Savitribai Phule Pune University

Faculty of Science and Technology

Syllabus for BE Mechanical Engineering (Sandwich)
2015 Course

Savitribai Phule Pune University, Pune

(2015 course)

BE Mechanical Engineering (Sandwich) Term–I

Code	Subject	Teaching Scheme (Hrs/week)			Examination Scheme					Total Marks	Credits		
		Lect	Tut	Pract	In Sem	End Sem	TW	PR	OR		TH	TW	OR/ PR
402061	Industrial In-plant Training - II #	One contact hour per student per week@			--	--	150	--	100#	**250**		**4**	**2**
402062	Project#				--	--	100		50#	**150**		**4**	**2**
402063	Technical Paper Presentation				--	--	--	--	50$	**50**		-	**2**
402064	Automobile Engineering (Self-Study - III)	--	--	--	30**	70	--	--	--	**100**	**4**	-	-
402065	Plant Engineering and Maintenance (Self-Study - IV)	--	--	--	30**	70	--	--	--	**100**	**4**	-	-
Total of Semester		**Max 60 Hrs**			**60**	**140**	**250**	**--**	**200**	**650**	**8**	**8**	**6**
											22		

@ The contact hours are provided for supervision of students in-plant training and to guide Industrial In plant Training - II, Project and Technical paper presentation.
# Oral based on term work and will be conducted by internal and external examiner. External examiner shall be from industry.
* Common with Mechanical Engineering (Refer BE Mechanical Engineering 2015 course syllabus for the same).
$ Assessment shall be done by internal and external examiners (Presentation required).
** In Sem Examination for Self-Study III and IV shall be taken in the form of assignments or exercises done during the semester.

BE Mechanical Engineering (Sandwich) Term–II

Code	Subject	Teaching Scheme (Hrs/week)			Examination Scheme					Total Marks	Credits		
		Lect	Tut	Pract	In-Sem	End Sem	TW	PR	OR		TH	TW	OR/ PR
402047	Energy Engineering*	3	--	2	30	70	25	--	25	**150**	**3**	-	**1**
402048	Mechanical System Design*	4	--	2	30	70	25	--	50	**175**	**4**	-	**1**
402066	Mechanical Vibrations	4	--	2	30	70	25	--	50	**175**	**4**	-	**1**
402068	Elective - I	4	--	2	30	70	25	--	25	**150**	**4**	-	**1**
402069	Elective - II	3	--	--	30	70		--	--	**100**	**3**	-	-
Total of Semester		**18**	--	**8**	**150**	**350**	**100**	--	**150**	**750**	**18**	-	**4**
											22		

Elective-I		Elective-II	
Code	**Subject**	**Code**	**Subject**
402068A	Computational Fluid Dynamics	**402069**A	Energy Audit and Management
402068B	CAD/ CAM Automation	**402069**B	Operations Research
402068C	Finite Element Analysis	**402069C**	Open Elective**
402068D	Hydraulics and Pneumatics		

Important Notes

1. *In- Sem theory examination will be conducted, approximately one and half month after the commencement of each semester.*
2. *In-Sem theory examination will be based on first three units from syllabus and will be conducted by the University.*

**Open elective – Board of studies (BoS) – Mechanical and Automobile Engineering will declare the list of subjects which can be taken under open elective or any other electives that are being taught in the current semester, to the same level, as elective – IV under Science and Technology faculty or individual college and industry can define new elective with proper syllabus using defined framework of elective IV and GET IT APPROVED FROM BOARD OF STUDIES AND OTHER NECESSARY STATUTORY SYSTEMS IN THE SAVITRIBAI PHULE PUNE UNIVERSITY BEFORE 30th November. Without approval from University statutory system, no one can introduce the open elective in curriculum.

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Savitribai Phule Pune University, Pune
BE Mechanical (Sandwich) (2015 Course)

Course Code: 402061 **Course Name : Industrial In-plant Training-II**

Teaching Scheme:	Credits	Examination Scheme:		
One contact hour per student per week	06 (TW & OR)		TW	150
			OR	100#

Course Objectives:

- To make the student conversant with industrial environment, organizational behavior and professional ethics.
- To understand various industrial aspects viz. manufacturing processes, industrial design, productivity improvement, value engineering, quality control etc.
- To analyze and solve engineering problems by correlating theory with industrial practices.

Course Outcomes:

On completion of the course, students will be able to

- Work in industrial environment with professional ethics.
- Understand various industrial aspects.
- Able to analyze and solve engineering problems.

***** Duration of training in industry: 6 months*****

GENERAL GUIDELINES
TO THE INSTITUTIONS RUNNING MECHANICAL ENGINEERING (SANDWICH) DEGREE COURSES AND TO THE STUDENTS OPTED FOR SANDWICH COURSE

Students shall undergo industrial in-plant Training for the period of 6 months. Students shall be given training in large or medium size manufacturing unit in various departments. Students shall be placed preferably in the industry where he had undergone previous in-plant training. Organizations shall be required to prepare training program beforehand, covering as much as possible from the below mentioned topics depending upon the type of industry. Students shall be asked to complete different assignments in various departments. Students are expected to analyze the problems systematically and offer suggestions / concluding remarks.

