

SYLLABUS FOR B.E. VII AND VIII SEMESTER

(With effect from 2018- 19 Academic year)

**BACHELOR DEGREE
IN
DEPARTMENT OF MECHANICAL ENGINEERING
OUT COME BASED EDUCATION**



**P.E.S. COLLEGE OF ENGINEERING,
MANDYA - 571 401, KARNATAKA**

*(An Autonomous Institution Affiliated to VTU, Belagavi)
Grant -in- Aid Institution (Government of Karnataka)*

PREFACE

PES College of Engineering, Mandya, started in the year 1962, has become autonomous institute in the academic year 2008-09. Since, then it has been doing the academics and assessment activities successfully. The college is running eight undergraduate and eight Postgraduate programs including MBA and MCA which are affiliated to VTU, Belagavi.

India has recently become a Permanent Member of the Washington Accord. The accord was signed by the National Board of Accreditation (NBA) on behalf of India on 13th June 2014. It enables not only the mobility of our degree globally but also establishes equivalence to our degrees with that of the member nations. The implementation of Outcome Based Education (OBE) has been the core issue for enabling the equivalence and of Indian degrees and their mobility across the various countries.

Our Higher Educational Institution has adopted the Choice Based Credit System (CBCS) based semester structure with OBE scheme and grading system. Which provides the flexibility in designing curriculum and assigning credits based on the course content and hours of teaching. There lies a shift in thinking, teaching and learning process moving towards Students Centric from Teachers Centric education which enhances the knowledge, skills and moral values of each student.

Choice Based Credit System (CBCS) provides the options for the students to select from the number of prescribed courses. The CBCS provides a 'cafeteria' type approach in which the students can Choose electives from a wide range of courses of their choice, learn at their own pace, undergo additional courses and acquire more than the required credits, adopt an interdisciplinary approach for learning which enables integration of concepts, theories, techniques. These are greatly enhances the skill/employability of students.

In order to increase the Industry/Corporate readiness, many Soft Skills, self learning components and Personality Development modules have been added to the existing curriculum. In order to enhance creativity and innovation Mini Project and Industrial visit and Interaction are made mandatory for all undergraduate programs.

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College Vision

“A leading institution imparting quality engineering and management education developing creative and socially responsible professionals”

College Mission

Mission of P E S College of Engineering is to,

- Provide state of the art infrastructure, motivate the faculty to be proficient in their field of specialization and adopt best teaching-learning practices.
- Impart engineering and managerial skills through competent and committed faculty using outcome based educational curriculum.
- Inculcate professional ethics, leadership qualities and entrepreneurial skills to meet the societal needs.
- Promote research, product development and industry-institution interaction.

About Department of Mechanical Engineering

The Department of Mechanical Engineering was established in the year 1962 during the origination of the institute. The department was granted academic autonomy in the year 2009. The department presently offers B.E in Mechanical Engineering, M Tech in Machine Design, M.Sc., (Engg.) by research and research leading to Ph.D. The present intake capacity of the department is 180 for BE, 24 for M Tech Machine Design. The department has a faculty-student ratio of 1:15 for UG courses and 1:12 for PG courses. The department has well established laboratories to meet the academic requirements of UG and PG programmes and a skilled technical faculty to train the students. The department has its own library which has a collection of about 4600 reference books.

The department is accredited with NBA for 3Years in 2019.

The department regularly organizes industrial visits, technical talk by experts from industries and institutes in contemporary areas to bridge the gap between syllabi and current corporate developments. The students are encouraged to undergo industrial training as well as to take up industry oriented projects during their academic course. Mechanical Engineering Association (MEA), formed by the students and faculty of the department regularly organizes co-curricular and extracurricular activities for the students.

Department Vision

“Be a department well recognized for its ability to develop competent mechanical engineers capable of working in global environment”

Department Mission

The Mission of the Department of Mechanical Engineering is to:

- Provide quality education by competent faculty.
- Provide adequate infrastructure and learning ambience for the development of essential technical skills.
- Inculcate a sense of higher education and research orientation.
- Foster industry interaction.

Program Educational Objectives (PEOs)

The Department of Mechanical Engineering has formulated the following programme educational objectives for the under-graduate program in Mechanical Engineering:

The Mechanical Engineering graduates will be able to:

- PEO1:** Use the fundamentals of basic science, mathematics and mechanical engineering, to pursue their career as engineers as well as to lead and manage teams in global organizations.
- PEO2:** Pursue advanced education, research and development and engage in the process of life-long learning.
- PEO3:** Become entrepreneurs in a responsible, professional and ethical manner to serve the society.

Program Specific Outcomes (PSOs)

Engineering graduates should be able to:

- PSO1:** Apply computer simulation and experimental methods in the design and development of sustainable products of mechanical systems.
- PSO2:** Utilize the knowledge of advanced manufacturing and condition monitoring techniques in industrial applications.

Program Outcomes (POs)

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to

comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PES COLLEGE OF ENGINEERING, MANDYA
(An Autonomous Institution, Under VTU)

Scheme of Teaching and Examination

VII Semester B.E. (ME)

Sl. No.	Course Code	Course Title	Teaching Dept.	Hrs/Week			Total Credit	Examination Marks		
				L	T	P		CIE	SEE	Total
1.	P18ME71	Core Course I Automatic Control Engineering	Mechanical	4	-	-	4	50	50	100
2.	P18ME72	Core Course II Mechanical Vibrations	Mechanical	4	-	-	4	50	50	100
3.	P18ME73	Core Course III Production Management	Mechanical	4	-	-	4	50	50	100
4.	P18ME74x	Professional Elective-III	Mechanical	2	1	-	3	50	50	100
5.	P18MEO75x	Open Elective-II	Mechanical	3	-	-	3	50	50	100
6.	P18MEL76	Laboratory I Design Lab	Mechanical	-	-	3	1.5	50	50	100
7.	P18MEL77	Laboratory II Simulations Lab	Mechanical	-	-	3	1.5	50	50	100
8.	P18ME78	Project Work Phase - I and seminar	Mechanical	-	-	4	2	100	-	100
Total							23	450	350	800

List of Electives					
Professional Elective-III			Open Elective - II		
Sl. No.	Course Code	Course title	Sl. No.	Course Code	Course title
1.	P18ME741	Power Plant Engineering	1.	P18MEO751	Total Quality Management
2.	P18ME742	Hydraulics and Pneumatics	2.	P18MEO752	Operations Research
3.	P18ME743	Theory of Plasticity	3.	P18MEO753	Renewable Energy Technology
4.	P18ME744	Gas Turbines and Jet Propulsion	4.	P18MEO754	Finite Element Method in Engineering

Scheme of Teaching and Examination

VIII Semester B.E. (ME)

Sl. No.	Course Code	Course Title	Teaching Dept.	Hrs/Week			Total Credit	Examination Marks		
				L	T	P		CIE	SEE	Total
1.	P18ME81	Core Course Industrial Robotics	Mechanical	4	-	-	4	50	50	100
2.	P18ME82x	Professional Elective-IV	Mechanical	2	1	-	3	50	50	100
3.	P18ME83	Internship	Mechanical	-	-	-	2	50	50	100
4.	P18ME84	Project Work Phase - II	Mechanical	-	-	-	6	100	100	200
5.	P18ME85	Self Study course and Seminar	Mechanical	-	-	4	2	50	-	50
Total							17	300	250	550

List of Electives		
Professional Elective-IV		
Sl. No.	Course Code	Course title
1.	P18ME821	Operations Research
2.	P18ME822	Foundry and Welding Technology
3.	P18ME823	Tribology
4.	P18ME824	Computational Fluid Dynamics

Course Title: AUTOMATIC CONTROL ENGINEERING			
Course Code: P18ME71	Semester: VII	L-T-P: 3-2-0	Credits: 04
Contact Period - Lecture: 52 Hours	Exam: 3 Hours	Weightage %: CIE: 50, SEE: 50	
Course Objectives: The course aims at strengthening the ability of students in design and analysis of linear continuous-time control systems to improve their static and transient behavior.			
Course Content			
Unit-1			
Introduction: Concept of automatic controls, open and closed loop control systems, concepts of feedback control systems, requirement of an ideal control system. Examples of control systems - speed control system, home heating system, traffic control system, liquid level control system. Mathematical Models of Physical Systems: Definition of Laplace transformation, transfer function models, mathematical models of mechanical systems, models of electrical circuits, models of DC and AC motors, models of hydraulic systems and models of thermal systems. Analogous Systems: Force-voltage analogy and force-current analogy.			10 Hrs
Self Study Component: Concept of superposition for linear systems with examples.			
Unit-2			
Block Diagrams and Signal Flow Graphs: Transfer functions definition, block diagram representation of system elements, reduction of block diagrams. Signal flow graphs-signal flow graph terminology from block diagram, Manson's gain formula.			10 Hrs
Self Study Component: Transfer function of multiple input multiple output control Systems			
Unit-3			
Time Response Analyses: Introduction, transient and steady state response of control system. First order system response to step and ramp inputs, concepts of time constant and its importance in speed of response. Second order system response to step input, transient response specifications. Steady-state error analysis, steady-state error constants- static position error constant, static velocity error constant and static acceleration error constant. Types of Controllers: Proportional, integral, proportional-integral, proportional-integral-differential controllers.			10 Hrs
Self Study Component: Study of various controllers in automated machines.			
Unit-4			
Mathematical Concept of Stability: Stability definition, characteristic root locations and stability, Routh's stability criterion, special cases of Routh's criterion. Frequency Response Analysis: Polar plots, relative stability- concepts phase margin and gain margin. Nyquist stability criterion, stability analysis using Nyquist plot. Frequency response analysis using Bode plot: Bode attenuation diagrams, stability analysis using Bode plots.			12 Hrs
Self Study Component: System compensation: Series and feedback compensation.			
Unit-5			
Root Locus Analysis: Introduction, definition of root loci, general rules for constructing root loci, root locus analysis of control systems. State-Space Analysis: Introduction, definitions, state-space equations, transformation matrix, controllability, and observability, Kalman and Gilberts test.			10 Hrs
Self Study Component: MATLAB program to generate root-locus plot.			
Text Books			
1. Katsuhiko Ogata, " Modern Control Engineering ", PHI Learning Pvt Ltd, 5 th Edition, 2010, ISBN: 9788120340107.			
2. Rao V Dukkupati, " Control Systems ", Narosa Publishing House, 2008, ISBN: 978-8173195549.			
Reference Books			
1. Joseph J. Distefano, Allen R. Stubberud and Avan J. Williams, " Feedback and Control Systems ", Schaum's Outlines series, Tata McGraw Hill, New Delhi, 2 nd Edition, 2003, ISBN: 9780070582880.			
2. I. J. Nagarath and M. Gopal, " Control systems ", New age International publishers, 4 th Edition, 2006, ISBN: 9788122417753.			

