioning systems

Course Outcomes: At the end of this course the students should be able to
- Illustrate the fundamental principles and applications of refrigeration and air conditioning system
- Obtain cooling capacity and coefficient of performance by conducting test on vapor compression refrigeration systems
- Present the properties, applications and environmental issues of different refrigerants
- Calculate cooling load for air conditioning systems used for various applications
- Operate and analyze the refrigeration and air conditioning systems.
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Unit 1: Fundamentals and Applications of Refrigeration and Air Conditioning   8 hrs
Fundamentals
Reverse Carnot cycle, block diagram of refrigerator & heat pump (numerical), modified reverse Carnot cycle (Bell Coleman cycle)
Applications
Domestic Refrigerator, Domestic Air Conditioners, Automotive Air Conditioners, Evaporative coolers, water coolers, Commercial Refrigeration- Dairy, Cold storage, Ice plant, Commercial Air Conditioning- Multiplex, Hospitals.

Unit 2: Refrigerants and Vapour Compression Cycle   8 hrs
Refrigerants
Classification of refrigerants, Desirable properties of refrigerants, environmental issues, Ozone depletion and global warming, ODP, GWP & LCCP, selection of environment friendly refrigerants, secondary refrigerants, anti-freeze solutions, Zeotropes and Azeotropes, refrigerant: recovery reclaims, recycle and recharge.

Vapour Compression Cycle
Working of simple vapour compression system, representation of vapour compression cycle (VCC) on T-s and P-h diagram, COP, EER, SEER, IPLV, NPLV, effect of operating parameters on performance of VCC, actual VCC, methods of improving COP using flash chamber, sub-cooling, liquid vapour heat exchanger, comparison of VCC with Reverse Carnot cycle,.

Unit 3: Refrigeration Systems	8 hrs

Vapour compression systems
Single stage, two stage and cascade VCC systems using single and multi evaporators

Vapour absorption systems
Introduction, Working of simple vapour absorption system (VAS), desirable properties of binary mixture (aqua-ammonia), performance evaluation of simple VAS (simple numerical treatment), actual VAS, Li-Br absorption system, three fluid system (Electrolux refrigeration), applications of VAS, comparison between VCC and VAC.

Unit 4: Psychrometry and Air conditioning	8 hrs

Introduction to air conditioning, psychrometry, psychrometric properties and terms, psychrometric relations, Psychrometric processes and its representation on psychrometric chart, BPF of coil, ADP, adiabatic mixing of two air streams, SHF, RSHF, GSHF, ESHF.
Thermodynamics of human body, comfort and comfort chart, factors affecting human comfort, concept of infiltration and ventilation, indoor air quality requirements, factors contributing to cooling load.

Unit 5 Air Conditioning Systems	8 hrs

Working of summer, winter and all year round AC systems, all air system, all water system, air water system, variable refrigerant flow and variable air volume systems, unitary and central air conditioning.

Components of refrigeration and air conditioning systems
Working of reciprocating, screw and scroll compressors, Working of air cooled, water cooled and evaporative condensers, Working of DX, Flooded, Forced feed evaporators, Expansion devices – Capillary tube, TXV, EXV, operating and safety controls.

Unit 6: Air Distribution Systems	8 hrs

Air handling unit, Classification of ducts, duct material, pressure in ducts, flow through duct, pressure losses in duct (friction losses, dynamic losses), air flow through simple duct system, equivalent diameter, methods of duct system design: equal friction, velocity reduction, static regain method (numerical on duct system design)
Fan coil unit, types of fans used air conditioning applications, fan laws, filters, supply and return grills, sensors (humidity, temperature, smoke).

Term work:
The term work shall consist of minimum eight experiments out of the following:
1) Test on Domestic Refrigerator for evaluation of EER
2) Test on vapour compression test rig
3) Test on air conditioning test rig
4) Test on ice plant test rig
5) Visit to Vapour absorption refrigeration plant
6) Estimation of cooling load of simple air conditioning system (case study)
7) Case study on cold storage
8) Visit to any air conditioning plant
9) Thermal analysis of refrigeration cycle using suitable software
10) Installation and servicing of split air conditioner

Text Books
1. Arora C. P., Refrigeration and Air Conditioning, Tata McGraw-Hill
2. Manohar Prasad, Refrigeration and Air Conditioning, Willey Eastern Ltd, 1983
3. McQuiston, " Heating Ventilating and air Conditioning: Analysis and Design" 6th Edition, Wiley India
4. Arora and Domkundwar, Refrigeration & Air Conditioning, Dhanpatrai & Company, New Delhi
5. Khurmi R.S. and Gupta J.K., Refrigeration and Air conditioning, Eurasia Publishing House Pvt. Ltd, New Delhi,1994.
6. Ballaney P.L., Refrigeration and Air conditioning, Khanna Publishers, New Delhi, 1992

Reference books

1. Dossat Ray J, Principles of refrigeration, S.I. version, Willey Eastern Ltd, 2000
2. Stockers W.F and Jones J.W., Refrigeration and Air conditioning, McGraw Hill International editions 1982.
3. Threlkeld J.L, Thermal Environmental Engineering, Prentice Hall Inc., New Delhi
4. Aanatnarayan, Basics of refrigeration and Air Conditioning, Tata McGraw Hill Publications
5. Roger Legg, Air Conditioning System Design, Commissioning and Maintenance
6. ASHRAE & ISHRAE handbook

(402042) CAD/CAM and Automation

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402042	CAD /CAM and Automation	3	---	2	30 (1 hr)	70 (2 ½ hrs)	---	50	---	150

Pre-requisite: Engineering Graphics, Machine drawing, Manufacturing processes, SOM.

Course Objectives: To teach students
- Basics of modelling.
- Discuss various geometries.
- Discretization of the solid model.
- Apply Boundary Conditions similar to real world.
- Generate solution to ensure design can sustain the applied load conditions.
- Discuss latest manufacturing methods.

Course Outcomes: After completion of the course students would be able to,
- Analyze and design real world components
- Suggest whether the given solid is safe for the load applied.
- Select suitable manufacturing method for complex components.

Unit 1: Computer Graphics   8 hrs
Computer Graphics Module, Transformations-Introduction, Formulation, Translation, Rotation, Scaling and Reflection. Homogenous Representation, Concatenated Transformation, Mapping of Geometric Models, Inverse Transformations. Projections: Orthographic and Isometric.

Unit 2: Modelling   8 hrs
Curves-Introduction, Analytic Curves - Line, Circle, Ellipse,Parabola, Hyperbola.Synthetic Curves - Hermite Cubic Spline, Bezier Curve, B-Spline Curve. Numericals on Line, Circle, Ellipse and Hermite Cubic Spline
Surfaces-Introduction, Surface Representation, Analytic Surfaces, Synthetic Surfaces, Hermite bicubic Surface, Bezier surfaces, B-spline Surfaces, Coons Surface [No analytical treatment].
Solids: Introduction, Geometry and Topology, Solid Representation, Boundary Representation, Euler's equation, Constructive Solid Geometry, Boolean operation for CSG, Hybrid Modeling, Feature Based Modeling, Parametric Modeling, Constraint Based Modeling, Mass, area, volume calculation.

Unit 3: Finite Element Analysis   10 hrs
Introduction, Stress and Equilibrium, Boundary Condition, Strain – Displacement Relations, Stress-Strain Relation, Potential Energy and Equilibrium: - Rayleigh-Ritz Method, Galerkin's Method.
One Dimensional Problem: Finite Element Modelling, Coordinate and Shape function, Potential Energy Approach, Galerkin Approach, Assembly of Global Stiffness Matrix and Load Vector, Properties of Stiffness Matrix, Finite Element Equations, Quadratic Shape Function, Temperature Effects .
Trusses: Introduction, 2D Trusses, Assembly of Global Stiffness Matrix.

Unit 4: Computer Aided Manufacturing   8 hrs
Introduction to Computer Aided Manufacturing.CNC Programming-CNC part programming adaptable to FANUC controller. Steps in developing CNC part program.CNC part programming for Lathe Machine – Threading & Grooving cycle(Canned cycle). CNC part programming for Milling Machine - Linear & circular interpolation, milling cutter, tool length compensation & cutter radius compensation. Pocketing, contouring & drilling, subroutine and Do loop using canned cycle.

Unit 5: Advanced Manufacturing Method – Rapid Prototyping   8 hrs

Introduction to Rapid Prototyping, classification of RP Processes, Working principle, models & specification process, application, advantages & disadvantages & case study of

- Stereo Lithography Apparatus (SLA)
- Laminated Object Manufacturing (LOM)
- Selective Laser Sintering (SLS)
- 3D Printing.
- Fused Deposition Modeling [FDM]

Rapid Tolling and STL format.

Unit 6: Robotics & Automation	8 hrs

Structure of Robotic System - Point to point & continuous path robotic systems, Joints, End Effectors, Grippers - Mechanical, Magnetic and Pneumatic. Drives, Controllers, Industrial Applications.

Types of Automation - Automation strategies, Group Technology & Coding Methods, Flexible Manufacturing System – Types, Advantages, Limitations. Computer Integrated Manufacturing and Computer Aided Process Planning.

Term Work: The term work shall consist of record of ten assignments based on the following topics:
1. Program on concatenated Transformation involving Three steps.
2. Stress and Deflection Analysis of 2D truss.
3. Stress and Deflection Analysis of Beam.
4. Stress and deflection analysis of plate 2D/3D.[Mechanical Component]
5. Tool path generation for Turning – Grooving and Threading.
6. Tool path generation for Milling – Facing, Pocketing, Contouring and Drilling.
7. Tool path generation of Turn Mill.
8. Tool path generation for Multi Axis Machining.
9. Robot simulation/Robot Gripper Design.
10. Case study on R.P.

