PUNE VIDYARTHI GRIHA'S

COLLEGE OF ENGINEERING AND TECHNOLOGY, PUNE-9

(AFFILIATED TO SAVITRIBAI PHULE PUNE UNIVERSIT, PUNE)

DEPARTMENT OF MECHANICAL ENGINEERING

CURRICULUM BOOK

ACADEMIC YEAR: 2016-17

FOR THE PROGRAMME

MECHANIAL ENGINEERING (UNDER GRADUATE)

PUNE VIDYARTHI GRIHA'S

COLLEGE OF ENGINEERING AND TECHNOLOGY

VISION

TO ACHIEVE EXCELLENCE IN ENGINEERING EDUCATION

MISSION

- **To satisfy all stakeholders**
- **To develop ethical, highly motivated engineering professionals with good human values, requisite skills and competencies**
- **To adopt innovative teaching mechanisms**
- **To promote research culture**
- **To contribute to country's economic development**
- **To be responsive to changes in technology, socio-economic and environmental conditions**

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To become premier source of competent Mechanical Engineering professionals for providing service to the society.

MISSION

1. To provide state of the art facility and to offer opportunities for multifaceted development and enriching learning experience for students, faculty and staff.
2. To enhance the status as a recognized academic and research centre in collaboration with other institutions and industry.
3. To provide interactive and innovative teaching to transform students into competent engineering professionals having good ethical, social and human values.
4. To deliver ready to employ engineering graduates who are adaptable and practicing lifelong learning to meet the ever changing requirements of the employers.

PROGRAM EDUCATIONAL OBJECTIVES

PEO1: To demonstrate the ability to design, develop products, systems and processes in multi-disciplinary engineering environment by application of principles of Science and Engineering.

PEO2: To develop experimental and computational skills necessary to formulate and solve industrial problems related to Mechanical Engineering.

PEO3: To offer sustainable solutions through research, technological competency, leadership skills and team work.

PEO4: To continue professional development through higher education and lifelong learning.

PEO5: To demonstrate socio-economic, ethical and environmental awareness while making professional decisions.

PROGRAMME OUTCOMES

Graduates of the mechanical engineering program will be able to -

1. Use basic knowledge in mathematics, science and engineering to solve problems specific to Mechanical engineering.
2. Investigate complex problems, gather data and then interpret and analyze the same leading to a meaningful solution.
3. Identify, formulate and design a mechanical system that meets desired specifications.
4. Function as a coherent member in multidisciplinary design teams, and deliver results through collaborative research.
5. Identify, formulate and solve mechanical engineering problems of complex nature.
6. Understand their professional and ethical responsibilities, and use technology for the benefit of mankind.
7. Communicate effectively in both verbal and written forms within and outside the engineering community, give and receive instructions.
8. Apply and understand impact of engineering solutions in societal and environmental contexts.
9. Self-educate and clearly understand the importance of lifelong learning.
10. Understand and apply the basic principles of project management and finance.
11. Apply modern computational tools to analyze mechanical engineering problems.
12. Design a mechanical system or, component to meet the desired needs within realistic constraints such as economic, environmental, social, health and safety.

PROGRAMME SPECIFIC OUTCOMES

1. Demonstrate competency in the areas of Thermal, Design and Manufacturing.
2. Ability to use skills and tools to work in interdisciplinary areas of engineering

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Final Year

Curriculum Book

Savitribai Phule Pune University, Pune 2012 Course

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

BE (MECH)

Semester I

Refrigeration & Air Conditioning

Course Title: Refrigeration & Air Conditioning		**Course Number: C401**	**Course Code: 402041**
Year: B.E.		**Semester: One**	
Designation of Course		Professional Core	
Teaching Scheme: 3 Hrs/Week		**Tutorial:** Nil	
Course Assessment Methods	**Direct methods**	In-semester Examination: 30 Marks	End Semester Examination: 70 Marks
			Practical/Oral/Term Work
	Indirect Methods	Assignments	
Prerequisites	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			
1	Learning the fundamental principles and different methods of refrigeration and air conditioning		
2	Study of various refrigeration cycles and evaluate performance using Mollier charts and/ or refrigerant property tables.		
3	Comparative study of different refrigerants with respect to properties, applications and environmental issues.		
4	Understand the basic air conditioning processes on psychometric charts, calculate cooling load for its applications in comfort and industrial air conditioning.		
5	Study of the various equipment-operating principles, operating and safety controls employed in refrigeration air conditioning systems		
Course Outcomes			
CO1	Illustrate the fundamental principles and applications of refrigeration and air conditioning system		
CO2	Obtain cooling capacity and coefficient of performance by conducting test on vapor compression refrigeration systems		
CO3	Present the properties, applications and environmental issues of different refrigerants		
CO4	Calculate cooling load for air conditioning systems used for various applications		
CO5	Operate and analyze the refrigeration and air conditioning systems.		
Course Contents			
Unit-I	Fundamentals and Applications of Refrigeration and Air Conditioning		
	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-II	Refrigerants and Vapour Compression Cycle
	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 ofVCC, actual VCC, methods of improving COP using flash chamber, sub-cooling, liquid vapour heat exchanger, comparison of VCC with Reverse Carnot cycle
Unit-III	Refrigeration Systems
	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-IV	Psychometric and Air conditioning
	Introduction to air conditioning, psychometric, psychometric properties and terms, psychometric relations, Psychometric processes and its representation on psychometric 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- V	Air Conditioning Systems
	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-VI	Air Distribution Systems
	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).