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3. F. Golnaraghi and B.C. Kuo, “**Automatic Control Systems**”, John Wiley and Sons, 9th Edition, 2009, ISBN: 9780470048962.
4. Ashfaq Husain and Haroon Ashfaq, “**Control Systems**”, Dhanpat Rai and Co., 2015, ISBN: 9788177000276.

At the end of the course, students will be able to,

Course Outcomes		Bloom's Level
CO1	Identify the different types of control systems and develop mathematical model for the mechanical, electrical, servo mechanism and hydraulic systems.	III
CO2	Make use of block diagrams and signal flow graphs to represent the systems consisting of number of components and develop mathematical models using reduction technique of these block diagrams and signal flow graphs.	III
CO3	Analyse the time response and steady-state error of the system.	IV
CO4	Apply the Routh's stability criterion to understand the stability of the various control systems and analyse frequency response of control system using Nyquist stability criterion and Bode plot.	III, IV
CO5	Develop root loci from open loop transfer functions of control systems and analyse the behavior of roots with system gain.	III, IV

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	01	02	
CO1	Identify the different types of control systems and develop mathematical model for the mechanical, electrical, servo mechanism and hydraulic systems.	3		3												
CO2	Make use of block diagrams and signal flow graphs to represent the systems consisting of number of components and develop mathematical models using reduction technique of these block diagrams and signal flow graphs.	3		3												
CO3	Analyse the time response and steady-state error of the system.	1	3													
CO4	Apply the Routh's stability criterion to understand the stability of the various control systems and analyse frequency response of control system using Nyquist stability criterion and Bode plot.	2	3													
CO5	Develop root loci from open loop transfer functions of control systems and analyse the behavior of roots with system gain.		3	2												

Course Title: MECHANICAL VIBRATIONS			
Course Code: P18ME72	Semester: VII	L-T-P: 4-0-0	Credits: 04
Contact Period - Lecture: 52 Hours	Exam: 3 Hours.	Weightage % : CIE: 50, SEE:50	
Course objectives: The course aims at enabling the students to synthesize their knowledge of engineering science and mathematics to formulate the solutions of mechanical vibratory systems.			
Course Content			
Unit-1			
Undamped Free Vibrations: Introduction, basic concepts of vibration, simple harmonic motion, types of vibration, elements of vibrating system, Equivalent stiffness of spring combinations- springs in series and parallel, single degree of freedom systems, determination of natural frequency using Newton's law and energy methods. Damped Free Vibrations: Introduction, types of damping, free vibrations with viscous damping, under-damped, over-damped and critically damped system and logarithmic decrement. 12 Hrs			
Self Study Component: Eddy current and Coulomb damping.			
Unit-2			
Forced Vibrations: Introduction, forced vibration with constant harmonic excitation, steady state vibrations, forced vibration with rotating and reciprocating unbalance, forced vibration with coulomb and viscous drag, vibration isolation, force transmissibility, forced vibrations due to excitation of the support; absolute motion and relative motion. 10 Hrs			
Self Study Component: Work done by a harmonic force on a harmonic motion, energy dissipated by damping.			
Unit-3			
Vibration Measuring Instruments: Vibrometer, velocity pick-up and accelerometer, frequency measuring instruments. Whirling of Shafts: Introduction, critical speed of a light shaft having a single disc without damping, critical speed of a light shaft having a single disc with damping. Fourier Series and Harmonic Analysis: Analytical methods and numerical methods. 08 Hrs			
Self Study Component: Beats phenomenon			
Unit-4			
Two Degrees of Freedom Systems: Introduction, undamped systems, principal modes of vibration, combined rectilinear and angular modes, undamped forced vibrations with harmonic excitation. Vibration absorbers, undamped dynamic vibration absorber (description only), influence coefficients, Maxwell's reciprocal theorem. Noise Engineering: Frequency and sound dependent human response, decibel scale, relationship between sound pressure level, sound power level and sound intensity scale. 10 Hrs			
Self Study Component: Centrifugal pendulum absorber			
Unit-5			
Multi Degree Freedom Systems: Introduction, determination of natural frequencies, Rayleigh's method, Dunkerley's method, Runge-Kutta Method, Stodola's method, Holzer's method, orthogonality principle, matrix iteration method. 12 Hrs			
Self Study Component: Rayleigh-Ritz method for finding natural frequencies.			
Text Books			
1. V. P. Singh, " Mechanical Vibrations ", Dhanpat Rai and Company Pvt. Ltd., 2016, ISBN: 9788177004014.			
2. G. K. Grover, " Mechanical vibrations ", Nemchand and Brothers, 8 th Edition, 2009, ISBN: 9788185240565.			
Reference Books			
1. Singiresu S Rao, " Mechanical Vibrations ", Pearson Education India, 4 th Edition, 2003, ISBN: 978-8177588743.			
2. S. Graham Kelly, Schaum's Outline Series, " Mechanical Vibrations ", Tata McGraw Hill, Special Indian edition, 2007, ISBN: 9780070616790.			

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3. J. S. Rao and K. Gupta, “**Theory and Practice of Mechanical Vibrations**”, New Age International Publications, 2001, ISBN: 9788122404425.
4. Leonanrd Meirovitch, “**Elements of Vibrations Analysis**”, Tata McGraw Hill, Special Indian Edition, 2007, ISBN: 8177000470.
5. Austin H Church, “**Mechanical Vibrations**”, John Wiley and Sons, ISBN: 9781114187887.

At the end of the course, students will be able to,

Course Outcomes		Bloom's Level
CO1	Apply basic concepts of vibrations to analyse damped and undamped free vibratory systems.	III
CO2	Apply basic concepts of vibrations to analyse forced vibratory systems.	III
CO3	Identify different vibration measuring instruments to analyse the vibration responses of mechanical systems.	III, IV
CO4	Analyse the natural frequencies and corresponding mode shapes of two degrees of freedom systems with the Applications of basics of vibrations.	III, IV
CO5	Apply numerical methods to analyse natural frequencies and mode shapes of multi degrees of freedom systems.	III, IV

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO			
		1	2	3	4	5	6	7	8	9	10	11	12	01	02		
CO1	Apply basic concepts of vibrations to analyse damped and undamped free vibratory systems.	3	2														
CO2	Apply basic concepts of vibrations to analyse forced vibratory systems.	3	2														2
CO3	Identify different vibration measuring instruments to analyse the vibration responses of mechanical systems.	3	2														2
CO4	Analyse the natural frequencies and corresponding mode shapes of two degrees of freedom systems with the Applications of basics of vibrations.	3	2														2
CO5	Apply numerical methods to analyse natural frequencies and mode shapes of multi degrees of freedom systems.	2	3														1

Course Title: PRODUCTION MANAGEMENT			
Course Code: P18ME73	Semester: VII	L-T-P: 4-0-0	Credits: 04
Contact Period - Lecture: 52 Hours	Exam: 3 Hours	Weightage %: CIE: 50, SEE: 50	
Course Objectives: The course aims at enabling the students to understand the basic concepts of management, production, forecasting, inventory and various scheduling techniques related to manufacturing.			
Course Content			
Unit-1			
Introduction: Introduction, Meaning and concepts of Production Management (PM), areas of PM, evolution of PM, product strategies, product focused system, production to stock or to order, productive system positioning strategies, product life cycle, relationship between the product life cycle and productive system types, process life cycles and technology, interdependent product lines, Organization of the Operations Functions: Process focused organization, product focused organization structure, difference between process and product focused. 10 Hrs			
Self Study Component: Functions of Production Management, meaning of productivity, techniques to improve productivity.			
Unit-2			
Forecasting: Need for forecasting, objectives and limitations of forecasting, uses of forecasting, Classification of Forecasting Methods: Time series method, components time series methods, simple moving average, weighted moving averages, exponentially weighted moving averages, least square or regression, trend model with seasonal variation, Delphi technique. 11 Hrs			
Self Study Component: Mean Absolute Deviation (MAD), Mean Square Error (MSE), Mean Absolute Percentage Error (MAPE).			
Unit-3			
Facilities Location and Layout: Introduction, general procedure for location, factors affecting location, locational analysis, cost analysis, quantitative method, weight method, GRID method, objectives of plant layout, factors affecting plant layout, material flow pattern. 10 Hrs			
Self Study Component: Factors to be considered to select foreign locations, types of plant layouts, list the computer approaches to layout design.			
Unit-4			
Scheduling: Define scheduling, scheduling strategies, scheduling sequence operation standard scheduling techniques, Johnson's rule for 2 machines, 3 machines and n machines, graphical method for 2 machines and n jobs, indexing method. 10 Hrs			
Self Study Component: Forward and backward scheduling, different types of control charts.			
Unit-5			
Inventory Control: Types of inventory control, parts associated with inventory control, inventory control terminology, classification of inventory items, selective control of inventory, problems on ABC analysis on inventory, deterministic model in inventory control. Production Control: Dispatching and expediting the orders, centralized and decentralized dispatching process order control. Follow up and progress reporting, rescheduling and priority rules. 11 Hrs			
Self Study Component: Order release, dispatching, reporting and status control, general duties of dispatching section.			
Text Books			
1. Buffa and Sarin, “Modern Production/Operations Management” , Wiley India Pvt. Ltd., 8 th Edition, 2007, ISBN: 9788126513727.			
2. Joseph G.Monks, “Operations Management” , Tata McGraw-Hill, 2 nd Edition, 2004, ISBN: 0070588708.			
Reference Books			
1. Barry Shore, “Operations Management” , McGraw Hill Inc., 1973, ISBN:			

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9780070570450.