Reference Books
1. Ibrahim Zeid and R. Sivasubramanian - CAD/CAM - Theory and Practice Tata McGraw Hill Publishing Co. 2009
2. Ibraim Zeid, "Mastering CAD/CAM" – Tata McGraw Hill Publishing Co. 2000
3. Chandrupatla T.R. and Belegunda A.D. -Introduction to Finite Elements in Engineering" - Prentice Hall India.
4. Segerling L.J. - Applied Finite Elements Analysis" John Wiley and Sons.
5. Rao P.N., Introduction to CAD/CAM Tata McGraw Hill Publishing Co.
6. Groover M.P.-Automation, production systems and computer integrated manufacturing' - Prentice Hall of India
7. YoramKoren - Robotics McGraw Hill Publishing Co.
8. James G. Keramas, Robot Technology Fundamentals, Delmar Publishers.
9. S.R.Deb, Robotics Technology and Flexible Automation, Tata McGraw Hill.
10. Lakshiminarayana H. V. Finite Element Analysis (Procedures in Engineering), University Press, 2004.
11. Chandrupatla T. R., Finite Element Analysis for Engineering and Technology, University Press, 2009.
12. Seshu P. Text book of Finite Element Analysis, PHI Learning Private Ltd. New Delhi, 2010.
13. Ian Gibson, David W. Rosen, and Brent Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer.

(402043) Dynamics of Machinery

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402043	Dynamics of Machinery	4	---	2	30 (1 hr)	70 (2 ½ hrs)	25	--	50	175

Prerequisites: Engg. Mechanics, TOM- I and TOM-II

Course Objectives
- To conversant with balancing problems of machines.
- To make the student conversant with fundamentals of vibration and noise.
- To develop competency in understanding of vibration and noise in Industry.
- To develop analytical competency in solving vibration problems.
- To make the student conversant with natural frequencies, Eigen values & Eigen vectors.
- To understand the various techniques of measurement and control of vibration and noise.

Course Outcomes
- Solutions to balancing problems of machines.
- Ability to understand the fundamentals of vibration and Noise.
- Ability to develop analytical competency in solving vibration problems.
- Ability to understand measurement and control of vibration and noise.
- Ability to calculate natural frequencies, Eigen values & Eigen vectors.
- Ability to measure vibrations, vibration characteristics and understand various methods for vibration control for real life problem.

Unit 1 : 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 2: 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, types of vibration, natural frequency, equivalent springs, modeling of a system, formulation of equation of motion by equilibrium and energy methods.
Undamped free vibrations: Natural frequency for longitudinal, transverse and torsional vibratory systems.
Damped free vibrations: Different types of damping, free vibrations with viscous damping - over damped, critically damped and under damped systems, initial conditions, logarithmic decrement, introduction to equivalent viscous damping, dry friction or coulomb damping - frequency and rate of decay of oscillations.

Unit 3: Single Degree of Freedom Systems - Forced Vibrations   8 hrs
Forced vibrations of longitudinal and torsional systems, Frequency Response to harmonic excitation, excitation due to reciprocating and rotating unbalance, base excitation, magnification factor, resonance phenomenon and phase difference, Quality Factor. Critical speed of shaft having single rotor of undamped systems.

Unit 4: Two Degree of Freedom Systems - Undamped Vibrations   8 hrs
Free vibration of spring coupled systems – longitudinal and torsional, natural frequency and mode shapes, Eigen value and Eigen vector by Matrix method, Geared systems. Introduction to Physical and Mathematical modeling: Bicycle, Motor bike and Quarter Car.

Unit 5: Measurement and Control of Vibration   8 hrs

Force and Motion transmissibility, Vibration Measuring devices, Accelerometers, Impact hammer, Vibration shaker-Construction, principles of operation and uses, Vibration Analyzer, Analysis of Vibration Spectrum, Standards related to measurement of vibration and accepted levels of vibration
Introduction to control of vibration, vibration control methods, passive and active vibration control, reduction of excitation at the source, control of natural frequency, Vibration isolators, Tunned Dynamic Vibration Absorbers, Introduction to Torsional Damper

Unit 6: Introduction to Noise   8 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, pass-by-noise, Reverberation chamber, Anechoic Chamber, Human Exposure to Noise and Noise standards.

List of Experiments:

The Term Work shall consist of *Eight Experiments and Two Assignments* of following list.

A] Compulsory Experiments (Sr. No. 1 to 5)
1. Balancing of wheel / rotor on computerized balancing machine OR Demonstration of wheel balancing during a visit to industry / workshop.
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 determine natural frequency of transverse vibration of beam using vibration analyzer.
5. Noise measurement and analysis using vibration Analyzer.

B] Any Three Experiments from the following-
1. To determine critical speed of shaft with single rotor.
2. To verify natural frequency of torsional vibration of two rotor system and position of node .
3. Experimental verification of principle of dynamic vibration absorber.
4. Experiment on shock absorbers and to plot its characteristic curve.
5. Analysis of machine vibration signature, using any analysis software package.

C] Compulsory Assignments
1. Determination of free response of SDOF damped system to demonstrate different damping conditions using suitable software.
2. Determination of total response of SDOF damped system to harmonic excitation using suitable software

Text Books

1. Rao S. S. "Mechanical Vibrations", Pearson Education Inc. New Delhi.
2. Grover G. K. "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

Reference Books

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. Dr Debabrata Nag, " Mechanical Vibrations", Wiley India Pvt. Ltd, New Delhi.
5. Kelly S. G. "Mechanical Vibrations", Schaum's outlines, Tata McGraw Hill Publishing Co. Ltd., New Delhi.

6. Meirovitch, "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, NewDelhi.

(402044A) Energy Audit and Management (Elective I)

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402044 A	Energy Audit and Management	3	---	--	30 (1 hr)	70 (2 ½ hrs)	--	--	--	100

Pre-Requisites: Economics, Basic Thermodynamics.

Course Objectives: Following concepts to be taught to the students,
- Importance of Energy Management.
- How to carry out Energy Audit.
- Methods to reduce consumption of energy and save cost.
- How to improve energy efficiency of overall system.
- Significance of Waste heat recovery and Cogeneration.

Course Outcomes: After successful completion of the course student would be able to,
- Carry out Energy Audit of there residence / society / college where they are studying.
- Carry out electrical tariff calculation and accurately predict the electricity bill required for the installation.
- Suggest various methods to reduce energy consumption of the equipment / office / premises.
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Unit 1: General Aspects of Energy Management   8 hrs
Current energy scenario - India and World, Current energy consumption pattern in global and Indian industry, Principles of Energy management, Energy policy, Energy action planning, Energy security and reliability, Energy and environment, Need of Renewable and energy efficiency.

Unit 2: Energy Auditing   10hrs
Need of Energy Audit, Types of energy audit, Components of energy audit, Energy audit methodology, Instruments, equipment used in energy audit, Analysis and recommendations of energy audit - examples for different applications, Energy audit reporting, Energy audit software. Energy conservation opportunities in Boiler and steam system, Furnace, DG sets, HVAC system, pumping system, Cooling tower and Compressed air system.

Unit 3: Energy Economics   8 hrs
Costing of Utilities- Determination of cost of steam, natural gas, compressed air and electricity. Financial Analysis Techniques - 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   10 hrs
Energy performance assessment and efficiency improvement of Boilers, Furnaces, Heat exchangers, Fans and blowers, pumps, Compressors and HVAC systems. Steam distribution, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system.

Unit 5: Electrical Energy Management and Lighting   8 hrs
Electricity billing, Electrical load management and maximum demand control, Power factor improvement and its benefit, Selection and location of capacitors, Distribution and transformer losses. Electrical motors- types, efficiency and selection. Speed control, Energy efficient motors. Electricity Act

2003. Lighting - Lamp types and their features, recommended illumination levels, lighting system energy efficiency.

Unit 6: Cogeneration and Waste Heat Recovery	8 hrs

Cogeneration- Need, applications, advantages, classification, the cogeneration design process. Waste heat recovery- Classification and application, Potential for waste-heat recovery in Industry, Commercial WHR devices, saving potential. CDM projects and carbon credit calculations.

Reference Books:

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
7. http://www.bee-india.nic.in

(402044B) Tribology (Elective I)

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402044 B	Tribology	3	---	--	30 (1 hr)	70 (2 ½ hrs)	--	--	--	100

Pre-Requisites: TOM-I, TOM-II and Machine design.

Course Objectives: After successful completion of this course, students will be able-
- To know about properties of lubricants, modes of lubrication, additives etc.
- To Select suitable/proper grade lubricant for specific application.
- To select suitable material combination for tribological contact.
- To Apply the basic theories of friction, wear and lubrications about frictional behavior commonly encountered sliding surfaces.
- To suggest an explanation to the cause of tribological failures.
- To design bearing, friction, wear test rig for laboratory purposes.