List of Practicals	1) Test on Domestic Refrigerator for evaluation of EER 2) Test on vapour compression test rig 3) Test on ice plant test rig 4) Visit to Vapour absorption refrigeration plant 5) Estimation of cooling load of simple air conditioning system (case study) 6) Case study on cold storage 7) Visit to any air conditioning plant 8) Thermal analysis of refrigeration cycle using suitable software 9) Installation and servicing of split air conditioner		
Text Books	**Author**	**Title of Book**	**Publication**
T1	Arora C. P	Refrigeration and Air Conditioning	Tata McGraw-Hill
T2	Sapali S. N.	Refrigeration & Air Conditioning	PHI EEE ISBN978-81-203-3360-4
Reference Books			
R1	Dossat Ray J	Principles of refrigeration	Willey Eastern Ltd, 2000
R2	Stockers W.F and Jones J.W	Refrigeration and Air conditioning	McGraw Hill International editions 1982.
R3	Threlkeld J.L	Thermal Environmental Engineering	Prentice Hall Inc., New Delhi
R4	Aanatnarayan	Basics of refrigeration and Air Conditioning	Tata McGraw Hill Publications
R5		ASHRAE & ISHRAE handbook	ASHRAE & ISHRAE
Self-Learning Facilities, Web Resources, Research papers for reference	NPTEL Lectures https://www.youtube.com/playlist?list=PLE2DA184A2E479885		
Contents beyond Syllabus	Nil		
Additional Experiments	N.A.		
Bridging Courses	N.A.		
Tutorials	N.A.		
Presentations	N.A.		

CAD CAM and Automation

Course Title: CAD/CAM AND AUTOMATION		**Course Number:** C402	**Course Code:** 402042
Year: B.E.		**Semester: VII**	
Designation of Course		Core	
Teaching Scheme: 3 Hrs/Week		**Tutorial:** Nil	
Course Assessment Methods	**Direct methods**	In-semester Examination: 30 Marks	End Semester Examination: 50/70 Marks
			Practical/Oral/Term Work
	Indirect Methods	Assignments	
Prerequisites	Engg. Mathematics, Machine Design		
Course Objectives: Following concepts to be taught to the students,			
1	Basics of Graphic Screen.		
2	Building Transformation Matrices.		
3	Concept of of Finite Element Analysis		
4	Technique of Automation		
5	Concept of of Curves, Surfaces and Solids generation		
6	CAM Technique.		
7	Robot Technology		
Course Outcomes: At the end of this course the students should be able to			
CO1	Frame and solve Transformation Matrices		
CO2	Apply the Technique of Finite Element Analysis.		
CO3	Explain the concepts in Automation Techniques		
CO4	Define, synthesize and analyze engineering curves in CAD interface.		
CO5	Write programs for manufacturing the components using CAD software Students		
CO6	Explain technological aspects of Robotics and develop basic programs.		
Course Contents			
Unit-I	**Computer Graphics**		
	Transformation-Introduction, Formulation, Translation, Rotation, Scaling, Reflection Homogenous Representation, Concatenated Transformation, Mapping of Geometric Models, Inverse Transformations, Projections: Orthographic, Isometric, and Perspective. Introduction to open GL and commands required for the transformation.		
Unit-II	**Modelling**		
	Curves:-Introduction, Analytic Curves, Line, Circle, Parabolas, Hyperbolas, Ellipses, Conics, Synthetic Curves, Hermite Cubic Spline, Bezier Curve, B-Spline Curve, Numericals on above topic. 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-III	**Finite Element Analysis**
	Introduction, Stress and Equilibrium, Boundary Condition, Strain - Displacement Relations, Stress-Strain Relation, Temperature Effects, 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. Introduction, Constant Strain Triangle Problem, Modeling and Boundary Conditions.
Unit-IV	**Computer Aided Manufacturing**
	CAD Hierarchy, Integrating CAD, NC and CAM, NC programming using G and M codes adoptable to FANUC controller for lathe and milling, Generative programming on CNC, DNC, Adaptive control system, CIM,CAPP.
Unit- V	**Introduction to Automation**
	Types of Automation, Transfer line mechanism, Geneva mechanism, Group Technology, Automated guided Vehicles, Automatic Storage and Retrieval System, Flexible Manufacturing System
Unit-VI	**Robot Technology**
	Classification and Structure of Robotic Systems Point-to-Point Robotic Systems, Continuous Path Robotic System. Configurations of Robotic system, Joints, Drives, Controller, Types of end effectors mechanical, magnetic, pneumatic etc., Industrial Applications of Robots, Robot Programming, Programming Languages
List of Practicals	Eight out of the following (two on CAD based, three on CAE based, three on CAM based and two on robot and R. P.) 1. Developing CAD model of mechanical sub assembly 2. Developing component/ assembly using CAD features. 3. Program on concatenated Transformation involving Three steps. 4. Stress and Deflection Analysis of 2D truss. 5. Stress and Deflection Analysis of Beam. 6. Stress and deflection analysis of plate 2D/3D.[Mechanical Component] 7. Tool path generation for Turning – Grooving and Threading. 8. Tool path generation for Milling – Facing, Pocketing, Contouring and Drilling. 9. Tool path generation of Turn Mill. 10. Tool path generation for Multi Axis Machining. 11. Robot simulation/Robot Gripper Design. 12. Case study on R.P.