2. Samuel Eilon, “**Elements of Production Planning and Control**”, Universal Publishing Corporation, 1991, ISBN: 9788185027098.
3. R. Panneerselvam, “**Production and Operations Management**”, PHI Publishers, 3rd Edition, 2006, ISBN: 9788120345553.

At the end of the course, students will be able to,

Course Outcomes		Bloom's Level
CO1	Apply basic strategies of production management to develop a new product with respect to product and process life cycle. Select suitable operational functions to organize better production system.	III,IV
CO2	Apply different forecasting techniques to predict and analyze trend model with seasonal variation.	III,IV
CO3	Identify the different methods for analysis of facility location and layout for effective flow of men and material.	III,IV
CO4	Analyze different scheduling techniques and strategies for optimal utilization of time and machines.	IV
CO5	Apply various inventory models to analyze and control production system.	III,IV

Course Articulation Matrix

Course Outcomes	Program Outcomes												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	01	02	
CO1		3													
CO2	3	3													
CO3	3	1													
CO4	2	3													
CO5	3	2													

Course Title: POWER PLANT ENGINEERING			
Course Code: P18ME741	Semester: VII	L-T-P: 4-0-0	Credits: 03
Contact Period - Lecture: 52 Hours	Exam: 3 Hours.	Weightage % : CIE: 50, SEE:50	
Course Objectives: The course is helps the student to understand about power plants and its working and the student must able to understand the importance of renewable sources.			
Course Content			
Unit-1			
<p>Introduction: Indian energy scenario, location of power plants in India, economics of power generation, classification, power plant terminologies in load estimation, load factor, use factor, diversity factor and demand factor, numericals, choice of power plant, factors affecting the operation of power plant, electro-gas dynamic generator, magneto hydro dynamics generator, fuel cell energy conversion. 08 Hrs</p> <p>Self Study Component: Thermionic and thermoelectric energy conversion.</p>			
Unit-2			
<p>Hydroelectric and Thermal Power Plant: Introduction, classification of the plant general layout and essential elements of hydroelectric power plant and its working, flow duration and mass curves, hydrographs, numericals. Hydrological cycle, selection of sites for hydroelectric power plant, advantages and disadvantages of hydroelectric power plant. Thermal Power Plant: General layout of steam power plant, coal burning methods; different types of stokers, equipment for preparation and burning of pulverized coal, unit system and bin system, pulverized fuel burners: long flame burner, short flame burner, tangential burner and cyclone burner. 12 Hrs</p> <p>Self Study Component: Applications, merits and demerits of thermal power plant.</p>			
Unit-3			
<p>Steam generation: A brief account of boilers: LaMont boiler, Benson boiler, Loeffler boiler and Velox boiler. Chimneys- natural, forced, induced and balanced draft. Steam Generator Accessories: Superheaters and reheaters, different types of cooling towers, coal and ash handling - different types of coal storage and coal conveyors, pneumatic and hydraulic methods of ash handling systems, feed water treatments. 10 Hrs</p> <p>Self Study Component: Lancashire boiler and Babcock-Wilcox boiler.</p>			
Unit-4			
<p>Diesel Engine Plant: General layout of Diesel power plant, method of starting diesel engines, cooling and lubrication system for the diesel engine, filters, centrifuges, oil heaters, intake and exhaust system. Gas Turbine Power Plant: Advantages and disadvantages of the gas turbine plant, open and closed cycle turbine plants with the accessories. Solar Power Plant: Introduction, layout, solar cell fundamentals and classification, Maximum Power Point Tracker (MPPT), solar panel. 10 Hrs</p> <p>Self Study Component: Super heater controls, methods of reheaters and dust collectors.</p>			
Unit-5			
<p>Nuclear Power Plant: Introduction, nuclear fuels, nuclear fission and fusion, working of a nuclear power plant, types of reactors- pressurized water reactor- boiling water reactor, effects of nuclear radiation, different methods for nuclear waste disposal-low, medium and high level waste disposal, advantages, disadvantages and limitations. Safety and Environmental Impact of Power Plant: Social and economic issues of power plant, thermal pollution from thermal power plants, noise pollution and its control, natural and artificial radio activity nuclear power and environment, radiations from nuclear power plant effluents, high level wastes, methods to reduce pollution, global warming- effects and its control, standardization for environmental pollution. 12 Hrs</p> <p>Self Study Component: Locations of nuclear power plants, express the various types of nuclear wastes.</p>			
Text Books			
1. Arora, S Domkundwar and AV Domkundwar, “A course in Power Plant Engineering”, Dhanpatrai and Co. Pvt. Ltd., 2014, ISBN:9788177001075.			

2. P. K. Nag, “**Power Plant Engineering**”, Tata McGraw Hill, 4th Edition. 2014, ISBN: 9789339204044.

Reference Books

1. Jagadish Lal, “**Hydraulic Machines**”, Metropollitan Book Co. Pvt Ltd., 1994, ISBN: 978 8120000261.
2. F.T. Morse, “**Power Plant Engineering**”, G. Van Nostrand, 3rd Edition 1953, ISBN: 9780442055561.
3. G.R.Nagpal and S.C.Sharma, “**Power Plant Engineering**”, Khanna Publishers, 16th Edition 2015, ISBN: 9788174093097.

At the end of the course, students will be able to,

Course Outcomes		Bloom's Level
CO1	Apply economical aspects to identify suitable locations for power plant and analyse the factors affecting the performance based on load variations.	III, IV
CO2	Identify various elements of hydro electric and thermal power plants and analyse hydro graphs and flow duration curve.	III, IV
CO3	Recognize various types of boilers and its accessories in steam power plant.	III
CO4	Identify elements, operations of Diesel, gas and solar power plants.	III
CO5	Apply the principles of nuclear fission and fusion to understand the working of a nuclear power plant and Identify safety, environmental issues of power plants.	III

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO			
		1	2	3	4	5	6	7	8	9	10	11	12	01	02		
CO1	Apply economical aspects to identify suitable locations for power plant and analyse the factors affecting the performance based on load variations.	3	2														
CO2	Identify various elements of hydro electric and thermal power plants and analyse hydro graphs and flow duration curve.	3	2														
CO3	Recognize various types of boilers and its accessories in steam power plant.	3															
CO4	Identify elements, operations of Diesel, gas and solar power plants.																
CO5	Apply the principles of nuclear fission and fusion to understand the working of a nuclear power plant and Identify safety, environmental issues of power plants.	3					1	1									

Course Title: HYDRAULICS AND PNEUMATICS			
Course Code: P18ME742	Semester: VII	L-T-P: 4-0-0	Credits: 03
Contact Period - Lecture: 52 Hours;	Exam: 3 Hours.	Weightage % : CIE: 50, SEE:50	
Course Objectives: This course exposes the students to understand the application of fluid power in process and manufacturing industries. To provide students with an understanding of the components utilized in modern industrial fluid power system. To develop a measurable degree of competence in the design, construction and operation of fluid power circuits.			
Course Content			
Unit-1			
Introduction to Hydraulic Power: Definition of hydraulic system, advantages, limitations, applications, Pascal's law, structure of hydraulic control system, problems on Pascal's law. Hydraulic Pump: Classification, pumping theory, construction and working of gear pumps, vane pumps and piston pumps, pump performance characteristics, pump selection factors, problems. Hydraulic Actuators: Single and double acting cylinder, mechanics of hydraulic cylinder loading, hydraulic cushioning, special types of cylinders. 12 Hrs			
Self Study Component: screw pump, gear motor, vane motor and piston motor.			
Unit-2			
Control Components in Hydraulic Systems: Directional control valves, symbolic representation, constructional features, pressure control valves - direct and pilot operated types. Flow Control Valves (FCV), non pressure and pressure compensated FCV, servo valve, cartridge valve and hydraulic fuse. Hydraulic Circuit Design and Analysis: Control of single and double acting hydraulic cylinder, regenerative circuit, double pump hydraulic system, counter balance valve application, hydraulic cylinder sequencing circuits, locked cylinder using pilot check valve, cylinder synchronizing circuits, speed control of hydraulic cylinder, automatic cylinder reciprocating system, hydraulic motor braking system, air-over-oil circuit. 12 Hrs			
Self Study Component: check valve, needle valve, pump unloading circuit.			
Unit-3			
Maintenance of Hydraulic Systems: Hydraulic oils, desirable properties, sealing devices, accumulators, reservoir system, filters and strainers, problem caused by gases in hydraulic fluids, wear of moving parts due to solid particle contamination, temperature control, troubleshooting and remedies in hydraulic systems. Introduction to Pneumatic Control: Definition of pneumatic system, advantages, limitations, applications, choice of working medium, characteristics of compressed air, structure of pneumatic control system, rod less cylinder types, working and advantages, rotary cylinder type construction and application, design parameters selection. 11 Hrs			
Self Study Component: Beta ratio of filters.			
Unit-4			
Pneumatic Control Valves: Directional control valves, pressure control valves, flow control valves, types and construction, use of memory valve, quick exhaust valve, time delay valve, shuttle valve, twin pressure valve, symbols, simple pneumatic control, direct and indirect actuation pneumatic cylinders, speed control of cylinders - supply air throttling and exhaust air throttling. 08 Hrs			
Self Study Component: Selection criteria of D C values.			
Unit-5			
Multi-Cylinder Applications: Coordinated and sequential motion control, motion and control diagrams, signal elimination methods, cascading method principle, practical application examples (up to two cylinders) using cascading method. Compressed Air: Production of compressed air- compressors, preparation of compressed air-driers, filters, regulators, lubricators, mufflers, distribution of compressed air, piping layout. 09 Hrs			
Self Study Component: Maintenance of lubricator.			
Text Books			
1. Anthony Esposito " Fluid Power with applications ", Pearson Education, 5 th Edition, Inc. 2000, ISBN: 9780130102256.			