Course Outcomes
- For these simplified course contents, student develops confidence in him/her to fulfill course objectives.
- Term work includes simple case study/assignment/seminar/visit and in-semester theory examination as a part of learning process encourages students.
- He/she proves himself/herself to be excellent practical engineer in any tribological industry.
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Unit 1: Introduction   8 hrs
1. Tribology definition.
2. Tribology in design- bearing material its properties and construction Tribological design of oil seals and gasket.
3. Tribology in industry (Maintenance).
4. Lubrication-Definition, basic modes of lubrication, properties of lubricants, additives, EP lubricants, Recycling of used oil, oil conservation, oil emulsion.
5. Bearing Terminology-Types of Sliding contact, rolling contact bearings.
6. Comparison between sliding and rolling contact bearing. (Theoretical treatment only)

Unit 2: Friction and wear   8 hrs
1. Friction- Introduction, laws of friction, Friction classification, causes of friction.
2. Theories of dry friction.
3. Friction measurement.
4. Stick-slip motion and friction instabilities.
5. Wear-classification, wear between solids, wear between solid and liquids, factors affecting wear.
6. Theories of wear.
7. Wear measurement.
8. Approaches to friction control and wear prevention. (Numericals)

Unit 3: Hydrodynamic lubrication   10 hrs
1. Theory of hydrodynamic lubrication, mechanism of pressure development in oil film.
2. Two dimensional Reynold's equation and its limitations, Petroff`s equation.
3. Infinitely long journal bearing, infinitely short journal bearing and finite bearing, Designing journal bearing using Raimondi and Boyd approach.
4. Hydrodynamic thrust bearing-Introduction, types.
5. Flat plate thrust bearing-Pressure equation, load, centre of pressure, frictional force equation.

6. Tiltling pad thrust bearing- bearing-Pressure equation, load, centre of pressure, frictional force equation. (Numericals on Raimondi and Boyd approach and thrust bearing only)

Unit 4: Hydrostatic lubrication   8 hrs

1. Hydrostatic lubrication-Basic concept, advantages, limitations, viscous flow through rectangular slot, load carrying capacity, flow requirement of hydrostatic step bearing, energy losses, optimum design of stepped bearing, compensators and their actions.
2. Squeeze film lubrication- Basic concept, circular and rectangular plate approaching a plane (Numericals on hydrostatic bearing, Squeeze film lubrication).

Unit 5: Elasto-hydrodynamic lubrication and Gas (air) lubrication   8 hrs

1. Elasto-hydrodynamic lubrication-Principle and applications, pressure viscosity term in Reynold's equation, Hertz theory, Ertel-Grubin equation, lubrication of spheres.
2. Gas(air) lubricated bearings-Introduction, advantages, disadvantages, applications of tilting pad bearing, hydrostatic and hydrodynamic bearing with air lubrication, Active and passive magnetic bearings(working principle, types and advantages over conventional bearing). (Theoretical treatment only)

Unit 6: Tribological Aspects   10 hrs

1. Lubrication in rolling, forging, drawing and extrusion.
2. Mechanics of tyre road interaction, road grip, wheel on rail road.
3. Surface engineering for wear and corrosion resistance-diffusion, plating and coating methods, selection of coatings, properties and parameters of coatings.
4. Other bearings-porous bearing, foil bearing, Lobe, hybrid bearing. (Theoretical treatment only)

Reference Books

1. Cameron A., "Basic Lubrication Theory", Wiley Eastern Ltd.
2. Bharat Bhushan, "Principles and Applications of Tribology" 2nd Edition, Wiley India
3. Mujumdar B. C., "Introduction to Tribology and Bearings", S. Chand and Company Ltd. New Delhi.
4. Fuller D. D., "Theory and Practice of Lubrication for Engineers", John Wiley and Sons.
5. Halling J., "Principles of Tribology", McMillan Press Ltd.
6. Bhushan B. and Gupta B. K., " Handbook of Tribology: Material, Coatings and Surface Treatments", McGraw Hill Ltd.
7. Davis J., "Surface Engineering for Corrosion and Wear Resistance", Woodhead Publishing, 2001.
8. Tadausz Burakowski, "Surface Engineering of Metals: Principles, Equipments and Technologies", Taylor and Francis.

(402044C) Reliability Engineering (Elective I)

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402044 C	Reliability Engineering	3	---	--	30 (1 hr)	70 (2 ½ hrs)	--	--	--	100

Pre-Requisites: Engineering Mathematics, Probability, Statistics.

Course Objectives: To teach students,
- Understanding of basic principles of Reliability for ensuring sustainable product design.
- Application to system requirements, design, manufacturing and testing, with real-world examples.
- Understand in detail Asset Management, Maintenance, Quality and Productiveness,

Course Outcomes: After completion of the course students would be able to,
- Understand and analyze different methods of failure.
- Calculate MTTF, MTBF, failure rate and hazard rate.
- Different probability methods applied to Reliability.
- Optimize Cost & reliability.
- Perform FEMA, FMECA, DOE, Taguchi method.
- Different methods to test reliability.
-

Unit 1: Fundamental concepts of Reliability   8 hrs
Reliability terminologies, Role of the reliability function in the organization, Interrelationship of safety, quality and reliability, life characteristic phases, Product liability-Significance, importance of reliability, Introduction to maintainability, availability.
Concepts of Failure, failure density, failure Rate, hazard rate, pdf, cdf. Modes of failure, Mean Time To Failure (MTTF), Mean Time Between Failure (MTBF), Numericals based on calculation of failure rate, hazard rate.
Warranty Management and Life cycle cost.

Unit 2: Probability Concepts and System Reliability   10 hrs
Basic probability concepts, Laws of probability, Introduction to independence, mutually exclusive, conditional probability, Discrete and continuous probability distributions, Comparison of probability distributions -binomial, normal, lognormal, Poisson, Weibull, exponential,
Standard deviation, variance, mean, mode and Central Limit Theorem.
Analysis of series, parallel, mixed configurationsystems ,Concept of k- out of n structure, Conditional probability method, delta-star method for conditional probability analysis, Tie-set and Cut Set method (Concepts and Numericals).

Unit 3: System reliability Analysis   8 hrs
Reliability Improvement- Redundancy, element redundancy, unit redundancy, standby redundancy-types of stand by redundancy, parallel components single redundancy, multiple redundancies (Numericals).
Introduction to Reliability allocation or apportionment, reliability apportionment techniques - equal apportionment, AGREE, ARINC, Minimum effort method (Numericals).

Unit 4: Reliability Management   8 hrs
Objectives of maintenance, types of maintenance, Maintainability, factors affecting maintainability, system down time, availability - inherent, achieved and operational availability (Numerical treatment).
Introduction to Reliability Centered Maintenance.

Design for maintainability and its considerations, Reliability and costs, Costs of Unreliability, Standards for Reliability-MIL Handbook 217F & Carderock Model. Technology aspects in Reliability Management, BIT (Built in testing).

Unit 5: Reliability in Design & Development	8 hrs

Reliability techniques- Failure mode, effects analysis (FMEA),Failure mode, effects and criticality analysis (FMECA)-Case Studies, Basic symbols, Fault Tree construction and analysis, Monte Carlo Simulation.
Introduction to Design of Experiments (DOE) and Taguchi Method.
Human factors in design and design principles.

Unit 6: Reliability Testing	8 hrs

Introduction to reliability testing, Stress strength interaction, Introduction to Markov model
Testing for Reliability and Durability- Accelerated Life Testing and Highly Accelerated Life Testing (HALT), highly accelerated stress Screening (HASS).
Reliability in manufacturing- Production FRACAS.
Reliability Data- Acquisition &graphical analysis.

Reference Books
1. Kapur, " Reliability in engineering Design", Wiley india
2. Chandrupatla, " Quality and Reliability in Engineering" Cambridge Uni. Press, India
3. S S. Rao, Reliability Based Design, McGraw Hill Inc. 1992
4. L.S.Srinath, Reliability Engineering, EWP , 4th Edition 2011
5. Bryan Dodson, Dennis Nolan, Reliability Engineering Handbook, Marcel Dekker Inc, 2002
6. Basu S.K, Bhaduri , Terotechnology and Reliability Engineering, Asian Books Publication
7. Alessandro Birolini, Reliability Engineering Theory and Practice, Springer
8. R.M. Parkhi, Market Leadership by Quality and Reliability, Vidyanand Publications 2012
9. V.N.A. Naikan, Reliability Engineering and Life Testing, PHI Learning 2010
10. Charles E. Ebeling, Reliability and Maintainability Engineering, TMH 2009
11. Dr. Robert B. Abernathy, The New Weibull Handbook.

(402044D) Machine Tool Design (Elective I)

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402044 D	Machine Tool Design	3	---	--	30 (1 hr)	70 (2 ½ hrs)	--	--	--	100

Pre-requisite: Manufacturing Processes, TOM, Machine Design.

Course Objectives: It expected to teach following concepts to the students,
- Selection of suitable drive to run the system.
- Design of machine tools structures, guide-ways.
- Design of Spindle, power screws.
- Dynamics of machine tools.
- Special features of machine tool design.

Course Outcome: After completion of the course student will be able to,
- Design gear box.
- Design different machine tools considering static and dynamic loads.
- Understand effect of vibrations on life of machine tools.
- Understand design considerations for Special features in Machine tools.
-

Unit 1: Drives   **10 hrs**
Design considerations for drives based on continuous and intermittent requirement of power, Types and selection of motor for the drive, Regulation and range of speed based on preferred number series, geometric progression. Design of speed gear box for spindle drive and feed gear box.

Unit 2: Design of Machine Tool Structure   **8 hrs**
Analysis of forces on machine tool structure, static and dynamic stiffness. Design of beds, columns, housings, bases and tables.

Unit 3: Design of Guide-ways   **8 hrs**
Functions and types of guide-ways, design criteria and calculation for slide-ways, design of hydrodynamic, hydrostatic and aerostatic slide-ways, Stick-Slip motion in slide-ways.

Unit 4: Design of Spindles, Spindle Supports and Power Screws   **10 hrs**
Design of spindle and spindle support using deflection and rigidity analysis, analysis of antifriction bearings, preloading of antifriction bearing. Design of power screws: Distribution of load and rigidity analysis.