Text Books	**Author**	**Title of Book**	**Publication**
T1	Ibrahim Zeid and R. Sivasubramanian	CAD/CAM - Theory and Practice	Tata McGraw Hill Publishing Co. 2009
T2	Seshu P.	Text book of Finite Element Analysis	PHI Learning Private Ltd. New Delhi, 2010.

Reference Books			
R1	Ibr aim Zeid	"Mastering CAD/CAM"	Tata McGraw Hill Publishing Co. 2000
R2	Ch andrupatla T.R. and Belegunda A.D	Introduction to Finite Elements in Engineering"	Prentice Hall India
R3	Groover M.P	Automation, production systems and CAM	Prentice Hall of India
R4	S.R.Deb	Robotics Technology and Flexible Automation,	Tata McGraw Hill.
Self-Learning Facilities, Web Resources, Research papers for reference			
Contents beyond Syllabus	Case study discussions		
Additional Experiments	N.A.		
Bridging Courses	Nil		
Tutorials	N.A.		
Presentations	N.A.		

DYNAMICS OF MACHINERY

Course Title **Dynamics of machinery**		**Course Number:** **C403**	**Course Code:** **402043**
Year: B.E.		**Semester: One**	
Designation of Course		Professional Core	
Teaching Scheme:4Hrs/Week		**Tutorial:** Nil	
Course Assessment Methods	**Direct methods**	In-semester Examination: 30 Marks	End Semester Examination: 70 Marks
			Practical/Oral/Term Work
	Indirect Methods	Assignments	
Prerequisites	Engineering Mechanics, Theory of Machines I . Theory of Machines I I		
Course Objectives			
1	Ability to understand the fundamentals of vibration and Noise		
2	Ability to develop analytical competency in solving vibration problems		
3	Ability to understand measurement and control of vibration and noise		
4	Ability to calculate natural frequencies, Eigen values & Eigen vectors		
5	Ability to measure vibrations, vibration characteristics and understand various method for vibration control for real life problems		
Course Outcomes			
CO1	Illustrate the fundamentals of vibration and Noise		
CO2	Obtain analytical competency in solving vibration problems		
CO3	Understand measurement and control of vibration and noise		
CO4	Calculate natural frequencies, Eigen values & Eigen vectors		
CO5	Measure vibrations, vibration characteristics and understand various methods for vibration control for real life problems		
Course Contents			
Unit-I	**BALANCING**		
	Static and Dynamic Balancing Machines. Balancing Of Rotating Masses In One And Several Planes, Balancing Of Reciprocating Masses In Single And Multi Cylinder Engines: In-Line, Radial And V-Type, Primary And Secondary Balancing Analysis Direct And Reverse Cranks Method,		
Unit-II	**Single Degree Of Freedom Systems - Free And Damped Vibrations**		
	Elements of A Vibratory System, S.H.M., Degrees Of Freedom, Modeling of A System, Concept Of Linear And Non-Linear Systems, Equivalent Spring, Linear And Torsional Systems. **Undamped Free Vibrations:** Natural Frequency By Equilibrium And Energy Methods For Longitudinal And Torsional Vibrations. **Damped Free Vibrations:** Different Types Of Damping, Equivalent Viscous Damping, Free Vibrations With Viscous Damping - Over Damped, Critically Damped And Under Damped Systems, Initial Conditions, Logarithmic Decrement, Dry Friction Or Coulomb Damping - Frequency And Rate Of Decay Of Oscillation		