2. Andrew Parr “**Pneumatics and Hydraulics**”, Jaico Publishing Co., 1st Edition, 2000, ISBN: 9788172241896.

Reference Books

1. S. R. Majumdar “**Oil Hydraulic Systems Principles and Maintenance**”, Tata McGraw Hill Publishing company Ltd., 2001, ISBN: 9780071406697.
2. S. R. Majumdar “**Pneumatic systems**”, by Tata McGraw Hill publishing Co, 1995, ISBN: 9780071359658.
3. Pippenger Hicks “**Industrial Hydraulics**”, McGraw Hill, New York, 2nd Edition, 1980, ISBN: 9780070664777.
4. Dr. H. D. Ramachandra “**Hydraulics and Pneumatics**”, Sudha Publications, 2013, ISBN: 9788193001042.

At the end of the course, students will be able to,

Course Outcomes		Bloom's Level
CO1	Apply Pascal's law for analysing the pressure distribution in hydraulic system.	III, IV
CO2	Identify the various control components in hydraulic system and design the hydraulic circuits.	III, IV
CO3	Identify different trouble shooting techniques in maintenance of hydraulic systems and also components of pneumatic system.	III
CO4	Apply the concepts of control elements in pneumatic system.	III
CO5	Identify the multi-cylinder applications in various fields and filters, regulators and lubricators in pneumatic system.	III

Course Articulation Matrix

Course Outcomes	Program Outcomes												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	3	1												
CO2	3		2											
CO3	3													
CO4	3													
CO5	3													

Course Title: THEORY OF PLASTICITY			
Course Code: P18ME743	Semester: VII	L-T-P: 4-0-0	Credits: 03
Contact Period - Lecture: 52 Hours	Exam: 3 Hours	Weightage %: CIE: 50, SEE: 50	
Course Objectives: To provide a basic understanding of the plasticity theory as applied to metal working processes and their analysis for improved quality and productivity.			
Course Content			
Unit-1			
Fundamental of Elasticity: Concept of stress, equilibrium equation stress transformation laws, spherical and deviator stress tensors, octahedral stresses, concept of strain, representation strain, compatibility equations, deviator and spherical strain tensors, strain transformation laws, octahedral strains, elastic strain energy, theories of strength, numerical.			
10 Hrs			
Self Study Component: Maximum principal stress theory (Rankine), maximum shear stress theory (Tresca).			
Unit-2			
Plastic Deformation of Metals: Crystalline structure in metals, mechanism of plastic deformation, factors affecting plastic deformation, strain hardening, recovery, recrystallization and grain growth, flow figures (Luder's lines). Yield Criteria: Introduction, yield or plasticity conditions, Tresca and Von-Mises criteria, experimental evidence for yield criteria (a) Lode's experiment (b) Quinney's experiment. The Haigh-Westergaard stress space. Traces of the yield surfaces in 2D stress space.			
10 Hrs			
Self Study Component: Maximum principal strain theory (Saint-Venant), total strain energy per unit volume (Haigh).			
Unit-3			
Stress- Strain Relations: Introduction, types of materials, empirical equations, theories of plastic flow, experimental verification of Saint-Venant's theory of plastic flow, concept of plastic potential, maximum work hypothesis, concepts of stress rate.			
10 Hrs			
Self Study Component: Mechanical work for deforming a plastic substance.			
Unit-4			
Slip Line Field Theory: Introduction, basic equations for incompressible two dimensional flow, continuity equations (Geiringer equation), stresses in conditions of plain strain, convention for slip lines, solutions of plastic deformation problem, geometry of slip line field, properties of slip lines, construction of slip line nets, super position of slip line fields.			
10 Hrs			
Self Study Component: Velocity discontinuity at certain slip lines.			
Unit-5			
Bending of Beams: Introduction, analysis of stresses, linear and non-linear stress-strain curve, shear stress distribution, residual stresses in plastic bending, numerical. Torsion of Bars: Introduction, plastic torsion of a circular bar, elastic- perfectly - plastic material, elastic work hardening material, residual stresses and numerical.			
12 Hrs			
Self Study Component: Plane strain bending of beam and plastic torsion of a circular bar.			
Text Books			
1. Sadhu Singh, "Theory of Plasticity and Metal Forming Processes", Khanna Publishers, 3 rd Edition, 2015, ISBN: 9788174090509.			
2. R. A. W. Slater, "Engineering Plasticity: Theory and Application to Metal Forming Processes", McMillan Press Ltd, 1 st Edition, 1977, ISBN: 9780333157091.			
Reference Books			
1. J. Chakraborty, "Theory of plasticity", Butter-Heinemann publisher, 3 rd Edition, 2007, ISBN: 9789380931715.			
2. Jacob Lubliner, "Plasticity Theory", Dover publications Inc, 1 st Edition, 2008, ISBN: 9780486462905.			
3. Avitzur, B., "Metal Forming Processes and Analysis", McGraw Hill, 1 st Edition, 1968, ISBN: 9780070025103.			
4. L. M. Kachanov, "Fundamentals of the Theory of Plasticity", Dover Publication,			

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1 st Edition, 2004, ISBN: 9780486435831.															
At the end of the course, students will be able to,															
Course Outcomes													Bloom's Level		
CO1	Apply the equation for stress transformation, spherical, deviator, octahedral stresses and strains, and analyse the same.												III, IV		
CO2	Identify factors affecting plastic deformation, strain hardening, recovery, recrystallization, cubical dilation, true stress - strain and analyse for Yield stress.												III, IV		
CO3	Analyse the plastic flow of material using various theories.												IV		
CO4	Develop basic equation for incompressible two dimensional flows, continuity equation and analyse the slip line field.												IV, V		
CO5	Analyse stress distribution in plastic bending of beams and residual stresses in torsion of bars.												IV		
Course Articulation Matrix															
Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	Apply the equation for stress transformation, spherical, deviator, octahedral stresses and strains, and analyse the same.	3	2												
CO2	Identify factors affecting plastic deformation, strain hardening, recovery, recrystallization, cubical dilation, true stress - strain and analyse for Yield stress.	3	2												
CO3	Analyse the plastic flow of material using various theories.		3												
CO4	Develop basic equation for incompressible two dimensional flows, continuity equation and analyse the slip line field.		3	2											
CO5	Analyse stress distribution in plastic bending of beams and residual stresses in torsion of bars.		3												

Course Title: GAS TURBINES AND JET PROPULSION			
CourseCode:P18ME744	Semester: VII	L-T-P:4-0-0	Credits:03
Contact Period -Lecture: 52 Hours;	Exam: 3 Hours.	Weightage %: CIE: 50, SEE: 50	
<p>Course Objectives: The objectives of the course are to develop the students an ability to understand the thermodynamics of compressor, turbine and combustion chambers, the linked system performance of all components in the gas turbine engine and to have a basic understanding on the working of aircraft and rocket engines.</p>			
Course Content			
Unit-1			
<p>Centrifugal Compressors: Ideal energy transfer. actual energy transfer- slip, analytical method of finding slip factor, power input factor, pressure coefficient, compressor efficiency, inlet or inducer section, when the entrance is axial, sizing of inducer section, pre-whirl, impeller passage, effect of impeller blade shape on performance, impeller channel, compressor diffuser, losses in centrifugal compressor, compressor characteristic, surging and choking.</p>			10 Hrs
<p>Self Study Component: Carnot cycle, Stirling cycle with regenerator.</p>			
Unit-2			
<p>Axial Flow Compressors: Introduction, description, performance analysis, momentum or filament analysis, spatial velocity diagram, symmetric stage, non-symmetric axial inflow, non-symmetric axial out flow, actual energy transfer, airfoil analysis one dimensional ideal incompressible flow, two dimensional flow with friction, blading efficiency, losses in terms of air angles and drag coefficient of performance- flow coefficient, pressure coefficient, work coefficient, blade loading, cascade characteristic, blade angles, Reynolds and Mach number effects, overall performance, compressor characteristics, numerical examples.</p>			12 Hrs
<p>Self Study Component: Compressor stall and surge.</p>			
Unit-3			
<p>Combustion Systems: Introduction, combustion mechanism, pressure losses, combustion intensity, combustion efficiency, shape of the combustion chamber, stabilizing or primary zone, dilution and mixing, combustion chamber arrangements, fuel injection system.</p>			
<p>Regenerator: Introduction, types of regenerator, heat transfer in direct type exchangers-, number of exchanger heat transfer units, capacity ratio, relation between Number of Transfer Unit (NTU) and Stanton number, relations between NTU and effectiveness (no derivation), Effect of flow arrangement, effect of $C_{min}/C_{max}<1$ for regenerator, log mean rate equation compared to effectiveness-NTU approach, rotary heat exchanger- effect of matrix speed, effect of longitudinal conduction, core pressure drop, economic approach of heat exchanger design, numerical examples.</p>			10 Hrs
<p>Self Study Component: Requirement of combustion chamber, exchanger heat transfer effectiveness.</p>			
Unit-4			
<p>Axial flow gas turbines: Introduction, ideal impulse turbine, impulse turbine with loss, blade speed ratio, velocity ratio and torque, velocity compounded turbine, reaction turbine, reheat factor, blade speed ratio for reaction turbine, comparison of turbine types, forces on blade, cascade analysis, three dimensional flow analysis – the free vortex blades, constant angle nozzle stage, turbine flow passage, impulse blading, reaction blading.</p>			10 Hrs
<p>Self Study Component: Turbine and nozzle efficiencies, degree of reaction- Impulse turbine.</p>			
Unit 5			
<p>Aircraft Propulsion: Principle of jet propulsion, classification of propulsive devices, basic working of turbojet, turboprop, turbofan, turboshaft. Theory of propulsion, thrust, thrust power, propulsive efficiency and thermal efficiency of turbojet engine.</p>			
<p>Rocket propulsion: Chemical Rockets, classification, performance parameters for chemical rockets and their relationship, energy and efficiencies. Solid propellant rockets: solid propellants, types, burning rate, grain configurations, typical fuels and oxidizers, properties and specifications, liquid propellant rockets, liquid propellant feed systems, injectors, liquid</p>			

propellant, precautions in propellant handling, hybrid rockets, cooling of rocket motors (description only). **10 Hrs**

Self Study Component: Types of propellers, combustion processes in solid and liquid propellant rockets.