Unit 5: Dynamics of Machine Tools   **8 hrs**
Dynamic characteristic of the cutting process, Stability analysis, vibrations of machine tools. Control Systems, Mechanical and Electrical, Adaptive Control System, relays, push button control, electrical brakes, drum control.

Unit 6: Special features in Machine Tool Design   **8 hrs**
Design considerations for SPM, NC/CNC, and micro machining, Retrofitting, Recent trends in machine tools, Design Layout of machine tool using matrices. Step-less drives Design considerations of Step-less drives, electromechanical system of regulation, friction, and ball variators, PIV drive, Epicyclic drive, principle of self locking,

Text Books

1. N.K. Mehta, "Machine Tool Design", Tata McGraw Hill, ISBN 0-07-451775-9.
2. Bhattacharya and S. G. Sen., "Principles of Machine Tool", New central book agency Calcutta, ISBN 81-7381-1555.
3. D. K Pal, S. K. Basu, "Design of Machine Tool", 4th Edition. Oxford IBH 2005, ISBN 81- 204-0968

Reference Books

1. N. S. Acherkan, "Machine Tool", Vol. I, II, III and IV, MIR publications.
2. F. Koenigsberger, "Design Principles of Metal Cutting Machine Tools", The Macmillan Company New York 1964

(402045A) Gas Turbine and Propulsion (Elective II)

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402045 A	Gas Turbine and Propulsion	3	---	--	30 (1 hr)	70 (2 ½ hrs)	--	--	--	100

Pre-requisites: Basic Thermodynamics, Fluid Mechanics, Turbo Machinery

Course Objectives
- Understand the thermodynamics of each component of a turbine engine which include inlets, fans, compressors, burners, turbines, afterburners and nozzles
- Know what the design variables are for each component
- Understand the linked system performance of all components in the engine and performance trends for each component
- Understand the basis for off-design performance

Course Outcome: At the end of this course the students should be able to
- Demonstrate the gas turbine power plant
- Illustrate the jet propulsion system
- Analyze the performance of gas turbine engine
- Present the technical details of compressors used in gas power systems

Unit 1: Introduction to Gas Turbine   **8 hrs**
Basic Mechanics, Simple Gas Turbine, Open cycle, closed cycles, single-shaft and twin-shaft arrangements, Combined and cogeneration cycle, Introduction to Aircraft propulsion and Rocket Propulsion(Principle, propellant and its properties), gas turbine design procedure, Environmental Issues, Industrial applications

Unit 2: Analysis of Shaft Power Cycles   **10hrs**
Idea Cycle: Assumption in ideal cycle, Simple Gas Turbine Cycle (Efficiency & Specific work), Heat Exchange Cycle, Reheat cycle, reheat Cycle with heat exchanger, intercooled compression Cycle with heat exchanger,
Practical Cycles: Methods of accounting for component losses—Stagnation properties, Compressor and Turbine Efficiencies, Polytrophic efficiency, Pressure Losses, Heat exchanger Effectiveness, Combustion efficiency Mechanical Losses, Variation of Specific Heat—Numerical on ideal cycle and considering all losses

Unit 3: Analysis of Propulsion Cycles   **8hrs**
Introduction to aircraft propulsion, Aircraft Intake, Nozzle and diffuser(Losses), criteria for performance, Thermodynamic analysis of turbojet engine, Thermodynamic analysis of turbofan engine, Thermodynamic analysis of turbo-prop engine, Parameter affecting the flight performance, thrust augmentation.

Unit 4: Axial Flow Turbine   **8hrs**
Concept of turbine - Cascade of Blade – Blade material, analysis of turbine stage - velocity triangles and characterization of blades and stages, utilization factor, Design of axial flow turbine - Performance analysis of turbines.

Unit 5: Axial Flow Compressor   **8hrs**
Basic operation (diffusion process), Cascade of Blade (Blade loading, Flow coefficient, blade and stage efficiency), compressor stage, Velocity triangle, Degree of reaction, work done factor, Factor affecting pressure ratio (losses),

Unit 6: Combustion System and Performance of Gas Turbine Engine   **8hrs**

Combustion system

Types of Combustion system, requirement of Combustion chamber, Combustion process in gas turbine, Factor effecting combustion chamber performance (pressure loss, combustion efficiency, outlet temperature distribution, stability limits and combustion intensity), Mixing and dilution.

Performance of gas turbine engine

Component characteristics of compressor and turbine, off design characteristics, Equilibrium point and procedure to find it, Equilibrium running of gas turbine generator, matching of gas generator with free turbine, part load performance

Text Books

1. H.I.H. Saravanamuttoo, G.F.C. Rogers, H. Cohen, "Gas Turbine Theory", 6th ed.
2. Jack D. Mattingly, "Elements of Gas Turbine Propulsion"
3. V Ganesan, "Gas Turbines", 3rd ed., Tata McGraw-Hill Education
4. Sutton, " Rocket Propulsion elements", 7th edition Wiley, India
5. Flack R., " Fundamentals of Jet Propulsion with Applications", Cambridge Uni. Press, India
6. J.D. Anderson, "Introduction to Flight", 5th ed., Tata McGraw Hill

(402045B) Product Design and Development (Elective II)

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402045 B	Product Design and Development	3	---	--	30 (1 hr)	70 (2 ½ hrs)	--	--	--	100

Pre-Requisites: Nil

Course Objectives: To explain students significance of,
- Product design and development.
- Hurdles in commercialization of product.
- Importance of reverse engineering.
- Focus of designing a product.
- Design validation plan.
- PLM and PDM

Course Outcome: After successful completion of the course students would be able to
- Design a sustainable product.
- Develop commercial Product
- Master in new techniques PLM and PDM

Unit 1: Introduction to Product Design and development   7 hrs
Definition of product design, Essential Factors for product design, Product design phases, Modern approaches to product design, standardization, simplification and specialization in product design product development, product development versus product design, product development team and product development planning, modern product development process with reference to ISO standard, product testing, product validation, Product verification and production validation

Unit 2: Product Development –Technical and Business Concerns   8 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 , Analysis of Gathered Information, Customer Population and Market Segmentation, Economic Analysis of Product (Numerical).

Unit 3: Product Development from Concept to Product Function   8 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, (numerical)concept scoring, process of concept embodiment, system modeling, functional modeling and decomposition, fast method, subtract and operate procedure

Unit 4: Reverse Engineering   8 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   8hrs
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)

Unit 6: Product Life Cycle Management and Product Data Management   7 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.

Case study based for design and development of any mechanical product.

Reference Books

1. A. K. Chitale; R.C. Gupta, Product Design and Manufacturing, Prentice Hall India.
2. Dieter George E., Engineering Design McGraw Hill Pub. Company, 2000.
3. Kevin Otto and Kristin Wood, Product Design : Techniques in Reverse Engineering and New Product Development ,Pearson Education Inc.
4. Grieves, Michael, Product Lifecycle Management McGraw Hill
5. Bralla, James G., Handbook of Product Design for Manufacturing, McGraw Hill Pub.
6. Karl Ulrich, product design and development, TMH.

402045C Operation Research (ELECTIVE II)

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402045 C	Operation Research	3	---	--	30 (1 hr)	70 (2 ½ hrs)	--	--	--	100

Pre-Requisites: Engineering Mathematics, Theory of probability, Statistics.

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: Learner will be able to.....
- Illustrate the need to optimally utilize the resources in various types of industries.
- Apply and analyze mathematical optimization functions to various applications.
- Demonstrate cost effective strategies in various applications in industry.

Unit 1: Introduction: Operation Research   **8 hrs**
Introduction: Definition, Evolution and Classification of Quantitative Methods and Operations Research Techniques, Methodology, Advantages and Limitations.
Linear Programming: Introduction, Formulation, Simplex Method (Big – M and Two Phase Methods), Dual Simplex Method (Conversion of primal to dual)
Introduction to Sensitivity Analysis.
Decision Theory: Meaning and Steps in Decision Making, Types of Management Decisions, Decision under Certainty, under Risk, under Uncertainty, Decision Trees.

Unit 2: Transportation Model   **8 hrs**
Introduction, Formulation, Basic Method of Solving Transportation Problem, Optimization Methods like UV and Stepping Stone Method, Concept of Trans-shipment Methods as an Extension of Transportation. Assignment Problem- Hungarian Method to solve Assignment Problem, Travelling Salesman as an Extension of Assignment Problem.

Unit 3: Theory of Games and Investment Analysis   **8 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.
Investment Analysis: Break-Even Analysis, Payback Period Method, A (A) R Method, DCF Method, IRR Method, Introduction to Probabilistic Models.

Unit 4: Inventory Control and Replacement Analysis   **8 hrs**
Inventory Control - Deterministic Models- Shortage, without shortage; Probabilistic Inventory Models, Introduction to Concept of Service level.
Replacement Analysis - Replacement of Items that Deteriorate, Replacement of Items that Fail Suddenly.

Unit 5: Queuing Theory and Sequencing models   **8 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: Network Models   **8 hrs**

Network Models: Fulkerson's rule, concept and types of floats, CPM and PERT, Introduction to crashing.

Simulation: Introduction, Monte-Carlo Simulation method, Simulation of Inventory and Queuing Problems.

Introduction to Multi Object Decision Making: Goal Programming Formulation.

Text Books

1. N. D. Vora, Quantitative Techniques.
2. Prem Kumar Gupta, D. S. Hira, Problems in Operations Research: Principles and Solutions, S. Chand, 1991
3. J. K. Sharma, Operations Research : Theory And Application, Laxmi pub. India.
4. Operations Research, S. D. Sharma, Kedar Nath Ram Nath-Meerut.