Unit-III	**Single Degree Of Freedom: Forced Vibrations**
	Forced Vibrations Of Longitudinal And Torsional Systems, Frequency Response Functions - Simple Harmonic Excitation, Excitation Due To Reciprocating And Rotating Unbalance, Base Excitation, Magnification Factor, Resonance Phenomenon And Phase Difference, Quality Factor, Vibration Isolation, Critical Speed Of Shaft Having Single Rotor - Damped And Undamped Systems.
Unit-IV	**Two degree of freedom system :Undamped Vibrations:**
	Free Vibration Of Spring Coupled Systems – Longitudinal And Torsional, Eigen Value Eigen Vector by matrix Frequency And Mode Shapes, Holzer Method, Free Vibration Of Mass Coupled Systems, Geared Systems, Introduction to Physical and Mathematical modeling: Bicycle ,Motor bike & Quarter Car
Unit- V	**Measurement and control of Vibration**
	Force And Motion Transmissibility **Vibration Measurement**: Measuring instruments for displacement, velocity, acceleration and Frequency, Different types of Pick up &Exciters, for Measurement of various systems like geared system. **Vibration Control:** Acceptable Vibrationsstandards, introduction to FFT analyzer, and Machine vibration signature analysis, tuned dynamic vibration absorber control of vibration, control of natural frequency, Vibration isolators, and absorbers Introduction to Torsional damper
Unit-VI	**Introduction to Noise**
	Fundamental of noise, Sound concept, decibels, white noise, weighted sound pressure level, logarithmic addition ,subtraction and averaging, sound intensity,noise measurement ,sound fields octave bands sound reflections, absorptions and transmissions pass by noise Reverberation chamber Anechoic Chamber, Human Exposure to noise & noise standards.
List of Practicals	**Compulsory 01 to 05** 1) Balancing of wheel/roter on computerised balancing machine. 2) To determine the natural frequency of damped vibration of single degree freedom system and to find its damping coefficient. 3) To obtain frequency response curve of single degree of freedom system for different amount of damping 4) 4.To determine natural frequencies of transverse vibration of beam using vibration analyzer. 5) 5.Noise measurement and analysis using vibration analyzer. **Any 03 from following** 6) To determine critical speed of shaft with single rotor 7) To verify natural frequency of torsional vibration of two rotor system & position of node . 8) Experimental verification of principal of dynamic vibration absorber 9) Experiment on shock absorber to plot its characteristic curve. 10) Analysis of machine vibration signature using any analysis software package. **Compulsory assignments** 1)Determination of free response of SDOF damped system to demonstrate different damping condition using suitable software. 2)Determination of total response of SDOF damped system to harmonic excitation using suitable software.

Text Books	**Author**	**Title of Book**	**Publication**
T1	Rao S.S	Mechanical Vibration	Pearson Education Kinderley New Delhi
T2	Grover G.K	Mechanical Vibration	NEM Chand & Bros Roorkee
Reference Books			
R1	Bell L.H Bell D.H	Industrial Noise Control	Marcel Dekker inc
R2	Thomson W.T	Theory of Vibration	CBS Publishers
R3	V.P.Singh	Mechanical Vibration	Dhanpat rai and sons New Delhi
R4	Kelly S.G.	Mechanical Vibration	Tata McGraw Hill Publications
Self-Learning Facilities, Web Resources, Research papers for reference	NPTEL Lectures https://www.youtube.com/playlist?list		
Contents beyond Syllabus	Random Vibration Introduction		
Additional Experiments	N.A.		
Bridging Courses	N.A.		
Tutorials	N.A.		
Presentations	N.A.		