Text Books

1. P.R. Khajuria and S. P. Dubey, “**Gas Turbines and Propulsive System**”, Dhanpat Rai Publication, 2012, ISBN: 9788189928483.
2. V Ganeshan, “**Gas Turbines**”, McGraw Hill Publication, 3rd Edition, 2010, ISBN: 9780070681927.

Reference Books

1. H. I. H Saravanamutto, GFC Rogers and H Cohen, “**Gas Turbine Theory**”, Pearson Education, 5th Edition, 2001, ISBN: 9788178085340.
2. S. M. Yahya, “**Turbines Compressor and Fans**”, McGraw Hill Education, 4th Edition, 2010, ISBN: 9780070707023.
3. Philip Hill, and Carl Peterson, “**Mechanics and Thermodynamics of Propulsion**”, Pearson Education, 3^d Edition, 2009, ISBN: 9788131729519.
4. G. P. Sutton and Oscar Biblarz, “**Rocket Propulsion elements**”, Wiley, 9th Edition 2017 ISBN: 9781118753651.
5. S. M. Yahya, “**Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion**”, New Age International Publishers, 6th Edition, 2018, ISBN: 9789386649911.

At the end of the course, students will be able to,

Course Outcomes		Bloom's Level
CO1	Apply the basics of energy transfer to analyse the performance of centrifugal compressors.	III, IV
CO2	Apply the basics of energy transfer to analyse the performance of axial flow compressors.	III, IV
CO3	Apply combustion mechanism to analyse the efficiencies of different combustion chamber and heat exchangers.	III, IV
CO4	Apply the basics of energy transfer to analyse the performance of axial flow turbines.	III, IV
CO5	Apply theory of propulsions to understand working of different propulsive devices and analyse their performance parameters.	III, IV

Course Articulation Matrix

Course Outcomes	Program Outcomes												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	01	02	
CO1	Apply the basics of energy transfer to analyse the performance of centrifugal compressors.	3	2												
CO2	Apply the basics of energy transfer to analyse the performance of axial flow compressors.	3	2												
CO3	Apply combustion mechanism to analyse the efficiencies of different combustion chamber and heat exchangers.	3	2												
CO4	Apply the basics of energy transfer to analyse the performance of axial flow turbines.	3	2												
CO5	Apply theory of propulsions to understand working of different propulsive devices and analyse their performance parameters.	3	2												

Course Title: TOTAL QUALITY MANAGEMENT (open elective-II)			
Course Code: P18MEO751	Semester: VII	L-T-P: 3-2-0	Credits: 03
Contact Period - Lecture: 52 Hours	Exam: 3 Hours	Weightage %: CIE: 50; SEE: 50	
Course Objectives: The course aims at enabling the students to understand the basic concepts of Total Quality Management (TQM). Identify and develop appropriate tools in TQM to solve real life problems.			
Course Content			
Unit-1			
Introduction: Definition, basic approach, Gurus of Total Quality Management (TQM), awareness, defining quality, primary elements of TQM, historical review, obstacles, benefits of TQM. Leadership: Definitions, characteristics of quality leaders, leadership concepts, the seven habits of highly effective people, ethics, the Deming philosophy, role of TQM leaders, implementation, quality council, core values, concepts and framework, quality statements, strategic planning, communications, decision making. 10 Hrs			
Self Study Component: Characteristics of successful teams.			
Unit-2			
Customer Satisfaction: Introduction to customer, customer perception of quality, feedback, using customer complaints, service quality, translating needs into requirements, customer retention, additional comments. Continuous Process Improvement: Introduction, process, the Juran trilogy, improvement strategies, types of problems, Plan Do Study Adjust (PDSA) cycle, Kaizen reengineering. Statistical Process Control: Pareto diagram, process flow diagram, cause and effect diagram, check sheets, histograms, statistical fundamentals, control charts, state of control, out of control process, control charts for variables, control charts for attributes, scatter diagrams. 12 Hrs			
Self Study Component: Objectives of performance measures.			
Unit-3			
Benchmarking: Introduction, benchmarking, reasons to benchmark, process, deciding what to benchmark, understanding current performance, planning, studying others, learning from the data, using the findings, pitfalls and criticisms of benchmarking. Quality Management Systems: Introduction, benefits of ISO registration, ISO 9000 series of standards, sector-specific standards, ISO 9001 requirements, implementation, documentation, writing the documents internal audits, registration, closing comments. 10 Hrs			
Self Study Component: Limitations of quality of cost, TQM exemplary organization.			
Unit-4			
Total Productive Maintenance (TPM): Definition, types of maintenance, steps in introduction of TPM in an organization, pillars of TPM – 5S, Jishu Hozen, quality maintenance, planned maintenance. Environmental Management Systems (EMS): Definition, basic EMS, EMS under ISO 14001, costs and benefits of EMS. TQM Tools and Techniques: The seven traditional tools of quality, Six sigma, concepts, methodology, applications to manufacturing, service sector including IT. 10 Hrs			
Self Study Component: Applications and importance of Measurement System Analysis (MSA).			
Unit-5			
Quality Function Deployment (QFD): Introduction, the QFD team, benefits of QFD, the voice of the customer, organization of information, house of quality, QFD process, examples and conclusion. Quality by Design: Introduction, rationale for implementation benefits, teams, communication models, implementation, tools, misconceptions and pitfalls. 10 Hrs			
Self Study Component: Computers and quality function (Data Collection), Kano model.			
Text Books			
1. Dale H. Besterfield, “ Total Quality Management ”, Pearson Publishers, 2018, ISBN: 9789353066314.			
2. V K Khanna, “ Total Quality Management ”, New Age International Publishers, 2008,			

ISBN: 9788122417999.

Reference Books:

1. Dr. S Kumar, “**Total Quality Management**”, 1st Edition, Laxmi Publications, 2016, ISBN: 9789385935817.

At the end of the course, students will be able to,

Course Outcomes		Bloom’s Level
CO1	Apply concepts of strategic planning, decision making and characteristics of leaders in organizations.	III
CO2	Apply the concepts of customer perception of quality, continuous process improvement and statistical process control.	III
CO3	Apply the concept of benchmarking process in quality control and quality management systems.	III
CO4	Identify different concepts of total productive management and environmental management systems.	III
CO5	Apply the concepts of quality function deployment and quality by design in Exemplary Organizations.	III

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO			
		1	2	3	4	5	6	7	8	9	10	11	12	01	02		
CO1	Apply concepts of strategic planning, decision making and characteristics of leaders in organizations.	3															
CO2	Apply the concepts of customer perception of quality, continuous process improvement and statistical process control.	3															
CO3	Apply the concept of benchmarking process in quality control and quality management systems.	3															
CO4	Identify different concepts of total productive management and environmental management systems.	3						1									
CO5	Apply the concepts of quality function deployment and quality by design in Exemplary Organizations.	3															

Course Title: OPERATIONS RESEARCH (open elective-II)		
Course Code: P18MEO752	Semester: VII	L-T-P: 4-0-0
Contact Period - Lecture: 52 Hours	Exam: 3 Hours	Weightage % : CIE: 50, SEE:50
Course Objectives: The course aims at enabling the students to understand the basic concepts of Operations Research. Identify and develop operation research models from the verbal description of real life and optimize the solutions.		
Course Content		
Unit-1		
Introduction: Definition, scope of Operations Research (OR) approach and limitations of OR models, characteristics and phases of OR, mathematical formulation of linear programming problems, graphical solution for maximization and minimization problems. 10 Hrs		
Self Study Component: Advantages and disadvantages of OR.		
Unit-2		
Linear Programming Problems: Simplex method, slack, surplus and artificial variables, degeneracy and procedure for resolving degeneracy, Big-M method, two phase method. 2 Hrs		
Self Study Component: Dual simplex method.		
Unit-3		
Transportation and Assignment: Formulation of transportation problem, initial feasible solution methods, optimality test, degeneracy in transportation problem, assignment problem, Hungarian method, traveling salesman problem. 10 Hrs		
Self Study Component: Unbalanced transportation and assignment problems.		
Unit-4		
Network Analysis in Project Planning (PERT and CPM): Project, project planning, project scheduling, project controlling, network terminologies. 10 Hrs		
Self Study Component: Crashing of networks.		
Unit-5		
Inventory and Models: Classical EOQ models, EOQ model with price breaks, EOQ with shortage, newsboy problem. 10 Hrs		
Self Study Component: Probabilistic EOQ model		
Text Books		
1. Taha H. A. “ Operations Research and Introduction ”, Pearson Education, 10 th Edition, 2014, ISBN: 97801344444017.		
2. Prem Kumar Gupta and D.S. Hira, S “ Operation Research ”, Chand Publication, 2011, ISBN: 9788121902816.		
Reference Books		
1. AM Natarajan, P. Balasubramani, and Tamilaravari “ Operation Research ”, Pearson Education, 2006, ISBN: 8131700003.		
2. Hiller and Liberman, “ Introduction to Operation Research ”, McGraw Hill, 5 th Edition 2001, ISBN: 8131700003.		
3. Ravindran, Phillips and Solberg, “ Operations Research: Principles and Practice ”, Wiley India, 2 nd Edition 2007, ISBN: 9780471086086.		
4. S.D. Sharma, “ Operations Research ”, Kedarnath Ramnath and Co. 2002, 2 nd Edition, 2002, ISBN: 9789385935145.		
At the end of the course, students will be able to,		
Course Outcomes		Bloom's Level
CO1	Formulate real world problems as a Linear programming model and demonstrate solution by graphical method.	IV
CO2	Apply the sensitivity analysis technique to identify the direction and magnitude of change of a Linear programming model.	III, IV
CO3	Apply the specific LPP like transportation and assignment and analyse the solution.	III, IV
CO4	Apply the different project model and analyze the solution.	III, IV
CO5	Apply the different Inventory models and analyze the solution.	III, IV