Reference Books

1. Belegundu, " Optimization Concepts and Applications in engineering, Cambridge Uni. Press, India
2. Hillier F.S., and Lieberman G.J., Operations Research, Eight Edition, Mc. Tata McGraw Hill, India
3. Ravindran, "Engineering optimization Methods and Appliations", 2nd edition, Wiley, India
4. Ravindran, Phillips and Solberg, Operations Research Principles and Practice, Second Edition, Mc. WSE Willey,
5. Operations Research - An introduction, Hamdy A Taha, Pearson Education.

(402045D) Advanced Manufacturing Processes (Elective II)

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402045 D	Advanced Manufacturing Processes	3	---	--	30 (1 hr)	70 (2 ½ hrs)	--	--	--	100

Prerequisite: Student must have knowledge of basic engineering sciences viz, Fluid Mechanics, Heat transfer

Course Objectives
1. To Introduce the students with Advanced Manufacturing Processes
2. To Introduce the student with Measurement techniques for micro machining
3. To Introduce the student

Course Outcomes
1. Selection of appropriate manufacturing process for advance components
2. Characterization of work pieces

Unit I: Metal Forming   **8 hrs**
Roll forming, High velocity hydro forming, High velocity Mechanical Forming, Electromagnetic forming, High Energy Rate forming (HERF), Spinning, Flow forming, Shear Spinning

Unit II: Advanced Welding, casting and forging processes   **8 hrs**
Friction Stir Welding – Introduction, Tooling, Temperature distribution and resulting melt flow
Advanced Die Casting - Vacuum Die casting, Squeeze Casting

Unit III: Advanced techniques for Material Processing   **8 hrs**
STEM: Shape tube Electrolytic machining, EJT: Electro Jet Machining, ELID: Electrolytic Inprocess Dressing, ECG: Electrochemical Grinding, ECH: Elctro-chemical Etching
Laser based Heat Treatment

Unit IV: Micro Machining Processes   **8 hrs**
Diamond micro machining, ultrasonic micro machining, micro elctro discharge machining

Unit V: Additive Manufacturing Processes   **8 hrs**
Introduction and principles, Development of additive manufacturing Technologies, general additive manufacturing processes, powder based fusion process, extrusion based system, sheet lamination process, direct write technologies

Unit VI: Measurement Techniques in Micro machining   **8 hrs**
Introduction, Classification of measuring System, Microscopes : Optical Microscope, Electron Microscopes, Laser based System, Interference Microscopes and comparators, Surface profiler, Scanning Tunneling Microscope, Atomic force micro scope, Applications.

Reference Books

1. Principles of Modern Manufacturing -- Groover, WILEY, India
2. Technology of Metal Forming processes --   Surender Kumar PHI Publication
3. Sheet metal forming: Processes and Applications -- Tayalan Atlan   ASM International USA
4. Friction Stir welding and Processing -- Rajiv S.Mishra ASM International
5. High Integrity Die casting Processes -- Edward J vinarcik John Wiley and Sons
6. Advanced Methods of Machining -- J.A. Mcgeough Chapman & Hall
7. Electro Chemical Machining --A.E. De Barr and D.A Oliver Mac Donald and company Publisher Ltd.
8. Micro machining of Engineering Materials -- Joseph Mcgeough Marcel Dekker, Inc.
9. Additive Manufacturing Techniques -- Ian Gibson Springer

Savitribai Phule Pune University, Pune 2012 Course

(402046) PROJECT STAGE I*

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402046	Project Stage I	--	2	--	---	----	50*	--	--	50

* Assessment should be carried out by panel of examiners from same Institute

INSTRUCTIONS FOR DISSERTATION 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 line 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. Legends below the title in 10 pt
d. Leave proper margin in all sides
e. 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. List of Figures
v. List of Tables
vi. Nomenclature
vii. Contents
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 centre. 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)

(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 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]

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

Title of the thesis
(TNR, 27pt, Bold, Centrally Aligned, Title Case)

By (TNR, 16pt, Centrally Aligned)

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

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

Institute Logo

Department of Mechanical Engineering
Name of the Institute [2015-16]
(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. Lele M.M.* , has successfully completed the Project Stage – I entitled "Performance analysis of…….." under my supervision, in the partial fulfillment of Bachelor of Engineering - Mechanical Engineering of University of Pune.

Date :

Place :

Guide's Name _____   Internal Examiner _____
Guide

Head Department _____   Principal, _____
and Institute Name   Institute Name

Seal

SEMESTER II

(402047) Power Plant Engineering

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402047	Power Plant Engineering	4	---	2	30 (1 hr)	70 (2 ½ hrs)	2	--	50	175

Prerequisites
Thermodynamics, Basic Mechanical Engineering, Turbo Machine, and Internal Combustion Engine

Course Objectives
- To develop an ability to apply knowledge of mathematics, science, and engineering.
- To develop an ability to design a system, component, or process to meet desired needs within realistic constraints.
- To develop an ability to identify, formulate, and solve engineering problems.
- To develop an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Course Outcomes
- Ability to have adequacy with Design, erection and development of energy conversion plants.
- Optimization of Energy Conversion plant with respect to the available resources.
- Scope of alternative erection of optimized, suitable plant at the location depending upon geographical conditions.

Unit 1: Introduction   8 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) Economics of Power Generation: Introduction, Cost of electric energy, Fixed and operating cost, (with numerical treatment), Selection and Type of generation, Selection of generation equipment, Performance and operation characteristics of power plants and Tariff methods.

Unit 2: Thermal Power Plant   10 hrs
A)Introduction: General layout of modern power plant with different circuits, working of thermal power plant, coal classification, coal, ash and dust handling, selection of coal for Thermal Power Plant, FBC boilers, high pressure boiler, Rankine cycle with reheat and regeneration, cogeneration power plant (with numerical)

B)Steam Condenser: Necessity of steam condenser, Classification, Cooling water requirements, Condenser efficiency, Vacuum efficiency, Cooling towers, air Leakage, Effects of Air Leakage on condenser performance, (Numerical Treatment)

Unit 3: Hydroelectric and Nuclear power plant   8 hrs
A)Hydroelectric Power Plant: Introduction, Site Selection, Advantages and Disadvantages of HEPP, Hydrograph , Flow duration curve ,Mass Curve, Classification of HEPP with layout.

B)Nuclear Power Plants: Elements of NPP, Nuclear reactor & its types, fuels moderators, coolants, control rod, classification of NPP, N-waste disposal

Unit 4: Diesel & Gas Turbine Power plant   8 hrs

A) Diesel Engine Power Plants: Plant Layout, Diesel Engine Power Plant Performance Analysis, application, selection of engine size, advantages & disadvantages of diesel power plant.

B) Gas Turbine Power Plant : Introduction, fuels, materials selection for GTPP, Brayton Cycle analysis, Thermal Efficiency, Work ratio, maximum & optimum pressure ratio, Actual cycle effect of operating variables on thermal efficiency, inter-cooling reheating, & regeneration cycle, Open, Closed & Semi Closed cycles Gas Turbine Plant , combined cycle plant (Numerical Treatment).

Unit 5: Non-Conventional Power Plants   8 hrs

Wind Power plant : Introduction, wind availability measurement, types of wind machines, site selection, and wind power generation.

Solar Power Plant : Introduction, components ,Types of Collectors & Solar Ponds, Low & High Temperature Solar Power Plant. Photovoltaic Power System, Heliostat

Tidal, OTEC, geothermal, magneto hydrodynamics, fuel cell, hybrid power plants, Challenges in commercialization of Non-Conventional Power Plants.

Unit 6: Instrumentation and Environmental Impact   8 hrs

A) Power Plant Instrumentation

Layout of electrical equipment, generator, exciter, short circuits & limiting methods, switch gear, circuit breaker, power transformers, methods of earthing, protective devices & Control system used in power plants, Control Room.

B) Environmental impact due to power plants.

Environmental aspects, introduction, constituents of atmosphere, different pollutants due to thermal power plants and their effects of human health, Environmental control of different pollutant such as particulate matter, Oxides of sulphur, nitrogen, global warming & green house effect, thermal pollution of water & its control. Noise pollution by power plants.

Term Work: Any Eight experiments of the following-

1) Visit to thermal Power plant /Co-generation Power plant or explain working of power plant by using suitable software.
2) Visit to HEPP/GTPP/Non-Conventional Power Plants.
3) Study of FBC system.
4) Study of High Pressure boilers.
5) Trial on steam power plant.
6) Trial on Diesel Power Plant.
7) Study of power plant instruments.
8) Study of Nuclear Power Plants.
9) Study of Environmental Impact of Power Plants.

Reference Books

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. K K Ramalingam ," Power Plant Engineering, SCITECH Publications Pvt Ltd.
4. Domkundwar & Arora, "Power Plant Engineering", Dhanpat Rai & Sons, New Delhi.
5. R.K.Rajput, "Power Plant Engineering", Laxmi Publications New Delhi.
6. R.Yadav , "Steam and Gas Turbines" ,Central Publishing House, Allahabad.
7. D.K.Chavan & G.K.Phatak, "Power Plant Engineering" , Standard Book House, New Delhi.
8. G.D.Rai, " Non-Conventional Energy Sources" Khanna Publishers,Delhi
9. S.P.Sukhatme, "Solar Energy" Tata McGraw-Hill Publications, New Delhi

(402048) Mechanical System Design

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402048	**Mechanical System Design**	4	---	2	30 (1 hr)	70 (2 ½ hrs)	--	--	50	150

Pre-requisite: Manufacturing Process, Machine design, Engineering Mathematics, TOM, 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
- The student will understand the difference between component level design and system level design.
- Ability to design various mechanical systems like pressure vessels, machine tool gear boxes, material handling systems, etc. for the specifications stated/formulated.
- Ability to learn optimum design principles and apply it to mechanical components.
- Ability to to handle system level projects from concept to product.