The training / assignments may be related to following areas:

1. Machines/ process diagnostics.
2. Quality assurance, quality improvement management.
3. Production planning and control, productivity improvement.
4. Costing and cost control, value engineering study.
5. Material inspection and movement, material management and control.
6. Inventory control, stores, facility planning.
7. Improvement in tool layout, tool selection, machine selection.
8. Maintenance of machines and maintenance of plants, housekeeping, safety precautions.
9. Plant layout, machine layout for minimum travel of the job, man and machine movement study time and motion study problems.
10. Computer based information study for stores, purchases, wastage of material, in process material planning and scheduling, assembly, storage of finish products, dispatch etc.

11. Placing a purchase order for inland/ foreign goods.
12. Import-export procedures.
13. Improvement of human skills, productivity.
14. Incentive schemes, labor laws, factory acts.

Term work shall consist of a comprehensive report based on student's observations, training received and assignments completed during six months of training. The report shall also include drawings, figures, process sheets, machine/ product specifications etc. Sandwich students shall obtain a certificate of successful completion of training from respective industry.

Examination:

Term work assessment shall be done on regular basis. Industry and institute both shall prepare assessment criteria and assessment schedule beforehand. Industry and College supervisors shall monitor the progress of students' during in-plant training. College Supervisor shall receive a confidential assessment report of the student from the industry.

Oral based on term work, shall be conducted after successful completion of training. Internal and external examiners. External examiner shall be from industry.

Savitribai Phule Pune University, Pune
BE Mechanical (Sandwich) (2015 Course)

Course Code: 402062 **Course Name : Project**

Teaching Scheme:	Credits	Examination Scheme:		
One contact hour per student per week	06 (TW & OR)		TW	100
			OR	50#

Course Objectives:

- To apply theory knowledge to solve live industrial problem.
- To understand the methodology to solve industrial problem in a systematic way.
- To develop creativity and innovative approach.

Course Outcomes:

On completion of the course, students will be able to

- Correlate and implement theory knowledge to solve specific industrial problems.
- Develop systematic approach to solve specific industrial problem.
- Competent to face industrial problems.

Student shall decide a suitable project in consultation with the industry authority. The scope of the project shall be such as to complete it within the stipulated training period. Project progress review shall be taken on regular basis by college and industry.
Student shall maintain a project activity book.

Project may be covering following industrial aspects:

1. Manufacturing/Fabrication of a proto-type machine including selection, concept, design, material, manufacturing of the components, assembly of components. Testing and performance evaluation.
2. Improvement of existing machine/equipment/process.
3. Design and fabrication of Jigs and fixtures, dies, tools, special purpose equipment, inspection gauges, measuring instruments for automats.
4. Computer aided design, analysis of components such as stress analysis.
5. Problems related to productivity improvements.
6. Problems related to value engineering.
7. Problems related material handling systems.
8. Energy audit of a section in an organization/plant, Industrial waste and its control.
9. Design of a test rig for performance evaluation of machine device.
10. Product design and development.
11. Detail cost estimation of products.
12. Analytical evaluation and experimental verification of any mechanical engineering problems encountered.
13. Quality systems and management.
14. Low cost automation.

Student shall prepare and submit a detailed report based on project work.

Examination:

The oral examination shall be based on the Project work. The examination shall be conducted by an internal and an external examiner (External Examiner shall be from industry).

Savitribai Phule Pune University, Pune
BE Mechanical (Sandwich) (2015 Course)

Course Code: 402063 **Course Name : Technical Paper Presentation**

Teaching Scheme:	Credits	Examination Scheme:		
One contact hour per student per week	02		OR	50[$]
			TW	--

Course Objectives:

- To develop interest in research and advanced technology.
- To encourage the student to study new trends in engineering research.
- To develop competency in understanding research in different areas of engineering.
- To develop communication and presentation skills.

Course Outcomes:

On completion of the course, students will be able to

- Understand advanced technology and research in engineering.
- Communicate and present the work effectively.

A Technical paper presentation is expected to be on a state-of-the-art technical topic related to Mechanical Engineering but outside the syllabus (extension of syllabus). The report and its presentation should be based on literature, collected and analyzed mainly from the latest research papers published in reputed national and international technical journals. (Minimum 3 research papers are to be submitted along with the report).