Course Articulation Matrix															
Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	Formulate real world problems as a Linear programming model and demonstrate solution by graphical method.		3												
CO2	Apply the sensitivity analysis technique to identify the direction and magnitude of change of a Linear programming model.	3	3												
CO3	Apply the specific LPP like transportation and assignment and analyze the solution.	3	3												
CO4	Apply the different project model and analyze the solution.	3	3												
CO5	Apply the different Inventory models and analyze the solution.	3	3												

Course Title: RENEWABLE ENERGY TECHNOLOGY (Open elective-II)			
Course Code: P18MEO753	Semester: VII	L-T-P: 4-0-0	Credits: 03
Contact Period - Lecture: 52 Hours	Exam: 3 Hours	Weightage %: CIE: 50, SEE:50	
Course Objectives: The course aims at strengthening the design capabilities of the students by exposing them to the design of different mechanical elements that are commonly used in machines.			
Course Content			
Unit-1			
<p>Introduction: Energy as a source, introduction to renewable energy technologies, Indian and global scenario of conventional and renewable energy sources, need for renewable energy sources. Energy Storage: Introduction, necessity of energy storage, energy storage methods, energy and environment. Solar Radiation: Solar thermal process, beam and global radiation, extra-terrestrial and terrestrial radiation, spectral distribution of extra-terrestrial radiation, solar constant, solar radiation at the earth's surface, solar radiation data. 09 Hrs</p> <p>Self Study Component: Hydrogen energy, depletion of solar radiation and thermionic converter.</p>			
Unit-2			
<p>Solar Radiation Measurement: Introduction, principles of working of solar radiation measuring devices - pyranometer, shading ring, pyr heliometer, sunshine recorder. Solar Thermal Systems: Introduction to solar thermal conversion, collection, solar energy collection devices - liquid flat plate collectors, solar air heaters, concentrating collectors (cylindrical, parabolic, paraboloid) application of solar energy water heating, solar heating and cooling, solar thermal power plant and solar pond, principle of working. 11 Hrs</p> <p>Self Study Component: Solar radiation geometry, solar radiation measuring angles, the slope, angstrom pyr heliometer.</p>			
Unit-3			
<p>Solar Photo Voltaic (SPV) Systems: Basic principle of SPV conversion, characteristics and classification of photo voltaic systems, solar cell fundamentals, types of solar cells, solar cell, module, panel and array construction, photovoltaic thermal systems. Geothermal Energy Conversion: Principle of working of different geothermal stations with schematic diagram, methods of harnessing the geothermal energy, potential in India, problems associated with geothermal conversion, scope of geothermal energy. 10 Hrs</p> <p>Self Study Component: Photovoltaic module I-V characteristics, efficiency and quality of the cell, heat pump and binary fluid geothermal power system.</p>			
Unit-4			
<p>Wind Energy: Availability of wind energy in India, wind machines: types and their characteristics, horizontal and vertical axis wind mills, wind turbine aerodynamics, problems associated with wind power. Tidal Power: Tides and waves as energy suppliers and their mechanics, tidal-energy conversion systems, limitations. Ocean Thermal Energy Conversion (OTEC): Principle of working, ocean temperature differences, OTEC systems, recent OTEC developments, problems associated with OTEC. 12 Hrs</p> <p>Self Study Component: power in the wind, OTEC cycle, bio fouling.</p>			
Unit-5			
<p>Energy from Biomass: Biomass resource, biomass conversion technologies, photosynthesis, energy plantation, biogas production by anaerobic fermentation, description of biogas plants (KVIC digester), problems involved with biogas production, bio fuels and biogas economic aspects, advantages and application of biomass. Hydrogen Energy: Utilization of hydrogen energy as renewable form of energy sources, production of hydrogen, electrolysis of water, thermal decomposition of water, thermo chemical production and bio-chemical production. 10 Hrs</p> <p>Self Study Component: Deenbhandhu bio gas plant and Iodine sulphur cycle.</p>			
Text Books			

1. G.D. Rai, “**Non-Conventional Energy Sources**”, Khanna publishers, 6rd Edition 2004, ISBN: 9788174090737.
2. Subhas. P. Sukhatme, J. K. Nayak, “**Solar energy**”, Tata McGraw Hill India, 3rd Edition, 2009, ISBN: 9780070142961.

Reference Books

1. N. K. Bansal, Manfred Kleeman and Mechaelmeliss, “**Renewable Energy Sources and Conversion Technology**”, Tata McGraw Hill, 2001, ISBN:9780074600238.
2. John. W. Twidell, Tony Weir, “**Renewable Energy Resources**”, Routledge, 4th Edition, 2014, ISBN: 9780415633581.

At the end of the course, students will be able to,

Course Outcomes		Bloom’s Level
CO1	Identify renewable energy resources and their utilization.	III
CO2	Apply the basic concepts of solar radiation to understand the working principle of different solar energy conversion devices.	III
CO3	Apply the working principle of solar photovoltaic and geothermal energy systems for harnessing solar and geothermal energy.	III
CO4	Apply the working principle of wind, tidal and ocean energy system for harnessing energy.	III
CO5	Identify characteristics of biomass energy and the methods of production of hydrogen for utilization as a renewable form of source of energy.	III

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	01	02	
CO1	Identify renewable energy resources and their utilization.	3														
CO2	Apply the basic concepts of solar radiation to understand the working principle of different solar energy conversion devices.	3														
CO3	Apply the working principle of solar photovoltaic and geothermal energy systems for harnessing solar and geothermal energy.	3														
CO4	Apply the working principle of wind, tidal and ocean energy system for harnessing energy.	3														
CO5	Identify characteristics of biomass energy and the methods of production of hydrogen for utilization as a renewable form of source of energy.	3														

Course Title: FINITE ELEMENT METHOD IN ENGINEERING (Open Elective-II)			
Course Code: P18MEO754	Semester: VII	L-T-P: 4-0-0	Credits: 03
Contact Period - Lecture: 52 Hours	Exam: 3 Hours	Weightage % : CIE: 50, SEE:50	
Course Objectives: The course aims to provide an introductory approach to finite element method as a basic numerical tool for solving mechanical engineering problems.			
Course Content			
Unit-1			
Introduction to FEM: Need for use of FEM, advantages and disadvantages of FEM, engineering applications of FEM, steps involved in FEM, discretization process, types of elements (1D, 2D, 3D), size of the elements, location of nodes, node numbering scheme, body force and surface force, strain- displacement relations, stress-strain relations, concept of plane stress and plane strain and their stress-strain relations, principle of minimum potential energy and derivation of potential energy functional for a 3D elastic body. 10 Hrs			
Self Study Component: Numerical integration by Gaussian quadrature.			
Unit-2			
Interpolation Models: Displacement function, nodal degrees of freedom, convergence criteria, geometric isotropy, Pascal's triangle for 2D polynomial, different co-ordinate systems used in FEM, interpolation or shape functions for 1D linear bar elements and 2D linear triangular (CST) element in cartesian and natural co-ordinate systems. Lagrangian polynomial, shape functions for linear quadrilateral element (QUAD 4), iso-parametric, sub-parametric and super-parametric elements, concept of Jacobian matrix, Jacobian matrix for CST element. 11 Hrs			
Self Study Component: Simplex, complex and multiplex elements, Pascal's pyramid for 3-D polynomials.			
Unit-3			
Element Stiffness Matrix and Load Vectors: Strain displacement matrix, stiffness matrix and load vector for linear bar element, strain displacement matrix and stiffness matrix for CST element, assembly of elements by direct stiffness method, treatment of boundary conditions-elimination and penalty methods, numericals on axially loaded uniformly tapered and stepped bars. 10 Hrs			
Self Study Component: Characteristics of stiffness matrix for CST element under plane stress and plane strain conditions.			
Unit-4			
Analysis of Plane Trusses: Introduction, plane truss and plane frame structures, plane truss-assumptions in analysis of truss, local and global coordinate systems, transformation of local variables to global coordinates, stiffness and stress matrices for plane truss element, analysis of truss members. 10 Hrs			
Self Study Component: Comparison of beams and trusses.			
Unit-5			
Analysis of Beams: Introduction, Hermite shape function for beam element in cartesian coordinates, stiffness matrix and load vector for beam element, and analysis of beams.			
Analysis of Heat Transfer Problems: Steady state heat transfer, 1D heat conduction-governing equation, boundary conditions, one-dimensional element, Galerkin's approach to heat conduction problems, numericals on 1D heat transfer through composite wall. 11 Hrs			
Self Study Component: Different types of boundary conditions in heat transfer problem.			
Text Books			
1 Chandrakanth S Desai and J. F. Abel, "Introduction to the Finite Element Method" , CBS, 1 st Edition, 2005, ISBN: 9788123908953.			
2 T. R. Chandrupatla and A. D. Belegundu, "Introduction to Finite Elements in Engineering" , Pearson, 4 th Edition, 2011, ISBN: 9780132162746.			
Reference Books			
1 Singiresu S Rao, "The Finite Element Method in Engineering" , Elsevier Publisher, 5 th Edition, 2008, ISBN: 9789380931555.			
2 O. C. Zienkiewicz, "The FEM its Basics and Fundamentals" , Elsevier Publisher, 6 th			

Edition, 2007, ISBN: 978-8131211182.																													
3 J. N. Reddy, “ Finite Element Method ”, McGraw Hill, International Edition, 2005, ISBN: 9780072466850.																													
4 Daryl. L. Logon, “ Finite Element Methods ”, Thomson Learning 5 th Edition, 2011, ISBN: 9780495668251.																													
5 David V. Hutton, “ Fundamentals of Finite Element Analysis ”, Tata McGraw Hill Publishing Co. Ltd, 2005, ISBN: 978-0070601222.																													
At the end of the course, students will be able to,																													
Course Outcomes													Bloom’s Level																
CO1	Apply the basic concepts and mathematical preliminaries of FEM required to solve basic field problems.													III, IV															
CO2	Develop interpolation models for 1D and 2D elements that satisfy convergence criteria and geometric isotropy and use isoparametric concept in the finite element analysis.													V															
CO3	Formulate element stiffness matrices and load vectors for different elements using variational principle and analyze axially loaded bars.													III, IV															
CO4	Make use of finite element formulations in analysing the stresses, strains and reactions of trusses and transversely loaded beams.													III, IV															
CO5	Analyse the stresses, strains and reactions of transversely loaded beams and heat transfer problems.													IV															
Course Articulation Matrix																													
Course Outcomes													Program Outcomes												PSO				
													1	2	3	4	5	6	7	8	9	10	11	12	01	02			
CO1	Apply the basic concepts and mathematical preliminaries of FEM required to solve basic field problems.													3	2														
CO2	Develop interpolation models for 1D and 2D elements that satisfy convergence criteria and geometric isotropy and use isoparametric concept in the finite element analysis.													1		3													
CO3	Formulate element stiffness matrices and load vectors for different elements using variational principle and analyze axially loaded bars.													1	3														
CO4	Make use of finite element formulations in analysing the stresses, strains and reactions of trusses and transversely loaded beams.													3	2														
CO5	Analyse the stresses, strains and reactions of transversely loaded beams and heat transfer problems.														3														