Unit 1: Design of Machine Tool Gearbox   **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, deviation diagram, difference between numbers of teeth of successive gears in a change gear box.

Unit 2: Statistical considerations in design   **6 hrs**
Frequency distribution-Histogram and frequency polygon, normal distribution - units of 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 conveyer 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   **10 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. S. 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 and DFMA   **8 hrs**

Optimum Design

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).

Design for manufacture, assembly and safety

General principles of design for manufacture and assembly (DFM and DMFA), principles of design of castings and forgings, design for machining, design for safety.

Term work: Term work shall consists of

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.

2. Assignments

The assignment shall be internally presented in the form of power point presentation by a group of two or three students. A report of assignment (Max 8 to 10 pages) along with print out of PPT is to be submitted.

Each student shall complete any two of the following:

1. Design review of any product/ system for strength and rigidity considerations.
2. Design review of any product/system for manufacturing, assembly and cost considerations.
3. Design review of any product/system for aesthetic and ergonomic considerations.
4. Analysis of any product/system using reverse engineering.
5. Case study of one patent from the product design point of view.
6. Failure mode and effect analysis of one product/component.
7. Design of Experiments (DOE)
8. Selection of gear box for various mechanical system like epicyclic gear trains , differential gear boxes , speed reducer etc
9. Design of Human Powered system.
10. Application of composite material for different mechanical components.
11. Design of material handling system for specific / various applications such as chain and screw conveyors
12. Concurrent engineering

Text Book

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

Reference Books

1. Shigley J. E. and Mischke C.R., "Mechanical Engineering Design", McGraw Hill Pub. Co
2. M. F. Spotts, "Mechanical Design Analysis", Prentice Hall Inc.
3. Black P.H. and O. Eugene Adams, "Machine Design" McGraw Hill Book Co. Inc.
4. Johnson R.C., "Mechanical Design Synthesis with Optimization Applications", Von Nostrand Reynold Pub.

5. S.K. Basu and D. K. Pal, "Design of Machine Tools,,, Oxford and IBH Pub Co.
6. Rudenko,"Material Handling Equipment", M.I.R. publishers, Moscow
7. P. Kannaiah ,"Design of Transmission systems", SCIETCH Publications Pvt Ltd.
8. Pandy, N. C. and Shah, C. S., "Elements of Machine Design", Charotar Publishing House.
9. Mulani, I. G., "Belt Conveyors"
10. Singiresu S. Rao, Engineering Optimization: Theory and Practice, , John Wiley & Sons.
11. M.V. Joshi, Process Equipment Design, Mc-Millan.
12. Design Data", P.S.G. College of Technology, Coimbatore.
13. Bhandari, V. B. Machine Design data book, Tata McGraw Hill Publication Co. Ltd.
14. I.S. 2825: Code for unfired pressure vessels.

(402049A) Refrigeration and Air Conditioning Equipment Design (Elective III)

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402049 A	Refrigeration and Air Conditioning Equipment Design	4	---	--	30 (1 hr)	70 (2 ½ hrs)	--	--	--	100

Pre-requisite
    Refrigeration and Air Conditioning, Engineering Thermodynamics,

Course Objectives
- Study of refrigeration cycles i.e. trans-critical cycle, cascade cycle, etc.
- Understanding of materials and designs of refrigeration and air conditioning equipment like controls, evaporators, condensers, cooling towers
- Learning of low temperature systems and heat pipe

Course Outcomes: At the end of this course the students should be able to
- Select the different components of refrigeration system i.e. condensers, evaporators, controls etc. for given applications
- Demonstrate the concepts of design of evaporators and condensers for unitary systems
- Analyses the performance of cooling tower and heap pipe.
- Illustrate the methods for production of ultralow temperature

Unit 1: Advanced Vapour Compression Cycles   **8 hrs**
Review of vapour compression cycle, Transcritical cycle and their types, presentation of cycle on P-h and T-s chart, Multi evaporator and multi compression systems, ammonia-CO_2 cascade cycle.
Compressor: classifications, applications, Characteristic curves & capacity controls for reciprocating & centrifugal compressors, sizing of reciprocating compressor.

Unit 2: Safety Controls   **8 hrs**
HP/LP and Oil pressure failure control, Thermal overload protection for hermetic motors, reduced voltage protection, motor over current protection, adjustable speed drives, variable frequency drives, flow failure switches, safety valves, purge valves, level controller
Operating Control **-** Solenoid valve, regulating valves

Defrost methods for sub-zero applications
Methods of defrosting: manual and auto, water, electric, hot gas, re-evaporator coils, defrosting: multiple evaporator systems, reverse cycle defrosting, vapor defrosting

Unit 3: Introduction to Cryogenics   **8 hrs**
Introduction, Figure of Merit, Limitations of VCS for the production of low temperatures, Joule-Thompson effect, Linde and Claude system, Liquefaction of gases such as N2 and He. Properties of cryogenic fluid,
Insulation: Types and materials

Unit 4: Condensers and Evaporators   **8 hrs**
Condensers
Types, thermal design and operational considerations: Shell and tube condensers - horizontal & vertical types,
Evaporators

Ttypes, rating & selections, and design considerations, Standards for evaporators & condensers

Unit 5: Cooling Towers	**8 hrs**

Types - basic relation - heat balance and heat transfer - characteristics, effects of - packing - geometry, design of cooling towers, spray design, cooling tower thermal performance, cooling tower theory, tower efficiency.

Unit 6: Heat Pipes	**8 hrs**

Structures - applications - basic relations - performance characteristics - effects of working fluid and operating temperature, wick - selection of material - pore size (basic concepts only)
Non-Conventional Refrigeration systems: vortex tube, pulse tube, thermoelectric refrigeration, magnetic refrigeration, steam-jet refrigeration.

Text Books
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

Reference Books
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

(402049B) Robotics (Elective III)

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402049 B	Robotics	4	---	--	30 (1 hr)	70 (2 ½ hrs)	--	--	--	100

Pre-Requisite: Engineering Mechanics, TOM, Mechatronics, Basics of Electrical Engineering, Control system.

Course Objective: To teach students,
1. Basics of robotics (Links, Actuators, Sensors etc).
2. Statistics & Kinematics of robots.
3. Desired motion of robot.
4. Control system necessary for accurate operation of the robot.

Course Outcomes: After completion of the course student would be able to,
1. Understand the complete design procedure of the robot.
2. Select correct mechanism for operation of the robot.
3. Select necessary actuators, sensors, control for satisfactory performance of the robot.

Unit 1: Introduction   **8 hrs**
Robots: Introduction, Structure, Classification and Application.
Joints & Links: Position and orientation of a rigid body, Homogeneous transformations, Representation of joints, link representation using Denavit-Hartenberg parameters.
Actuators: Brushless DC Motor (construction, working and selection)
Sensors: GPS, IMU, Vision, PVDF Tactile (construction, working and selection)
Grippers: Hydraulic and Servo (construction, working and selection)

Unit 2: Kinematics and Kinematics of Robot   **10 hrs**
Kinematics of serial robots: Direct and inverse kinematics problems, workspace of a serial robot, Inverse kinematics of constrained and redundant robots, Inverse kinematics solution for the general 6R serial manipulator.
Kinematics of parallel robots: Degrees-of-freedom of parallel mechanisms and manipulators, Active and passive joints, Constraint and loop-closure equations, Direct kinematics problem, Mobility of parallel manipulators, Closed-from and numerical solution, Inverse kinematics of parallel manipulators

Unit 3: Statics of Robot Manipulators   **10 hrs**
Statics of robot manipulators: Linear and angular velocity of links, Velocity propagation, Manipulator Jacobians for serial and parallel manipulators, Velocity ellipse and ellipsoids, Singularity analysis for serial and parallel manipulators, Loss and gain of degree of freedom, Statics of serial and parallel manipulators, Singularity analysis and statics.

Unit 4: Dynamics of Robot   **8 hrs**
Dynamics of serial and parallel robots: Mass and inertia of links, Lagrangian formulation for equations of motion for serial and parallel manipulators, Generation of symbolic equations of motion using a computer, Simulation (direct and inverse) of dynamic equations of motion, Examples of a planar 2R and four-bar mechanism, Recursive dynamics.

Unit 5: Motion Planning and Control   **8 hrs**
Motion planning and control: Joint and Cartesian space trajectory planning and generation, potential field method for motion planning, independent joint PID control (parallel form) and its tuning (ZN step response method), Control of a multi-link manipulator, Control of constrained manipulators, Force control and hybrid position/force control

Unit 6: Artificial Intelligence and Image Processing   **10 hrs**

Linear Kalman Filter: Algorithm, Application

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

Image Processing: Introduction, Need, Image acquisition, Masking, Sampling and quantization, Image Processing Technique-edge detection, noise reduction; Image Segmentation.