Report	Number of pages 15 to 20 (Soft copy and 1 hardcopy) Excluding a) Title b) Certificate c) Acknowledgement d) Abstract e) Index f) References. (Web site names should not be mentioned)
Text	Font size – 12 Font type – Times New Roman Spacing – 1.5
Binding	Spiral Binding
Page size	A 4
Internal assessment	One midterm presentation by the student on the assigned topic
Examination	Two examiners, one internal and one external examiner. External examiner shall be from Academics / Research Institutes. Assessment shall be equally based on Report and Presentation / question answers (Oral). Time allowed for Presentation - Maximum 10 minutes, Question/Answer- Maximum 5 minutes

Savitribai Phule Pune University, Pune
BE Mechanical (Sandwich) (2015 Course)

Course Code: 402064 **Course Name : Automobile Engineering (Self-Study - III)**

Teaching Scheme:	Credits	Examination Scheme:		
Theory: Self Study	04	Theory:	In-Sem	30**
			End-Sem	70

Pre-requisite:

Engineering Mechanics, Theory of machines, Thermodynamics, Basics of electronics

Course Objectives:

- To make the student conversant with fundamentals of Automobile systems.
- To develop competency in understanding different automobile systems, its development and performance.
- To make the student conversant with the automobile safety, automobile electronics and performance testing of automobiles.
- To understand the various off road vehicles.

Course Outcomes:

On completion of the course, students will develop

- Ability to understand the fundamentals of Automobile systems.
- Ability to understand Automobile systems, its development and performance.
- Ability to analyze automobile safety, automobile electronics and performance testing of automobiles.
- Ability to understand construction and working of off road vehicles.

Course Contents

Unit 1: Introduction to Automobile Bodies

Automobile history and development, Classification, vehicle layout- engine location and drive arrangement, vehicle specifications.

Vehicle Chassis System: Types of vehicle bodies, types of Chassis (backward, forward, semi-forward controlled etc.), constructional details of chassis, frames, sub frames, frameless vehicles, defects in frames, vehicle dimensions, details of chassis material, Vehicle Classifications as per AIS.

Axle: Constructional details of front axle and rear axle, live and dead axles, live axle arrangement, single, double and triple reduction rear axle.

Unit 2: Automobile Transmission Systems

Clutch: Clutch Components (constructional details, materials, and types), various types of clutches, and different types of clutch actuations.

Gear Box: Gearbox necessity, functions of all resistances, tractive effort, performance curves, power required for acceleration and gradability, selection of gear ratio (numerical treatment), Types of gear box, Fluid flywheel and Torque convertor, CVT, IVT, overdrive.

Transmission Line: Effect of driving thrust and torque reaction, Propeller Shaft, Universal joints, final drive and its types, differential and its types.

Wheels and Tyres: Different types of wheels with Constructional details, Requirement of Wheel alignment and wheel balancing, types of tyres, tyre construction, tread design, failures and its causes.

Unit 3: Steering, Suspension and Brakes:

Steering Systems: Steering mechanism, under-steer and over-steer, steering geometry, center point steering, cornering force, slip angle, scrub radius, steering characteristic, steering gearbox, Power steering, collapsible steering.

Suspension Systems: Sprung and un-sprung mass, roll center, factors affecting ride comfort, types of suspension linkages, type of springs (leaf, coil, air springs and torsion bar springs), damping and shock absorbers, rubber suspension, independent suspension, hydro elastic suspension, self-leveling suspension (active suspension), hydro gas suspension.

Brakes: Types of brake systems (drum, disc), constructional details, Operation- mechanical, hydraulic, air brakes, servo and power braking, Stopping distance, Factors affecting brake performance, ABS.

Unit 4: Automobile Safety and Electronics

Role of safety systems in automobiles, Active and passive safety, crashworthiness, Types of impacts, crash/roll over, importance of ergonomics in automobile safety, pedestrian safety and its importance, types of head restraints, air bags, seats, safety glass, mirrors, importance of bumpers, AIS regulations as per CMVR.

Fundamental of automotive electronic, Basic electronic control, Digital engine control system, Components of engine management system, Basic sensors arrangements and types, Automotive traction control, Automotive lamps and indicators, types, Horn, Windscreen wiper, Speedometers etc, Resent treads in automotive.

Unit 5: Vehicle Performance and Testing

Vehicle performance parameters, road resistance, traction and tractive efforts, power requirement for propulsion, road performance curves, Stability of vehicles, SAE vehicle axis system, vehicle body moments, roll over.

Vehicle road test, free acceleration test, coast down test, wheel test, Types of test tracks (high speed, pavement, corrugated, mud, steering, gradient etc.), different laboratory testing (testing on chassis dynamometers, accelerated virtual Evaporative emission , oil consumption etc.), crash testing and it's types, breaking distance test, battery testing, endurance testing.

Unit 6: Off-Road Vehicles

Constriction layout and application of off-road machine, multi-axle vehicles, different types of bulldozers, hydraulic dozers, dump truck-loaders, tankers and dumpers (single bucket, multi buckets and rotary type). General description, specification and function of light, medium and heavy wheeled tractors, constriction details of transport vehicle.