Course Title: DESIGN LAB																
Course Code: P18MEL76			Semester: VII			L-T-P: 0-0-3			Credits: 1.5							
Contact Period - Lecture: 36 Hours ;				Exam: 3 Hours			Weightage %: CIE: 50, SEE: 50									
Course Objectives: This course enables the students to understand the basic concepts of natural frequency of spring-mass system, vibration characteristics of rotor, pressure distribution in journal bearing.																
Course Content																
PART- A																
Exp-1: Determination of natural frequency of single DOF undamped spring-mass free vibration system.																
Exp-2: Determination of natural frequency of single DOF undamped equivalent spring-mass free vibration system.																
Exp-3: Study of single DOF damped torsional free vibration system.																
Exp-4: Study of forced vibration of single DOF equivalent spring - mass – damper system																
Exp-5: Determination of natural frequency by Dunkerley’s principle																
Exp-6: Determination of critical speed of a rotating shaft.																
Exp-7: Determination of vibration characteristics of rotor (Demonstration only).													21 Hrs			
PART-B																
Exp-8: Determination of Fringe constant of Photo elastic material using a Circular disc subjected To diametric compression.																
Exp-9: Determination of stress concentration using Photo elasticity for a circular disk with circular hole under compression																
Exp-10: Performance study of governors.																
Exp-11: Determination of a Pressure distribution in Journal bearing																
Exp-12: Determination of Principal Stresses and strains in a member subjected to combined loading using Strain rosettes.																
Exp-13: Determination of gyroscopic torque in a Gyroscope.													15 Hrs			
Reference Books																
1. V.P. Singh, “ Mechanical Vibrations ”, Dhanpat Rai and Co (P) Ltd., ISBN: 1234567150209.																
2. S.S. Rattan, “ Theory of Machines ”, Tata McGraw-Hill, New Delhi, 4 th Edition, 2015, ISBN: 9789351343479.																
At the end of the course, students will be able to,																
Course Outcomes													Bloom’s Level			
CO1	Identify safe operating practices and requirements for laboratory experiments													III		
CO2	Apply principles of vibration to analyse characteristics of single degree of freedom systems.													III, IV		
CO3	Apply the concepts of stress concentration and pressure distribution to analyse photo elastic material and journal bearing respectively.													III, IV		
CO4	Analyze the performance parameters of governors and gyroscopes.													IV		
CO5	Make use of experimental data to prepare clear and concisely lab reports as an individual or as a team member to communicate effectively.													III,V		
Course Articulation Matrix																
Course Outcomes		Program Outcomes												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	01	02	
CO1	Identify safe operating practices and requirements for laboratory experiments	3													2	
CO2	Apply principles of vibration to analyse characteristics of single degree of freedom systems.	3	3													
CO3	Apply the concepts of stress concentration and	3	3													

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	pressure distribution to analyse photo elastic material and journal bearing respectively.																	
CO4	Analyze the performance parameters of governors and gyroscopes.		3															
CO5	Make use of experimental data to prepare clear and concisely lab reports as an individual or as a team member to communicate effectively.	3									3	3						

Course Title: SIMULATIONS LAB																
Course Code: P18MEL77			Semester: VII			L-T-P: 0-0-3			Credits: 1.5							
Contact Period - Lecture: 36 Hours				Exam: 3 Hours			Weightage % : CIE: 50, SEE:50									
Course Objectives: This course enables the students to simulate Turning, Drilling, Milling/Cutting operations using simulation packages, to build hydraulic circuits using single acting cylinder and double acting cylinder and to generate response plot of control system using MATLAB.																
Course Content																
PART -A																
1. Modeling of simple machine parts and generating machine codes for CNC production using standard CAM packages.																
2. Simulation of Turning, Drilling, Milling/Cutting operations on a Computer using CAM packages.																
3. Three typical simulations to be carried out using simulation packages like Master CAM, or any equivalent software. 21 Hrs																
PART- B																
4. Design and building of hydraulic circuits using single acting cylinder and double acting cylinder and its analysis.																
5. Unit-step response plot of control system using MATLAB, for (i) its open loop transfer function and (ii) its state-space equation and to determine rise time, peak time, maximum overshoot and settling time in the unit-step response plot.																
6. Root locus plot, Bode plot and Nyquist plot of control systems using MATLAB, for (i) its open loop transfer function and (ii) its state-space equation. 15 Hrs																
Reference Books																
1. P.N. Rao, “ CAD/CAM Principles and Application ”, Tata McGraw Hill, 3 rd edition, 2010, ISBN: 0070681937.																
2. Groover, “ Computer Aided Design/Computer Aided Manufacturing ”, Tata McGraw Hill. 2003.																
3. Rao V Dukkupati, “ Control Systems ”, Narosa Publishing House, 2008, ISBN: 978-8173195549.																
At the end of the course, students will be able to,																
Course Outcomes													Bloom’s Level			
CO1	Apply the basic concepts of advanced manufacturing techniques to commercially available CAM tool.												III			
CO2	Apply the basics of machining processes such as Turning, Drilling and Milling to CAM tool.												III			
CO3	Develop MATLAB programs to plot step-response curve, root locus, Nyquist and Bode plots of control systems.												V			
CO4	Interpret the results obtained for preparing a report as an individual to communicate effectively.												VI			
Course Articulation Matrix																
Course Outcomes		Program Outcomes											PSO			
		1	2	3	4	5	6	7	8	9	10	11	12	01	02	
CO1	Apply the basic concepts of advanced manufacturing techniques to commercially available CAM tool.	3				3										2
CO2	Apply the basics of machining processes such as Turning, Drilling and Milling to CAM tool.	3														
CO3	Develop MATLAB programs to plot step-response curve, root locus, Nyquist and Bode plots of control systems.	2		3		2										

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CO4	Interpret the results obtained for preparing a report as an individual to communicate effectively.					3						3	3				
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Course Title: PROJECT WORK PHASE-I and SEMINAR																											
Course Code: P18ME78				Semester: VII				L-T-P: 0-0-4				Credits: 2															
Contact Period - Lecture: 36 Hours				Exam: 3 Hours				Weightage %: CIE: 100																			
Course Objectives: This course enables the students to conduct a project work on topics related to mechanical engineering or interdisciplinary topics integrated with mechanical engineering.																											
Course Content : The Project Work Phase - I and seminar evaluation shall be of 100 marks CIE. It is based on the submission of report consisting Title, Introduction, Literature Survey, Objectives and Methodology (50 marks) and presentation (50 marks).																											
Course Outcomes														Bloom's Level													
CO 1	Identify title, introduction, literature survey and objectives and methodology.											Formulation of		III													
Course Articulation Matrix																											
Course Outcomes														Program Outcomes												PSO	
														1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	Identify title, introduction, literature survey and Formulation of objectives and methodology.													2	3	2	2	1	2		2	2	2	1		1	

Course Title: INDUSTRIAL ROBOTICS			
Course Code: P18ME81	Semester: VIII	L-T-P: 4-0-0	Credits: 04
Contact Period - Lecture: 52 Hours	Exam: 3 Hours	Weightage % : CIE: 50, SEE: 50	
<p>Course Objectives: The course aims at enabling the students to familiarize students with brief history of robot and basic concepts of industrial robot. Expose the students to kinematics of robots and programming of robot. Make the students familiar with various applications of robots in industry.</p>			
Course Content			
Unit-1			
<p>Introduction: Automation and robotics, brief history of robotics, classifications of robots, geometrical configuration, advantages and applications of each, work volume, wrist and its motions, links and joints. End Effectors: Types of grippers and tools, resolution, accuracy and repeatability, numericals. 10 Hrs</p> <p>Self Study Component: Latest developments in robots.</p>			
Unit-2			
<p>Structure of Robotic System: Robot drive system, hydraulic, electric and pneumatic drive system, advantages and disadvantages, feedback components, position and velocity sensors, types of actuators, internal state sensors, encoders, potentiometers and resolver, external state sensors, tactile sensing, proximity sensing, range sensing, and force-torque sensors. 10 Hrs</p> <p>Self Study Component: Applications of hydraulic, electric and pneumatic drive system.</p>			
Unit-3			
<p>Kinematic Analysis and Coordinate Transformation: Direct kinematic problem in robotics, geometry based direct kinematic analysis, coordinate and vector transformation using matrices, the orientation matrix and translator vector, homogeneous transformation matrices, three dimensional homogeneous transformations, Denavit-Hartenberg (DH) convention, implementing the DH convention, obtaining the DH displacement matrices. 10 Hrs</p> <p>Self Study Component: Applications of DH method in three axis robot arm and wrist.</p>			
Unit-4			
<p>Robot Programming: Introduction, methods of robot programming, lead through method, textual robot language method, a robot program as a path in space, motion interpolation, wait, signal and delay commands, branching, the textual robot languages, generations of robot programming languages, robot language structure, robot language elements and functions, programs. 12 Hrs</p> <p>Self Study Component: Capabilities and limitations of lead through methods.</p>			
Unit-5			
<p>Autonomous Mobile Robots: Locomotion, key issues for locomotion, legged mobile robots, leg-types and configurations and stability, examples of legged robot locomotion, gaits-biped, quadruped and hexaped, wheeled mobile robots, wheeled locomotion, design space. Applications of Robots in Manufacturing: Material transfer, general considerations in robot material handling pick and place, palletizing operations, machine loading and unloading; die casting, plastic moulding, forging, machining and stamping press operations. 10 Hrs</p> <p>Self Study Component: Applications of robots in processing operations.</p>			
Text Books			
<ol style="list-style-type: none"> 1. Michell Grover, Mitchel Weiss and Roger Nagel, “Industrial Robots”, McGraw Hill, 2nd Edition, 2012, ISBN: 139780070265097. 2. K.S. Fu, R.C. Gonzales and Lee, “Robotics”, McGraw Hill, 1st edition, 2008, ISBN: 139780070265103. 			
Reference Books			
<ol style="list-style-type: none"> 1. Yoramn Koren, “Robotics for Engineers”, Mc Graw hill Intl. Book Co., 1987, ISBN: 139780070353992. 2. Robert J. Schilling, “Fundamentals of Robotics”, PHI, 1st Edition, 2011, ISBN: 			

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139788120310476.