Energy Audit and Management

Course Title: **Energy Audit and Management**		**Course Number:** **C 404**	**Course Code:** **402044A**
Year: B.E.		**Semester:**	
Designation of Course		Elective	
Teaching Scheme: 3 Hrs/Week		**Tutorial:** Nil	
Course Assessment Methods	**Direct methods**	In-semester Examination: 30 Marks	End Semester Examination: 50/70 Marks
			Practical/Oral/Term Work
	Indirect Methods	Assignments	
Prerequisites	Economics, Basic Thermodynamics		
Course Objectives: Following concepts to be taught to the students,			
1	Importance of Energy Management.		
2	How to carry out Energy Audit.		
3	Methods to reduce consumption of energy and save cost.		
4	How to improve energy efficiency of overall system.		
5	Significance of Waste heat recovery and Cogeneration.		
Course Outcomes: At the end of this course the students should be able to			
CO1	Comprehend and review the Energy situation in the country as well as the world.		
CO2	Apply the knowledge of Energy Audit using appropriate instruments and software in any environment.		
CO3	Evaluate financial aspects of the alternatives in the field of Energy.		
CO4	Undertake performance assessment and efficiency improvement in thermal and electrical utilities.		
CO5	Evaluate the environmental and socioeconomic issues related to energy management.		
Course Contents			
Unit-I	: **General Aspects of Energy Management**		
	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-II	**Energy Auditing**		
	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-III	**: Energy Economics**		
	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-IV	**Energy Efficiency in Thermal Utilities**		
	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- V	**Electrical Energy Management and Lighting**		
	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-VI	**: Cogeneration and Waste Heat Recovery**		
	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.		
Text Books	**Author**	**Title of Book**	**Publication**
T1		Energy Performance assessment for equipment and Utility Systems.-Vol. 2,3.4	BEE Govt. of India
T2	Energy Management	W. R. Murphy	Butterworth Heinemann
Reference Books			
R1	Wayne C. Turner	Energy Management Handbook	The Fairmont Press Inc., 5th Edition, Georgia.
R2	Abbi Y. A., Jain Shashank	Handbook on Energy Audit and Environment management	TERI, Press, New Delhi, 2006
R3	Albert Thumann P.E. CEM, William J. Younger CEM	Handbook of Energy Audit	The Fairmont Press Inc., 7th Edition
R4	Anthony L Kohan	Boiler Operator's Guide	McGraw Hill Fourth Edition
R5	Robert L.Loftness	Energy Hand book	Von Nostrand Reinhold Company
Self-Learning Facilities, Web Resources, Research papers for reference	www.enrgymanagertraining.com http://www.bee-india.nic.in		

Contents beyond Syllabus	Case study discussions
Additional Experiments	N.A.
Bridging Courses	Nil
Tutorials	N.A.
Presentations	N.A.

Operation Research

Course Title: OPERATION RESEARCH		**Course Number: C045**	**Course Code: 402045C**
Year: FINAL YEAR(B.E.)		**Semester: FIFTH(07)**	
Designation of Course		Professional Core	
Teaching Scheme: 03 Hrs./Week (Theory).		**Tutorial:** NIL	
Course Assessment Methods	**Direct methods**	In-semester Examination: 30 Marks	End Semester Examination: 70 Marks
			Term Work
	Indirect Methods	Assignments, Presentations	Seminars, Q&A session, Class Test, Group Discussion.
Prerequisites	Knowledge of PHYSICS, BASIC MATHEMATICS.		
Course Objectives			
1	Ability to understand the scope of operations research in engineering industry.		
2	Ability to develop analytical competency in solving optimization functions in Transportation methods for the organization		
3	Ability to understand OR technique for better strategic management of various resources		
4	Ability to calculate optimal solution for various industrial problems.		
5	Ability to learn various cost effective strategies in various applications in industry		
Course Outcomes			
CO1	Illustrate the need to optimally utilize the resources in various types of industries.		
CO2	Apply and analyze mathematical optimization functions to various applications		
CO3	Demonstrate cost effective strategies in various applications in industry.		
CO4	Evaluate various cost effective strategies in various applications in industry.		
CO5	To practice obtaining optimal solution for various industrial project management problems.		
Course Contents			
Unit-I	**Introduction: Operation Research**		
	• 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-II	**Transportation Model**
	• 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-III	**Theory of Games and Investment Analysis**
	• 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-IV	**Inventory Control and Replacement Analysis**
	• 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- V	**Queuing Theory and Sequencing models**
	• 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-VI	**Network Models**
	• 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	**Author**	**Title of Book**	**Publication**
T1	Prem Kumar Gupta, D. S. Hira	Problems in Operations Research: Principles and Solutions	S. Chand, 1991
T2	J. K. Sharma	Operations Research : Theory And Application	Laxmi pub. India
T3	S. D. Sharma	Operations Research	Kedar Nath Ram Nath-Meerut.

Reference Books			
R1	Belegundu	Optimization Concepts and Applications in engineering	Cambridge Uni. Press, India
R2	Hillier F.S., and Lieberman G.J	Operations Research, Eight Edition	Mc. Tata McGraw Hill, India
R3	Ravindran	Engineering optimization Methods and Appliations‖, 2nd edition	Wiley, India
R4	Ravindran Phillips and Solberg	Operations Research Principles and Practice, Second Edition	Mc. WSE Willey,
R5	Hamdy A Taha	Operations Research - An introduction	Pearson Education
Self-Learning Facilities, Web Resources, Research papers for reference	https://www.informs.org/About-INFORMS/What-is-**Operations-Research**		
Contents beyond Syllabus	Case study discussions.		
Additional Experiments	N.A.		
Bridging Courses	N.A.		
Tutorials	N.A.		
Presentations	PPT Presentations.		