Reference Books:

1. K. Newton and W. Seeds, T. K. Garrett, "Motor Vehicle", 13th Edition, Elsevier publications.
2. Dr. Kripal Singh, "Automobile Engineering - Vol. 1", Standard publishers Distributors.
3. N. K. Giri, "Automobile Engineering", Khanna publications, Delhi.
4. Goering C. E., D. W. Smith, P. K. Turnquist, St. Joseph Mich , "Off-Road Vehicle Engineering Principles", ASAE 2005.
5. SAE Manuals and Standards.

Savitribai Phule Pune University, Pune
BE Mechanical (Sandwich) (2015 Course

Course Code: 402065 Course Name : Plant Engineering and Maintenance (Self-Study - IV)

Teaching Scheme:	Credits	Examination Scheme:		
Theory: Self Study	04	Theory:	In-Sem	30**
			End-Sem	70

Pre-requisite:

Basic Mechanical Engineering, Manufacturing Engineering, Industrial organization

Course Objectives:

- Basic principles of plant Engineering.
- Various plant facilities and layout planning.
- Maintenance management practices.
- Preventive maintenance and life cycle costing.
- General procedure for failure analysis and plant safety aspects.
- Advanced topics in maintenance engineering.

Course Outcomes:

On completion of the course, students will develop

- Understand basic principles of plant engineering, classify maintenance work and able to perform manpower planning.
- Identify basic plant facilities and selection of layout for product/process engineering.
- Identify maintenance problems and calculate machine availability and system downtime.
- To understand product life cycle cost estimation.
- Learn steps to be followed for failure analysis and conservation of plant safety.
- Understand advanced techniques in maintenance engineering.

Course Contents

UNIT 1: Organization of Plant Engineering

Principles of Plant management functions, Classification of maintenance work, routine maintenance, emergency work, service work, preventive maintenance. Project work, Corrective work, Assessment of maintenance work. Performance and productivity measurement; problem solving techniques. Manpower planning and training for maintenance and safety staff.

UNIT 2: Plant Facilities and Layout Planning

Basic Plant facilities, (a) Building: Types of Building structures, Ventilation and lighting, Roads and parking. (b) Electrical power generation, distributions, utilization, stand by units. (c) Heating, ventilation and Air conditioning. (d) Water supply, Purification, use and disposal. (e) Sanitation. (f) Planning and estimation of auxiliary services, such as water, steam, compressed air.

Layout of facilities-Types of layouts, selection of layout. Group technology aspect. P. Q. Analysis, PQRST analysis, material flow, REL charts, space requirements, space diagram. Use of computer for optimization of layouts. Muther's plant layout procedure, Layout generation using REL chart.

UNIT 3: Maintenance Management Practices

Objectives of maintenance, Types of maintenance, breakdown, preventive, periodic or predictive, condition based maintenance as predictive preventive maintenance. Maintainability, factors affecting maintainability, system down time, availability - inherent, achieved and operational availability.

Online or off-line, concept of health as well as usage monitoring. Quantitative decision making for selection of maintenance system & management classification of material, MICLASS, CUSDD,

Software for Classification and Coding. Maintenance problems occurring in product and process type industries and Power plants and their management.

Spare Parts Management- Simulation and Software needed for spare parts management and inventory planning.

UNIT 4; Preventive Maintenance and Life Cycle Costing

Periodic Preventive Management - Scheduled maintenance and period for P.M. Life cycle cost taking into consideration maintenance, reliability, hazard function etc. Life cycle costing: Rigorous models, mathematical formulation etc.

UNIT 5: Failure Analysis and Plant Safety issues

Failure Analysis: Need and scope of failure analysis and prevention, Engineering disasters and understanding failures, Fundamental sources of failures, Industrial engineering tools for failure analysis: Pareto diagram, Fishbone diagram and FMEA, Fault tree analysis, Reliability-I, General procedure of failure analysis.

Plant safety -fire protection and prevention, safety against mechanical hazards, chemical hazards, accident prevention practices and codes. Pollution control-Waste disposal, existing limiting norms. Recycling of waste.

UNIT 6: Advancements in Maintenance Engineering

Condition based maintenance using vibration signature, SOAP, ferrography, Infra-red Camera, fluorescent dye, Particle Analyzers and other diagnostic techniques. Reliability Centered Maintenance (RCM).

Total Productive Maintenance: Organization, merits and demerits, Terotechnology and its influence on plant engineering and maintenance, specific application areas, Overall effectiveness of equipment (OEE), Design for maintainability and its considerations, Reliability and costs, Costs of Unreliability.

Text Books:

1. A. K. Gupta,"Terotechnology and Reliability Engineering", McMillan Publications.
2. B. Bhadury and S. K. Basu, "Terotechnology: Reliability Engineering and Maintenance Management", Asian Books, New Delhi 2002.
3. Sushikumar Srivastava, "Industrial Maintenance Management" S. Chand and Co. Ltd., New Delhi.
4. H.P. Garg, "Industrial Maintenance", S. Chand and Co. Ltd., New Delhi.
5. L.S.Srinath, Reliability Engineering, EWP, 4th Edition 2011.