Text Books:

1. S B Niku, *Introduction to Robotics, Analysis, Control, Applications*, 2nd Edition, Wiley Publication, 2015.
2. John Craig, *Introduction to Robotics, Mechanics and Control*, 3rd Edition, Pearson Education, 2009
3. Mathia, *Robotics for Electronics Manufacturing,* Cambridge Uni. Press, India
4. A Ghosal, *Robotics: Fundamental Concepts and Analysis*, Oxford University Press, 2013.
5. R K Mittal & I J Nagrath, *Robotics and Control*, McGraw Hill Publication, 2015.
6. K Astrom & T Hagglund, *PID Controllers: Theory, Design and Tuning*, 2nd Edition, The Instrumentation, Systems, and Automation Society, 1995.
7. Asfahl, *Robots and Manufacturing Automation*, Wiley, India, 2012

(402049C) Industrial Engineering (Elective III)

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402049 C	Industrial Engineering	4	---	--	30 (1 hr)	70 (2 ½ hrs)	--	--	--	100

Pre-requisite: Manufacturing Process, Engineering Mathematics.

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.

Course Outcomes: Learner will be able to.....
- Apply the Industrial Engineering concept in the industrial environment.
- Manage and implement different concepts involved in methods study and understanding of work content in different situations.
- Undertake project work based on the course content.
- Describe different aspects of work system design and facilities design pertinent to manufacturing industries.
- Identify various cost accounting and financial management practices widely applied in industries.
- Develop capability in integrating knowledge of design along with other aspects of value addition in the conceptualization and manufacturing stage of various products.

Unit 1: Introduction to Industrial Engineering and Productivity   **7 hrs**
Introduction: Definition and Role of Industrial Engineering, Contribution of Taylor and Gilbreth, Organisation : Concept of organisation, characteristics of organisation, elements of organisation, organisational structure, organisation charts; Types of organisation- formal line, military organisation, functional organization, line & staff organisation; Introduction to management principles, authority and responsibility, span of control, delegation of authority.
Productivity : Definition of productivity, Productivity of materials, land, building, machine and power. Measurement of productivity: factors affecting the productivity, Productivity Models and Index (Numerical), productivity improvement programmers.

Unit 2: Method Study   **7 hrs**
Work Study : Definition, objective and scope of work-study. Human factors in work-study.
Method Study : Definition, objective and scope of method study, activity recording and exam aids, Charts to record moments in shop - operation process charts, flow process charts, travel chart, two handed chart and multiple activity charts. Charts to record movement at work place - principles of motion economy, classification of moments, SIMO chart, and micro motion study.
Definition and installation of the improved method, brief concept about synthetic motion studies.(Numerical); Introduction to Value Engineering and Value Analysis;

Unit 3: Work Measurements   **7 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	7 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)
Supply Chain Management: Concept, Strategies, Supply Chain Network, Push and Pull Systems, Logistics, Distribution; Order Control strategies: MTO, MTA, MTS.

Unit 5: Facility Design	7 hrs

Facility Location Factors and Evaluation of Alternate Locations; Types of Plant Layout; Computer Aided Layout Design Techniques; Assembly Line Balancing (Numerical);
Material Handling: Principles, Types of Material Handling Devices; Stores Management
Inventory Control: Functions, costs, classifications- deterministic and probabilistic inventory models, Concept of EOQ, purchase model without shortages (Numerical); ABC and VED Analysis.

Unit 6: Engineering Economy, Human Resource and Industrial Safety	7 hrs

Engineering Economy and Costing: Elementary Cost Accounting and Methods of Depreciation; 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, 360^0).
Industrial Safety: Safety Organisation, Safety Programme, General Safety Rules.

Text Books
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 Organisation & Engineering Economics, Khanna publication.

Reference Books
1. Introduction to Work Study by ILO, ISBN 978-81-204-1718-2, Oxford & IBH
   Publishing 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, CRC Press,2002
5. Martin Murry, SAP ERP: Functionality and Technical Configuration, SAP Press; 3rd New edition (2010).
6. Barnes, Motion and time Study design and Measurement of Work, Wiley India

(402050 A) Computational Fluid Dynamics (Elective IV)

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402050 A	Computational Fluid Dynamics	4	---	2	30 (1 hr)	70 (2 ½ hrs)	25	--	--	125

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 discretize the governing differential equations and domain by Finite Difference Method.
- 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 career in industry in CAE through use of software tools.
- To prepare the students for research leading to higher studies.

Course Outcomes:
- Ability to analyze and model fluid flow and heat transfer problems.
- Ability to generate high quality grids and interprete the correctness of numerical results with physics.
- Ability to use a CFD tool effectively for practical problems and research.
- Ability to conceptualize the programming skills.

Unit 1: Introduction to CFD   **8 hrs**
CFD – a research and design tool, CFD as third dimension of engineering supplementing theory and experiment, Steps in CFD solution procedure, strengths and weakness of CFD, Flow modelling using control volume - finite and infinitesimal control volumes, Concept of substantial derivative, divergence of velocity, Basic governing equations in integral and differential forms – conservation of mass, momentum and energy (No derivations), Physical interpretation of governing equations, Navier-Stoke's model and Euler's model of equations.

Unit 2: Basic Discretization Techniques   **10 hrs**
Introduction to grid generation (Types of grids such as structured, unstructured, hybrid, multiblock, Cartesian, body fitted and polyhedral etc.), Need to discretize the domain and governing equations, Finite difference approximation using Taylor series, for first order (Forward Difference Approximation, Backward Difference Approximation, Central difference Approximation) and second order (based on 3 node, 4 node and 5 node points),explicit and Implicit approaches applied to 1D transient conduction equation, Couette flow equation ($\frac{\partial p}{\partial x} = 0$) using FTCS and Crank Nicholson's Method, Stability Criteria concept and physical interpretation, Thomas Tri-diagonal matrix solver.

Unit 3: Two Dimensional Steady and unsteady heat conduction   **8 hrs**
Solution of two dimensional steady and unsteady heat conduction equation with Dirichlet, Neumann, robbins and mixed boundary condition – solution by Explicit and Alternating Direction Implicit method (ADI Method), Approach for irregular boundary for 2D heat conduction problems.

Unit 4:   Application of Numerical Methods to Convection – Diffusion System   **10 hrs**
Convection: first order wave equation solution with upwind, Lax–Wendroff, Mac Cormack scheme, Stability Criteria concept and physical interpretation
Convection –Diffusion: 1D and 2D steady Convection Diffusion system – Central difference approach, Peclet Number, stability criteria, upwind difference approach, 1 D transient convection-diffusion system

Unit 5: Incompressible Fluid Flow   **8 hrs**

Solution of Navier-Stoke's equation for incompressible flow using SIMPLE algorithms and its variation (SIMPLER), Application to flow through pipe, Introduction to finite volume method.

Unit 6: CFD as Practical Approach   **8 hrs**

Introduction to any CFD tool, steps in pre-processing, geometry creation, mesh generation, selection of physics and material properties, specifying boundary condition, Physical Boundary condition types such as no slip, free slip, rotating wall, symmetry and periodic, wall roughness, initialising and solution control for the solver, Residuals, analysing the plots of various parameters (Scalar and Vector contours such as streamlines, velocity vector plots and animation). Introduction to turbulence models. Reynolds Averaged Navier-Stokes equations (RANS), k- , k-ω. Simple problems like flow inside a 2-D square lid driven cavity flow through the nozzle.

Term Work: Practicals to be performed: Any 8 in the given list below (from 1-9) should be performed with mini project (Sr.No.10) compulsory.

1 Generation of different meshes
a.   Structured mesh
b.   Unstructured mesh,
c.   Multiblock, etc.
2.   Program on 1D transient heat conduction by FTCS OR Crank Nicholson scheme
3.   Program on 1-D (first order)wave equation by Upwind scheme and study the impact of CFL number on the stability and solution .
4.   Program on 2D Transient Conduction equation / 2D Convection-Diffusion Equation
5.   Numerical simulation and analysis of boundary layer over a flat plate (Blausius Equation) are using any CFD software or computer programming.
6.   Numerical simulation and analysis of boundary layer for a a). Developing flow through a) Pipe b) Fully developed flow through a pipe.
7.   Numerical simulation and analysis of 2D square lid driven cavity using any CFD software. Effect of Reynolds number on the vorticity patterns.
8.   CFD Analysis of external flow: Circular Cylinder or Aerofoil (NACA 0012)
9.   CFD analysis of heat transfer in pin fin.
10. Mini project on any practical application. Students should take a problem of their choice and verify the CFD solution with experimental data / research paper.

Reference Books
1.   John D Anderson: Computational Fluid Dynamics- The Basics with Applications, McGraw-Hill
2.   J. Tu, G.-H. Yeoh and C. Liu: Computational Fluid Dynamics: A practical approach, Elsevier.
3.   A. W. Date: Introduction to Computational Fluid Dynamics, Cambridge University Press, India
4.   P. S. Ghoshdastidar: Computer Simulation of Fluid flow and heat transfer, Tata McGraw-Hill.
5.   Bates, Computational Fluid Dynamics, Wiley India
6.   C. Hirsch: Numerical Simulation of internal and external flows Vol. 1, John Wiley
7.   Tannehill, Anderson, and Pletcher: Computational Fluid Mechanics and Heat transfer, CRC Press.
8.   J. H. Ferziger and M. Peric: Computational Methods for Fluid Dynamics, 3rd Edition, Springer
9.   Zikanov, Essential Computational Fluid Dynamics, Wiley India
10. Batchelor, An Introduction to fluid Dymanics, Cambridge Uni. Press, india

(402050B) Finite Element Analysis (Elective IV)

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402050 B	Finite Element Analysis	4	---	2	30 (1 hr)	70 (2 ½ hrs)	25	--	--	125

Pre-Requisites:
- Mechanics of materials
- DME I and DME II (Static and dynamic failure theories)
- Engineering Graphics
- Fundamentals of Programming Language

Course Objectives
- 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
Upon completion of this course, the student will be able to:
- 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.
- 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.