BE (MECH)

Semester II

Power Plant Engineering

Course Title: POWER PLANT ENGINEERING		**Course Number: C407**	**Course Code:402047**
Year: B.E.(MECHANICAL)		**Semester: VIII**	
Designation of Course		Professional Core	
Teaching Scheme: 04 Hrs/Week (Theory),02 Hrs/week(Practical)		**Tutorial:** NIL	
Course Assessment Methods	**Direct methods**	In-semester Examination: 30 Marks	End Semester Examination: 70 Marks
			Oral&Term Work
	Indirect Methods	Assignments, Presentations	Quiz, Q&A session,ClassTest, Group Discussion.
Prerequisites	Thermodynamics,Fluid Mechanics,Heat Transfer,Turbo Machines.		
Course Objectives:			
1	Describe sources of energy and various types of power plants.		
2	Analyze different types of steam cycles and estimate efficiencies in a steam power plant. Classify different types of coupled vapor cycles and list the advantages of combined cycles power plant.		
3	Describe basic working principles of gas turbine and diesel engine power plants. Define the performance characteristics and components of such power plants		
4	List the principal components and types of nuclear reactors.		
5	List types, principles of operations, components and applications of steam turbines, steam generators, condensers, feed water and circulating water systems.		
Course Outcomes: At the end of this course the students should be able to			
CO1	decide the appropriate type of power plant Knowledge of the operation, construction and design of various types and components of power plants.		
CO2	select and use different instruments to compute performance parameters of various power plants.		
CO3	Analyse the effect of parameters on performance of power plants		
CO4	Calculate the various factors of plant load and economy		
CO5	Apply Knowledge of environmental aspects of power plants		
Course Contents			
Unit-I	INTRODUCTION		
	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.		

	Practical/Tutorial
	NIL
Unit-II	Thermal Power Plants
	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)
	Practical/Tutorial
	1) Visit to thermal Power plant /Co-generation Power plant or explain working of power plant by using suitable software. 2) Study of FBC system. 3) Study of High Pressure boilers. 4)Trial on Steam Power Plant.
Unit-III	Hydroelectric & Nuclear Power Plants
	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
	Practical/Tutorial 1) Study of Nuclear Power Plants.2)Visit to Hydro Power Plant.
Unit-IV	Diesel &Gas Turbine Power Plants
	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).
	Practical/Tutorial
	1) Trial on Diesel Power Plant
Unit- V	Non Conventional Power Plants
	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.
	Practical/Tutorial
	NIL

Unit-VI	Instrumentation &Environmental Impact		
	A) Power Plant Instrumentation Layout of electrical equipment, generator, exciter, short circuits & limiting methods, switch gear, circuit breaker, power transformers, methods of earthling, 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.		
	Practical/Tutorial		
	1) Study of power plant instruments. 2) Study of Environmental Impact of Power Plants.		
Text Books :-	**Author**	**Title of Book**	**Publication**
T1	P.K.Nag.	Power Plant Engineering	McGraw Hill
T2	E.I.Wakil.	Power Plant Engineering	McGraw Hill
Reference Books :			
R1	Domkundwar & Arora	Power Plant Engineering	Dhanpat Rai &Sons
R2	P.C.Sharma	Power Plant Engineering	Laxmi Publications
R3	R.K.Rajput	Power Plant Engineering	Laxmi Publications
R4	G.D.Rai	Non Conventional Energy Sources	Khanna Publications
R5	S.P.Sukhatme	Solar Enrgy	McGraw Hill
Self-Learning Facilities, Web Resources, Research papers for reference	Web sites on all types of power plants		
Contents beyond Syllabus	NIL		
Additional Experiments	NIL		
Bridging Courses	Guest Lectures From Power Plant Export Persons		
Tutorials	03 (Unit1&2;Unit3&4;Unit5&6)		
Presentations	CD;PPT,Animations.		