Reference Books:

1. A. K. S. Jardine, "Maintenance, Replacement & Reliability" HMSO, London.
2. R. A. Collacatt, "Mechanical fault Diagnosis and Condition Monitoring", Chapman and Hall Ltd.
3. Higgin L. R., "Handbook of Maintenance Engineering", McGraw Hill, 2002.
4. Rudenko N., "Material Handling equipment" MIR Publications Mascow.
5. Edward Srivastava- Maintenance Management.
6. R.C. Rosaler, "Handbook of Plant Engineering" - McGraw Hill.
7. Becker et al. Failure analysis and prevention, ASM Handbook (2002)
8. Hutching et al. Failure analysis, ASM International (1981) Besterfield et al. Total quality management, Pearson (2002)
9. H. B. Maynard, K Jell, Maynard's Industrial Engineering Hand Book, McGraw Hill.

Savitribai Phule Pune University, Pune
BE Mechanical (Sandwich) (2015 Course)

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

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

Course Objectives:

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

Course Outcomes:

On completion of the course, students will develop

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

Course Contents

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

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

B) Thermal Power Plant: General layout of modern thermal power plant with different circuits, site selection criteria, classification of coal, coal blending, coal beneficiation, selection of coal for thermal power plant, slurry type fuels, pulverized fuel handling systems, fuel burning methods, FBC systems, high pressure boilers, ash handling system, Rankine cycle with reheat and regeneration (Numerical Treatment), steam power plants with process heating (Numerical Treatment)

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

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

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

UNIT 3: Hydroelectric and Nuclear Power Plant 6 Hrs

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

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

UNIT 4: Diesel and Gas Turbine Power plant 6 Hrs

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

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

UNIT 5: Non-Conventional Power Plants 6 Hrs

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

Geothermal Plant: superheated steam system, flash type, binary cycle plant **Tidal Power Plant:** components, single basin, double basin systems **OTEC Plant:** principal of working, Claude cycle, Anderson Cycle, **MHD Power Generation:** Principal of working, Open Cycle MHD generator, closed cycle MHD generators **Fuel cell:** alkaline, acidic **Wind Power Plant:** wind availability, wind mills and subsystems, classification of wind turbines, operating characteristics, wind solar hybrid power plants, challenges in commercialization of non-conventional power plants, environmental impacts of NCPP

UNIT 6: Instrumentation and Economics of Power Plant 6 Hrs

A) Power Plant Instruments: Layout of electrical equipment, switch gear, circuit breaker, power transformers, methods of earthling, protective devices

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

Text Books:

1. Domkundwar & Arora, Power Plant Engineering, Dhanpat Rai & Sons, New Delhi
2. Domkundwar & Domkundwar- Solar Energy and Non-Conventional Sources of Energy, Dhanpat Rai& Sons, New Delhi.
3. R.K.Rajput, Power Plant Engineering‖, Laxmi Publications New Delhi.

4. D.K.Chavan & G.K.Phatak, Power Plant Engineering‖, Standard Book House, New Delhi.

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

Term Work shall consist of following assignments:

IMP Notes for Term Work:

Any Eight Experiment should be conducted (*from Experiment No. 1 to 10*) and *Experiment No 1, 2, 7,* and *8* are compulsory

Experiment No: 3 - 9 can be performed using suitable simulation software

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

Savitribai Phule Pune University, Pune
BE Mechanical (Sandwich) (2015 Course)

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

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

Pre-requisite:

Manufacturing Process, Strength of Materials, Machine design, Engineering Mathematics, Theory of Machines, 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 analyse the defects and failure modes in components

Course Outcomes:

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

- Understand the difference between component level design and system level design.
- 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 handle system level projects from concept to product.

Course Contents

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

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

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

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

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

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

Belt conveyors, Flat belt and troughed belt conveyors, capacity of conveyor, rubber covered and fabric ply belts, belt tensions, conveyor pulleys, belt idlers, tension take-up systems, power

requirement of horizontal belt conveyors for frictional resistance of idler and pulleys.

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

Design of Cylinders:

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

Design of Pressure vessel:

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

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

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

UNIT 6: Optimum Design **8 Hrs**

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

Text Books:

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

Term Work shall consist of following assignments:

1. One design project

The design project shall consist of two imperial size sheets (Preferably drawn with 3D/2D CAD software) - one involving assembly drawing with a part list and overall dimensions and the other

sheet involving drawings of individual components, manufacturing tolerances, surface finish symbols and geometric tolerances must be specified so as to make it working drawing. A design report giving all necessary calculations of the design of components and assembly should be submitted. Projects shall be in the form of design of mechanical systems including pressure vessel, conveyor system, multi speed gear box, I.C engine, etc.

Each Student shall complete any one of the following assignments.