Unit 1: Fundamentals Concepts of FEA   10hrs
Introduction– Brief History of FEM, Finite Element Terminology (nodes, elements, domain, continuum, Degrees of freedom, loads & constraints) General FEM procedure, Applications of FEM in various fields, P & h formulation, Advantages and disadvantages of FEM. Consistent units system.
Review of Solid Mechanics Stress equilibrium equations, Strain-Displacement equations, Stress-Strain-Temperature Relations, Plane stress, plane strain and axi-symmetric problems, Strain energy, Total potential energy. Essential and natural boundary conditions
Review of Matrix Algebra (Vectors, Matrices, Symmetric banded matrix, Determinants, Inverses), banded skyline solutions. Introduction to solvers (Sparse solver, iterative solver, PCG, block Lanczos).
Introduction to different approaches used in FEA such as direct approach, Variational approach, weighted residual, energy approach, Galerkin and Raleigh Ritz approach.

Unit 2: 1D Elements   8hrs
Types of 1D elements. Displacement function, Global and local coordinate systems, Order of element, primary and secondary variables, shape functions and its properties.
Formulation of elemental stiffness matrix and load vector for spring, bar, beam, truss and Plane frame.
Transformation matrix for truss and plane frame, Assembly of global stiffness matrix and load vector, Properties of stiffness matrix, half bandwidth, Boundary conditions elimination method and penalty approach, Symmetric boundary conditions, Stress calculations.

Unit 3: 2D Elements   10 hrs

Types of 2D elements, Formulation of elemental stiffness matrix and load vector for Plane stress/strain such as Linear Strain Rectangle (LSR), Constant Strain Triangles (CST), Pascal's triangle , primary and secondary variables, properties of shape functions. Assembly of global stiffness matrix and load vector, Boundary conditions, solving for primary variables (displacement), Overview of axi-symmetric elements

Unit 4: Isoparametric Elements   10 hrs

Concept of isoparametric elements, Terms Isoparametric, super parametric and subparametric. Isoparmetric formulation of bar element.
Coordinate mapping - Natural coordinates, Area coordinates (for triangular elements), higher order elements (Lagrangean and serendipity elements). Convergence requirements- patch test, Uniqueness of mapping - Jacobian matrix. Numerical integration – 2 and 3 point Gauss Quadrature, full and reduced integration. Sub-modeling, substructuring.

Unit 5: 1D Steady State Heat Transfer Problems   8 hrs

Introduction, Governing differential equation, steady-state heat transfer formulation of 1D element for conduction and convection problem, boundary conditions and solving for temperature distribution.

Unit 5: Dynamic Analysis   8 hrs

Types of dynamic analysis, General dynamic equation of motion, point and distributed mass, lumped and Consistent mass, Mass matrices formulation of bar and beam element.
Undamped-free vibration- Eigenvalue problem, Evaluation of eigenvalues and eigenvectors (natural frequencies and mode shapes).

Term Work: The term work shall consist of record of any three from 1 to 4* and any three from 5 to 8** assignments of the problems based on following topic-
1. Computer program for stress analysis 2-D truss subjected to plane forces
2. Computer program for modal analysis 1-D beam (simply supported or cantilever beams)
3. Computer program for frames subjected to transverse forces and moments
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. 2D Forced convection problem using FEA software.
7. Modal analysis of any machine component using FEA software.
8. Stress and deflection analysis of any machine component consisting of 3-D elements 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 FEA software such as Abaqus, ANSYS, Msc-Nastran, Optistruct/Radioss, Comsol-Multiphysics

   ** 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.

Text Books
   1. A First Course in the Finite Element Method, Daryl L. Logan
   2. Concepts and Applications of Finite Element Analysis, R. D. Cook, et al. Wiley, India

Reference Books
1. Chandrupatla T. R. and Belegunda A. D., "Introduction to Finite Elements in Engineering", Prentice Hall India.
2. Seshu P., "Text book of Finite Element Analysis", PHI Learning Private Ltd. New Delhi, 2010.
3. Bathe K. J., "Finite Element Procedures", Prentice-Hall of India (P) Ltd., New Delhi.

4. Fagan M. J., "Finite Element Analysis, Theory and Practice", Pearson Education Limited
5. Kwon Y. W., Bang H., "Finite Element Method using MATLAB", CRC Press, 1997
6. S. Moaveni, "Finite element analysis, theory and application with Ansys",
7. Fundamental of Finite Element Analysis, David V. Hutton, Tata McGraw-Hill
8. Gokhale N. S., Deshpande S. S., Bedekar S. V. and Thite A. N., "Practical Finite Element Analysis", Finite to Infinite, Pune

(402050C) Design of Pumps, Blowers and Compressors
(Elective IV)

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402050C	Design of Pumps, Blowers and Compressors	4	---	2	30 (1 hr)	70 (2 ½ hrs)	25	--	--	125

Pre-Requisite: Turbo Machines, Engineering Thermodynamics,

Course Objectives: To teach students.
- Different applications of Pumps, Fans, blowers & Compressors.
- Different types of Pumps, Fans, blowers & Compressors.
- How to design Pumps, Pumps, Fans, blowers & Compressors..

Course Outcomes: After completion of the course students would be able to
- Select suitable Pump, Blower, fan or compressor for a given application.
- Design Pump, Blower, fan or compressor for a given application

Unit 1: Fundamentals of Fluid Machinery   **8 hrs**
Introduction to pumps, Introduction to blowers and compressors, Basic equations of energy transfer between fluid and rotor, Performance characteristics, Dimensionless parameters, Specific speed, stage velocity triangles, work and efficiency.

Unit 2: Reciprocating Pumps   **8hrs**
Introduction: Types, Component and Working of Reciprocating pump, Discharge, Work done and power required to drive for single acting and double acting, Coefficient of discharge, slip, Effect of acceleration of piston on velocity and pressure, indicator diagram, Air Vessel, Operating characteristics.

Unit 3: Design of Pumps   **10 hrs**
Design procedure and design optimization of Pumps, selection of pumps, Thermal design- Selection of materials for high temperature and corrosive fluids. Hydraulic design- Selection of impeller and casing dimension using industrial manuals.

Unit 4: Theory of Fans and Blowers   **8 hrs**
Classification of blowers, Basics of stationary and moving air, Eulers characteristics, velocity triangles and operating pressure conditions, Equations for blowers, Losses and hydraulic efficiency, flow through impeller casing, inlet nozzle, Volute, diffusers, leakage, mechanical losses, surge and stall, Applications of blowers and fans.

Unit 5: Design of Fans and Blowers   **10 hrs**
Rotor design airfoil theory, vortex theory, cascade effects, degree of reaction, Design procedure for selection and optimization of Blowers. Stage pressure rise, stage parameters and design parameters. Design of impeller and casing dimension in aerodynamic design.

Unit 6: Design of Compressors   **8 hrs**
Basic theory, classification and application, Working with enthalpy-entropy diagram, construction and approximate calculation of centrifugal compressors, impeller flow losses, slip factor, diffuser analysis, performance curves of centrifugal compressors, Basic design features of axial flow compressors; velocity triangles, enthalpy-entropy diagrams, stage losses and efficiency, work done factor, simple stage of axial flow compressors.

Term Work

Assignments:

    A. Assignments using suitable software on any one of following
        1. Computer programs for iterative and interactive design of pumps.
        2. Computer programs for iterative and interactive design of fan / blower.
    B. Any four Assignments
    C. Industrial visit or case study

Textbooks

1. Turbine, "Compressors and Fans" S.M.Yahya, Tata Mc-Graw Hill Publishing Company, 1996R. K. Rajput, "Fluid Mechanics and Hydraulic Machines" S. Chand
2. R. K. Bansal, "Fluid Mechanics and Hydraulic Machines", Laxmi Publication
3. V. Ganeshan "Gas Turbines" II edition, Tata Mc-Graw Hill Publishing Company
4. R.. Yadav"Steam and Gas Turbine" Central Publishing House, Allahabad

Reference Books

1. Shepherd, D.G., "Principles of Turbomachinery", Macmillan, 1969.
2. John Tuzson, "Centrifugal Pump Design," John Wiley
3. Stepanff, A.J., "Blowers and Pumps ", John Wiley and Sons Inc., 196
4. Austin H. Chruch, "Centrifugal pumps and blowers", John Wiley and Sons, 1980.
5. Val S.Labanoff and Robert Ross, "Centrifugal Pumps Design and Applications" Jaico P House.
6. Igori Karassik, "Pump Hand Book," McGraw-Hill International Edition.
7. G.K.Sahu "Pumps" New age international publishers.

(402051) PROJECT STAGE II

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
402051	Project Stage II	--	6	--	--	--	150	--	50	200

INSTRUCTIONS FOR DISSERTATION 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''	25.4 mm

7. All paragraphs will be 1.5 line 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. Legends below the title in 10 pt
d. Leave proper margin in all sides
e. Illustrations as far as possible should not be photo copied.

11. Photographs if any should 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. List of Figures
v. List of Tables
vi. Nomenclature
vii. Contents
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 centre. 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 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]

A Dissertation on
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Title
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By
(TNR, 16pt, Centrally Aligned)

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

Guide Guide's Name
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Institute Logo

Department of Mechanical Engineering Name of the Institute [2015-16]
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C E R T I F I C A T E

This is to certify that *Mr. Lele M.M.* , has successfully completed the Dissertation entitled "Performance analysis of…….." under my supervision, in the partial fulfilment of Bachelor of Engineering - Mechanical Engineering of University of Pune.

Date :

Place :

Guide's Name _____   External Examiner _____
Guide

Head Department _____   Principal, _____
and Institute Name   Institute Name