Mechanical System Design

Course Title: Mechanical System Design		**Course Number: C408**	**Course Code: 402048**
Year: B.E.		**Semester: Tewo**	
Designation of Course		Professional Core	
Teaching Scheme: 4 Hrs/Week		**Tutorial:** Nil	
Course Assessment Methods	**Direct methods**	In-semester Examination: 30 Marks	End Semester Examination: 70 Marks
			Practical/Oral/Term Work
	Indirect Methods	Assignments	
Prerequisites	Mechine Design I, Machine Design II, Strength of Materials, Theory of Machines I, Theory of Machines II		
Course Objectives			
1	Design a Machine Tool Gearbox		
2	Apply Statistical and Product Design Considerations		
3	Apply Design Principles of Material Handling Systems		
4	To study Design considerations of Cylinders and Pressure Vessels		
5	Apply Design concepts to I. C. Engine components		
6	Understand Optimum Design concepts		
Course Outcomes			
CO1	Use design theory to manage and further develop as an engineer.		
CO2	Determine the appropriate engineering knowledge and methods to solve engineering problems.		
CO3	Design a system, component, or process to meet desired needs within realistic constraints, including economic, environmental, social, political, ethical, health, safety, manufacturability, and sustainability..		
CO4	Identify, formulate, and solve engineering problems.		
CO5	Understand the impact of engineering solutions in a global, economic, environmental, and societal context.		
CO6	Use the technical skills and modern engineering tools necessary for engineering practice		
Course Contents			
Unit-I	**Design of Machine Tool Gearbox**		
	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-II	**Statistical considerations in design**		
	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-III	**Design of Belt conveyer system for material handling**
	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-IV	**Design of Cylinders and Pressure vessels**
	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- V	**Design of I. C. Engine components**
	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-VI	**Optimum Design and DFMA**
	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.
List of Practicals	**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, **2. Assignments** 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 Books	**Author**	**Title of Book**	**Publication**
T1	Bhandari V.B	Design of Machine Elements	Tata McGraw-Hill
T2	Juvinal R.C	Fundamentals of Machine Components Design	Wiley, India
Reference Books			
R1	Shigley J. E. and Mischke C.R	Mechanical Engineering Design Principles of refrigeration	McGraw Hill Pub. Co
R2	M. F. Spotts	Mechanical Design Analysis	Prentice Hall Inc.
R3	Black P.H. and O. Eugene Adams‖	Machine Design	McGraw Hill Book Co. Inc.
R4	Johnson R.C.	Mechanical Design Synthesis with Optimization Applications	Von Nostrand Reynold Pub.
R5	S.K. Basu & D. K. Pal	Design of Machine Tools	Oxford and IBH Pub Co
R6	Rudenko	Material Handling Equipment	M.I.R. publishers, Moscow
R7	P. Kannaiah systems	Design of Transmission	SCIETCH Publications Pvt Ltd.
R8	Mulani, I. G.	Belt Conveyors‖	Company Catalogue
R9	Singiresu S. Rao,	Engineering Optimization: Theory and Practice	John Wiley & Sons
R10	M.V. Joshi, , Mc-	Process Equipment Design	Millan.
R11	--	Design Data	.S.G. College of Technology, Coimbatore.
R12	--	I.S. 2825: Code for unfired pressure vessels.	ISO
Self-Learning Facilities, Web Resources, Research papers for reference	Nil		
Contents beyond	Nil		

Syllabus	
Additional Experiments	N.A.
Bridging Courses	N.A.
Tutorials	N.A.
Presentations	N.A.

Industrial Engineering

Course Title: Industrial Engineering		**Course Number: C 409**	**Course Code: 402049C**
Year: 2015-16		**Semester: II**	
Designation of Course		Elective/	
Teaching Scheme: 4 Hrs/Week		**Tutorial:**	
Course Assessment Methods	**Direct methods**	On-line/In-semester Examination: 30 Marks	End Semester Examination: 70 Marks
			Practical/Oral/Term Work
	Indirect Methods	Assignments, Presentations	
Prerequisites	Manufacturing Process, Engineering Mathematics.		
Course Objectives			
1	To introduce the concepts , principles and framework of contents of Industrial Engineering		
2	To acquaint the students with various productivity enhancement techniques.		
3	To acquaint the students with different aspects of Production Planning and Control and Facility Design.		
4	To introduce the concepts of various cost accounting and financial management practices as applied in industries.		
5	o acquaint the students with different aspects of Human Resource activities and Industrial Safety rules.		
Course Outcomes	Learner will be able to.....		
CO1	Apply the Industrial Engineering concept in the industrial environment		
CO2	Manage and implement different concepts involved in methods study and understanding of work content in different situations.		
CO3	Undertake project work based on the course content.		
CO4	Describe different aspects of work system design and facilities design pertinent to manufacturing industries		
CO5	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.		
Course Contents			
Unit-I	Introduction to Industrial Engineering and Productivity 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 programmer		

	Practical/Tutorial
	Numericals on the basis of various types of productivity and productivity indices
Unit-II	Method Study
	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
	Practical/Tutorial
	Drawing of various flow process charts
Unit-III	Work Measurement
	Work Measurement : 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.
	Practical/Tutorial
	Numericals based on time study and work measurement
Unit-IV	Production Planning and Control
	Introduction : Types of production systems, Need and functions of PPC, Aggregate production planning Capacity Planning, ERP: Modules, Master Production Schedule; MRP I 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
	Practical/Tutorial
	Numericals based on forecasting techniques and inventory control.
Unit- V	Facility Design
	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.