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

Savitribai Phule Pune University, Pune
BE Mechanical (Sandwich) (2015 Course)

Course Code: 402066 **Course Name: Mechanical Vibrations**

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

Pre-requisites:

Engineering Mechanics, Theory of Machines and Engineering Mathematics - III

Course Objectives:

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

Course Outcomes:

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

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

Course Contents

UNIT 1: Single Degree of Freedom Systems – Free Vibration **8 Hrs**

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

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

UNIT 2: Single Degree of Freedom Systems – Damped Free Vibration **8 Hrs**

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

UNIT 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 rotating and reciprocating unbalance, base excitation, magnification factor, Force and Motion transmissibility, Quality Factor. Half power band with method, Critical speed of shaft having

single rotor of un-damped systems.

UNIT 4: Two Degree of Freedom Systems-Un-damped Vibrations **8 Hrs**

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

Unit 5: 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 6: Measurement and Control of Vibrations **8 Hrs**

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

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

Text Books:

1. Rao S. S. "Mechanical Vibrations", Pearson Education Inc. Dorling Kindersley (India) Pvt. Ltd.
2. Grover G. K. "Mechanical Vibrations", Nem Chand and Bros., Roorkee
3. Wiiliam J Palm III, "Mechanical Vibration" Wiley India Pvt. Ltd, New Delhi
4. UickerJ.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 P Ltd., New Delhi

Reference Books:

1. Weaver, "Vibration Problems in engineering" ,5th Edition Wiley India Pvt. Ltd, New Delhi.
2. Alok Sinha, "Vibration of Mechanical System", Cambridge university Press , India
3. Dr Debabrata Nag, "Mechanical Vibrations", Wiley India Pvt. Ltd, New Delhi.
4. Kelly S. G. "Mechanical Vibrations", Schaum_s outlines, Tata McGraw Hill Publishing Co.Ltd., New Delhi.
5. Meirovitch, "Elements of Mechanical Vibrations", McGraw Hill
6. Ver, "Noise and Vibration Control Engineering", Wiley India Pvt. Ltd, New Delhi
7. Shrikant Bhave, "Mechanical Vibrations Theory and Practice", Pearson, New Delhi

List of Experiments:

A] Compulsory Experiments (Sr. No. 1 to 5)

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

B] Any Three Experiments from the following:

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

C] List of Compulsory Assignment:

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

OR

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

Savitribai Phule Pune University, Pune
BE Mechanical (Sandwich) (2015 Course)

Course Code:402068A **Course Name: Computational Fluid Dynamics (Elective - I)**

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

Pre-requisites:

Fluid Mechanics, Heat transfer, Numerical methods, Programming Languages.

Course Objectives:

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

Course Outcomes:

On completion of the course, students will have

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

Course Contents

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

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

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

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

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

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

UNIT 4: Solution to Convection-Diffusion Equations **6 Hrs**

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

UNIT 5: Solution to Navier – Stokes Equations **6 Hrs**

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

UNIT 6: Introduction to Turbulence Modeling **2 Hrs**

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

Text Books:

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

Reference Books:

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

Term Work shall consist of following assignments:

Practical’s to be performed: Minimum 7 including

- Any three practical’s with programming (*from practical No. 1 to 8*) and
- Any three practical in Open source or Commercial Software (*from practical No. 9 to 13*)
- Mini project (*practical No.14*) in Open source or Commercial Software tool

1. 1D steady state conduction using finite volume method
2. 1D Unsteady state conduction using finite volume method
3. 2D steady state conduction using finite volume method
4. 2D Unsteady state conduction using finite volume method
5. 2D Advection using finite volume method
6. 1D conduction convection problem using finite volume method
7. 1D conduction convection problem using finite volume method
8. Solution of Navier Stokes equation using SIMPLE algorithm for Lid Driven Cavity flow problem
9. Numerical simulation and analysis of boundary layer over a flat plate (Blausius Equation) are using any CFD software.
10. Numerical simulation and analysis of boundary layer for a
    a) Developing flow through Pipe

b) Fully developed flow through a pipe.

11. CFD Analysis of external flow: Circular Cylinder or Aerofoil (NACA 0012)
12. CFD analysis of heat transfer in pin fin.
13. Numerical simulation and analysis of 2D square lid driven cavity using any CFD software. Effect of Reynolds number on the vorticity patterns.
14. Mini project on any practical application. Students should take a problem of their choice and verify the CFD solution with experimental data / research paper.(Mandatory)

Savitribai Phule Pune University, Pune
BE Mechanical (Sandwich) (2015 Course)

Course Code: 402068 B **Course Name: CAD CAM and Automation (Elective- I)**

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

Pre-requisites:

Engineering Mathematics, Computer Aided Machine Drawing, Advanced Computer Aided Engineering, MATLAB

Course Objectives:

The purpose of this course is to make the students to get familiarized with various computer aided tools that can be implemented in various industrial applications

Course Outcomes:

After this course students can able to

- Design various curves and surfaces. Develop MATLAB program for various curves.
- Distinguish different approaches of CAPP and understand criteria for selecting CAPP system.
- Explain Reverse Engineering and use of CMM.
- Understand concept of CIM and scope of CIM in industry.
- Understand concept of LEAN Manufacturing.
- Understand Concept of Internet of Things (IoT).