	Practical/Tutorial		
	Numericals based on different types of line balancing		
Unit-VI	Engineering Economy, Human Resource and Industrial Safety		
	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). Industrial Safety: Safety Organisation, Safety Programme, General Safety Rules.		
	Practical/Tutorial		
	Numericals based on break even analysis , contribution and profit volume ratio		
Text Books	**Author**	**Title of Book**	**Publication**
T1	M Mahajan	Industrial Engineering and Production Management	Dhanpat Rai and Co.
T2	O. P. Khanna	Industrial engineering and management	Dhanpat Rai publication
Reference Books			
R1	Introduction to Work Study by ILO, ISBN 978 81-204-1718-2	Introduction to Work Study by ILO, ISBN 978-81-204-1718-2	Oxford & IBH Publishing Company, New Delhi, Second Indian Adaptation, 2008.
R2	H.B. Maynard, K Jell Maynard	Industrial Engineering Hand Book	McGraw Hill Education.
R3	Askin	Design and Analysis of Lean Production System	Wiley, India
R4	Zandin K.B	Most Work Measurement Systems, ISBN 0824709535, CRC Press,2002	CRC Press,2002
R5	Barnes	Motion and time Study design and Measurement of Work	Wiley India
Self-Learning Facilities, Web Resources, Research papers for reference	Nil		
Contents beyond Syllabus	Nil		
Additional Experiments	Nil		
Bridging Courses	Nil		
Tutorials	Nil		
Presentations	Nil		

Finite Element Analysis

Course Title: Industrial Engineering		**Course Number: C 409**	**Course Code: (402050B)**
Year: 2015-16		**Semester: II**	
Designation of Course		Elective/	
Teaching Scheme: 4 Hrs/Week		**Tutorial:**	
Course Assessment Methods	**Direct methods**	On-line/In-semester Examination: 30 Marks	End Semester Examination: 70 Marks
			Practical/Oral/Term Work
	Indirect Methods	Assignments, Presentations	TW: 25
Prerequisites	Mechanics of materials DME I and DME II (Static and dynamic failure theories) Engineering Graphics Fundamentals of Programming Language		
Course Objectives			
1	To familiarize students with the displacement-based finite element method for displacement and stress analysis and to introduce related analytical and computer tools.		
2	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.		
3	To study approximate nature of the finite element method and convergence of results are examined.		
4	It provides some experience with a commercial FEM code and some practical modeling exercises.		
Course Outcomes	Learner will be able to.....		
CO1	Derive and use 1-D and 2-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses.		
CO2	Apply mechanics of materials and machine design topics to provide preliminary results used for testing the reasonableness of finite element results.		
CO3	Explain the inner workings of a finite element code for linear stress, displacement, temperature and modal analysis.		
CO4	Interpret the results of finite element analyses and make an assessment of the results in terms of modeling (physics assumptions) errors, discretization (mesh density and refinement toward convergence) errors, and numerical (round-off) errors.		
Course Contents			
Unit-I	**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.
	Practical/Tutorial
	Programing on simultaneous equation
Unit-II	**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.
	Practical/Tutorial
	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
Unit-III	**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
	Practical/Tutorial
	Static stress concentration factor calculation for a plate with center hole subjected to axial loading in tension using FEA software.
Unit-IV	**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.		
	Practical/Tutorial		
	Numericals based on Integration.		
Unit- V	**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.		
	Practical/Tutorial		
	2D Forced convection problem using FEA software.		
Unit-VI	**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).		
	Practical/Tutorial		
	Modal analysis of any machine component using FEA software.		
Text Books	**Author**	**Title of Book**	**Publication**
T1	Daryl L. Logan	A First Course in the Finite Element Method	Wiley, India
T2	R. D. Cook	Concepts and Applications of Finite Element Analysis,	Wiley, India
Reference Books			
R1	Chandrupatla T. R. and Belegunda A. D.,	Introduction to Finite Elements in Engineering	Prentice Hall India..
R2	Seshu P	Text book of Finite Element Analysis	PHI Learning Private Ltd. New Delhi, 2010.
R3	Bathe K. J.	Finite Element Procedures‖,	Prentice-Hall of India (P) Ltd., New Delhi.
R4	Fagan M. J.	Finite Element Analysis, Theory and Practice‖,	Pearson Education Limited
R5	Kwon Y. W., Bang H.	Finite Element Method using MATLAB‖,	CRC Press, 1997
Self-Learning Facilities, Web Resources, Research papers for reference	NPTEL Lectures		
Contents beyond Syllabus	Programing assignment based on object oriented concept to solve the generalised problems		
Additional	Program to create stiffness matrix for two dimensional element using integral		

Experiments	formulation with matlab
Bridging Courses	Numerical Method
Tutorials	Assignment on Beam element
Presentations	Rayleigh Ritz and Galerking Method