Course Contents

UNIT 1: Design of Curves & Surfaces: 6 Hrs

Design of Curves: Analytic Curves, PC curve, Ferguson, Composite Ferguson, curve Trimming and Blending, Bezier segments, de Casteljau's algorithm, Bernstein polynomials, Bezier- subdivision, Degree elevation, Composite Bezier, Splines, Polynomial Splines, B-spline basis functions, Properties of basic functions, Knot Vector generation, NURBS.

Design of Surfaces: Differential geometry, Parametric representation, Curves on surface, Classification of points, Curvatures, Developable surfaces, Surfaces of revolution, Intersection of surfaces, Surface modelling, 16-point form, Coons patch, B-spline surfaces.

UNIT 2: Computer Aided Process Planning 6 Hrs

Role of process planning in CAD/CAM Integration – Computer Aided Process Planning –Development, Benefits, Model and Architecture – CAPP Approaches – Variant, Generative and Hybrid – Process and Planning systems – CAM-I, D-CLASS and CMPP – Criteria in selecting a CAPP System.

UNIT 3: Computer Aided Inspection 6 Hrs

Engineering Tolerances – Need for Tolerances – Conventional Tolerances – FITS and LIMITS – Tolerance Accumulation and Surface quality – Geometric Tolerances – Tolerances Practices in design, Drafting and manufacturing – Tolerance Analysis – Tolerance synthesis – Computer Aided Quality control – Contact Inspection Methods – Non Contact Inspection Methods - Non optical and optical.

UNIT 4: Reverse Engineering **6 Hrs**

Scope and tasks of Reverse Engineering – Domain Analysis – Process Duplicating – Tools for RE – Developing Technical data – Digitizing techniques – Construction of surface model – Solid part model – Characteristic evaluation – Software's and its application – CMM and its feature capturing – surface and solid modelling.

Unit 5: Data Management **6 Hrs**

Strategies for Reverse Engineering Data management – Software application – Finding renewable software components – Recycling real time embedded software – Design experiments to evaluate a RE tools – Rule based detection for RE user interface – RE of assembly programs

Unit 6: Introduction To The Internet Of Things (IoT) **6 Hrs**

Introduction, Internet of Things Concepts, Internet of Things Framework, Information and Communication Technology, Infrastructure, Derived Qualities of Modern ICT, Potential for Product, Process, and Business Model Innovations, Implications and Challenges

Future Trends in Manufacturing Systems (06 Hours)

Lean Manufacturing: Definition, Principles of Lean Manufacturing, Characteristics of Lean Manufacturing, Value of Product, Continuous Improvement, Focus on Waste, Relationship of Waste to Profit, Four Functions of Lean Production, Performance Measures, The Supply Chain, Benefits of Lean Manufacturing. Introduction to Agile and Web Based Manufacturing systems.

Text Books:

1. Groover M.P and E W Zimmer.-CAD/CAM Computer Aided Design and Manufacturing Prentice Hall of India
2. Ibrahim Zeid and R. Sivasubramanian, "CAD/CAM Theory and Practice", Revised First special Indian Edition, Tata Mc Graw Hill Publication, 2007

Reference Books:

1. Catherine A. Ingle, "Reverse Engineering", Tata Mc Graw Hill Publication, 1994
2. David D. Bedworth, Mark R. Henderson, Philp M. Wolfe, "Computer Integrated Design and manufacturing", Mc Graw Hill International series, 1991
3. Donald R. Honra, "Co-ordinate measurement and reverse Engineering, American Gear Manufacturers Association.
4. Ibrahim Zeid, "Mastering CAD/CAM", special Indian Edition, Tata Mc Graw Hill Publication, 2007
5. Linda Wills, "Reverse Engineering" Kluwer Academic Press, 1996
6. Internet of Things A to Z: Technologies and Applications, edited by Qusay F. Hassan, IEEE Press, Wiely
7. Groover M.P.-Automation, production systems and computer integrated manufacturing 'Prentice Hall of India

Term Work shall consist of following assignments:

1. Demonstration of Application Programming Interface (API).
2. MATLAB program for any analytic curve.
3. MATLAB Program for any synthetic curve.
4. Assignment on Computer Aided Process Planning
5. Case study on Reverse Engineering.
6. Case study on Internet of Things(IoT)
7. Assignment on Geometric modelling and tolerances(GD & T)
8. Industrial visit on CIM

Savitribai Phule Pune University, Pune
BE Mechanical (Sandwich) (2015 Course)

Course Code: 402068C **Course Name: Finite Element Analysis (Elective- I)**

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

Pre-Requisites:

Strength of Materials, DME I and DME II (Static and dynamic failure theories), Engineering Mathematics & Numerical Methods, Heat Transfer, Dynamics of Machinery, Fundamentals of Programming Language

Course Objectives:

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

Course Outcomes:

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

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

Course Contents

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

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

Brief history of FEM, Finite Element terminology (nodes, elements, domain, continuum, degrees of freedom, loads & constraints), general steps involved in FEM, applications of FEM in various fields, advantages and disadvantages of FEM, consistent units system, essential and natural boundary conditions, symmetric boundary conditions.

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

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

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

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

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

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

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

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

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

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

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

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

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

Numerical integration –Gauss Quadrature in 1 & 2 dimension, Order of Gauss integration, full and reduced integration, sub-modeling, substructuring.

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

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

UNIT 6: Dynamic Analysis **6 Hrs**

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

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

Text Books:

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

Reference Books:

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

The term work shall consist of record of any three from 1 to 4* and any three from 5 to 9 assignments of the problems based on following topic:**

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

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

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

*3. Validate results of the program with analytical method or 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.

Savitribai Phule Pune University, Pune
BE Mechanical (Sandwich) (2015 Course)

Course Code: 402068D **Course Name : Hydraulics and Pneumatics (Elective- I)**

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

Pre-requisites:

Fluid Mechanics, Manufacturing Processes and Machines, Mechatronics

Course Objectives:

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

Course Outcomes:

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

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

Course Contents

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Text Books:

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

Reference Books:

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

Term Work shall consist of following experiments and assignments:

1. Test on Gear/Vane/Piston pump and plotting performance characteristics
2. Following experiments to be done on hydraulic trainer (any 3)
   a. Regenerative circuit
   b. Speed control circuit
   c. Sequencing circuit
   d. Traverse and feed circuit etc.
3. Following experiments to be done on pneumatic trainer (any 3)
   a. Automatic reciprocating circuit
   b. Speed control circuit
   c. Pneumatic circuit involving Shuttle valve/ Quick exhaust valve / Two pressure valve
   d. Electro pneumatic circuits
4. Test on pressure relief valve/flow control valve

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

Savitribai Phule Pune University, Pune
BE Mechanical (Sandwich) (2015 Course)

Course Code: 402069A **Course Name: Energy Audit and Management (Elective- II)**

Teaching Scheme:	Credits	Examination Scheme:		
Theory: 03 hrs per week	03	Theory:	In-Sem	30
			End-Sem	70

Course Objectives:

Following concepts to be taught to the students,

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

Course Outcomes:

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

- Compare energy scenario of India and World.
- Carry out Energy Audit of the Residence / Institute/ Organization.
- Evaluate the project using financial techniques
- Identify and evaluate energy conservation opportunities in Thermal Utilities.
- Identify and evaluate energy conservation opportunities in Electrical Utilities.
  Identify the feasibility of Cogeneration and WHR

Course Contents

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

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

UNIT 2: Energy Audit **6 Hrs**

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

UNIT 3: Energy Economics **6 Hrs**

Costing of Utilities- Determination of cost of steam natural gas, compressed air and electricity, Financial Analysis Techniques (Numerical) - Simple payback, Time value of money, Net Present Value(NPV), Return on Investment (ROI), Internal Rate of Return (IRR), Risk and Sensitivity analysis.

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

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

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

Electricity billing, Electrical load management and maximum demand control, penalties, Power factor improvement and benefits, Selection and location of capacitors. Distribution and

transformer losses, Electrical motors- types, efficient motors, Introduction of Electricity recommended illumination levels, Lighting improvement (Numerical) efficiency and selection, Speed control, Energy Act 2003,Lamp types and their features, system performance assessment and efficiency

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

Cogeneration- Need, applications, advantages, classification, Introduction to Tri-generation, Waste heat recovery- Classification, Application, Concept of Pinch analysis, Potential of WHR in Industries, Commercial WHR devices, saving potential. CDM projects and carbon credit calculations.

Case study - Energy Audit of Institute/Department.

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

Savitribai Phule Pune University, Pune
BE Mechanical (Sandwich) (2015 Course)

Course Code: 402069B **Course Name : Operation Research (Elective- II)**

Teaching Scheme:	Credits	Examination Scheme:		
Theory: 03 hrs per week	03	Theory:	In-Sem	30
			End-Sem	70

Course Objectives:

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

Course Outcomes:

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

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

Course Contents

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

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

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

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

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

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

Replacement Analysis - Replacement of Items that Deteriorate, Replacement of Items that Fail Suddenly.

UNIT 4: Project Management **6 Hrs**

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

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

Queuing Theory - Introduction, Basis Structure, Terminology (Kendal's Notations) and Applications. Queuing Model M/M/1: /FIFO, M/M/c. Sequencing models: Solution of sequencing Problem - Processing of n jobs through two machines, Processing of n jobs through three machines, Processing of two jobs through m Machines, Processing of n jobs through m Machines

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

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

Text Books:

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

Reference Books:

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