3. Richard D. Klafter, C Thomas A, “**Robotic Engineering**”, PHI, 1993, ISBN: 139788120308428.

4. R.K. Mittal and J. Nagarath, “**Robotics and Control**” Tata McGraw Hill, 6th Edition, 2007, ISBN: 0070482934.

At the end of the course, students will be able to,

Course Outcomes		Bloom's Level
CO1	Identify robots based on geometrical configuration, work volume, resolution, and accuracy of various configurations of robot.	III
CO2	Identify different types of drive system and sensors required for specific applications.	III
CO3	Analyse kinematics and coordinate transformation of robots using DH method.	IV
CO4	Develop robot task program using robot language.	V
CO5	Apply the concepts of different autonomous mobile robot systems in manufacturing industries.	III

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO			
		1	2	3	4	5	6	7	8	9	10	11	12	01	02		
CO1	Identify robots based on geometrical configuration, work volume, resolution, and accuracy of various configurations of robot.	3														2	
CO2	Identify different types of drive system and sensors required for specific applications.	3															
CO3	Analyse kinematics and coordinate transformation of robots using DH method.	1	3												2	2	
CO4	Develop robot task program using robot language.	1		3													2
CO5	Apply the concepts of different autonomous mobile robot systems in manufacturing industries.	3															

Course Title: OPERATIONS RESEARCH			
Course Code: P18ME821	Semester: VIII	L-T-P: 4-0-0	Credits: 03
Contact Period - Lecture: 52 Hours	Exam: 3Hours	Weightage % : CIE: 50, SEE:50	
Course Objectives: The course aims at enabling the students to understand the basic concepts of Operations Research. Identify and develop operation research models from the verbal description of real life and optimize the solutions.			
Course Content			
Unit-1			
Introduction: Definition, scope of Operations Research (OR) approach and limitations of OR models, characteristics and phases of OR, mathematical formulation of Linear Programming Problems (LPP), graphical solution for maximization and minimization problems.			10 Hrs
Self Study Component: Advantages and disadvantages of operations research.			
Unit-2			
Linear Programming Problems: Simplex method, slack, surplus and artificial variables, degeneracy and procedure for resolving degeneracy. Big-M method, two phase method.			12 Hrs
Self Study Component: Dual simplex method.			
Unit-3			
Transportation and Assignment: Formulation of transportation problem, initial feasible solution methods, optimality test, degeneracy in transportation problem, assignment problem, Hungarian method, traveling salesman problem.			10 Hrs
Self Study Component: Unbalanced transportation and assignment problems.			
Unit-4			
Network Analysis in Project Planning (PERT and CPM): Project, project planning, project scheduling, project controlling, network terminologies, PERT and CPM.			10 Hrs
Self Study Component: Crashing of networks.			
Unit-5			
Game Theory: Formulation of games, two people-zero sum game, games with and without saddle point, graphical solution (2 x n, m x 2 game) and dominance property. Queuing Theory: Queuing system and their characteristics. The M/M/1 queuing system, steady state performance analyzing of M/M/1 system.			10 Hrs
Self Study Component: Competitive games.			
Text Books			
1. Taha H. A “ Operations Research and Introduction ”, Pearson Education, 10 th Edition, 2014, ISBN No.9780134444017.			
2. S.D. Sharma “ Operations Research ”, Kedarnath Ramnath and Co., 2 nd Edition, 2002, ISBN : 978938593545.			
Reference Books			
1. AM Natarajan, P. Balasubramani, A Tamilaravari “ Operations Research ”, Pearson Education 2006, ISBN: 8131700003.			
2. Hiller and Liberman, “ Introduction to Operations Research ”, McGraw Hill, 5 th Edition, 2001, ISBN: 8131700003.			
3. Ravindran, Phillips and Solberg “ Operations Research ”, Principles and practice Wiley India, 2 nd Edition, 2007, ISBN: 9780471086086.			
4. Prem Kumar Gupta, D.S. Hira S “ Operation Research ”, Chand Publication, 2011, ISBN: 9788121902816.			
At the end of the course, students will be able to,			
Course Outcomes			Bloom's Level
CO1	Formulate real world problems as a Linear programming model and demonstrate solution by graphical method..		IV
CO2	Apply the sensitivity analysis technique to identify the direction and magnitude of change of a Linear programming model.		III, IV

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CO3	Apply the specific LPP like transportation and assignment and analyse the solution.															III, IV
CO4	Apply the different project model and analyze the solution.															III, IV
CO5	Apply the different Inventory models and analyze the solution.															III, IV
Course Articulation Matrix																
Course Outcomes		Program Outcomes												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	01	02	
CO1	Formulate real world problems as a Linear programming model and demonstrate solution by graphical method.		3													
CO2	Apply the sensitivity analysis technique to identify the direction and magnitude of change of a Linear programming model.	3	3													
CO3	Apply the specific LPP like transportation and assignment and analyze the solution.	3	3													
CO4	Apply the different project model and analyze the solution.	3	3													
CO5	Apply the different Inventory models and analyze the solution.	3	3													

Course Title: FOUNDRY AND WELDING TECHNOLOGY			
Course Code: P18ME822	Semester: VIII	L-T-P: 4-0-0	Credits: 03
Contact Period - Lecture: 52 Hours	Exam: 3 Hours	Weightage % : CIE: 50, SEE:50	
Course Objectives: The course aims at understanding and strengthening the knowledge of advancements in Foundry and Welding technology to the students by exposing them to different Foundry and welding techniques that are commonly used in industries.			
Course Content			
Unit-1			
<p>Solidification of Castings: Introduction, concept of solidification of metals, solidification of pure metals, nucleation, homogeneous or self-nucleation, heterogeneous nucleation, growth, solidification of alloys, alloyed metal characteristics, main types of alloys, solid solution alloys, their characteristics and solidification, phase diagram, coring or segregation, types of segregation, solute distribution, solidification phenomenon and grain structure, mechanism of dendrite, formation and dendrite growth solidification rate, directional solidification and control of solidification to obtain sound castings. Metallurgy of Cast Steel: Composition, structure, control of properties, macrostructure, microstructure, inclusions, heat-treatment, annealing, normalizing, stress relief annealing, liquid quench and tempering. 10 Hrs</p> <p>Self study component: Alloy steels, measurement of hardenability and its significance, production heat treating.</p>			
Unit-2			
<p>Principles of Gating: Gating System, requirements, purposes of functions of the gating system, pouring cups and basins, spruers, gates, their characteristics and different types, design of gating system, objectives achieved from good design, defects occurring due to improper design of gating system, turbulence in gating system, metal flow rate and velocity calculations, design criteria for pouring basin, design of sprue, pouring time, design of runner and gates, pressurized and unpressurized gating system, streamlining the gating system, practical rules for gating practice, elimination of slag and dross for copper, ferrous and light metal alloys. Principles of Riser: Introduction, functions of a riser, types of riser, open and blind risers, riser and directional solidification, increasing riser efficiency and promoting directional solidification, insulating materials, exothermic materials, chills, padding, feeder head (or riser system), design, general principles, riser shape, riser size, Chvorinov's rule, riser location and riser feeding distance. 10 Hrs</p> <p>Self study component: Riser practice for alloys- heat loss from risers.</p>			
Unit-3			
<p>Casting Design Considerations: Functional design, mechanical strength, dimensional design factors, simplification of foundry practice, molding and coring, elimination of coring, metallurgical design, Shakeout/ Cleaning/ Finishing: Modern developments, punch out machines, shakeout tables and decks, high frequency shakeouts, vibrating shakeout conveyors, rotary separators, robots and manipulators, fettling (cleaning) of castings; removal of cores, cleaning of castings surfaces, hand methods and mechanical methods, blast cleaning, process control, blast cleaning abrasives, air blasting, mechanical blast cleaning (wheelabrator system), hydro blasting, safety considerations when blast cleaning nonferrous casting, chemical cleaning, removal of gates and riser, removal of fins and other unwanted projections from castings, finishing of castings; grinding castings. 10 Hrs</p> <p>Self study component: Surface treatment of castings.</p>			
Unit-4			
<p>Special Welding Processes: Electron beam welding, laser beam welding, ultrasonic welding, explosion welding, electro slag and electro gas welding, cold pressure welding, friction stir welding, diffusion bonding and adhesive bonding. Cracks in Welding: Introduction, classifications in weld cracks, hot and cold cracks, nomenclature, location and orientation of weld cracks, weld metal cracks, base metal cracks, factors contribution to weld cracking. 12 Hrs</p> <p>Self study component: Specific weld cracks: Chevron cracks, lamellar cracks, reheat cracking, stress corrosion cracking.</p>			

Unit-5

Defects in Welding: Classification of weld defects, general sources of weld defects, surface or visual defects, subsurface weld defects, weld defects in arc welding processes, resistance welding defects, defects in friction welding, defects in welds of other welding processes.

Weld Inspection, Quality Control and Inspection of Welding Defects: Introduction, destructive tests, tensile test, bend test, toughness testing test, hardness, visual inspection, liquid penetrate testing, magnetic particle testing, eddy current testing, magneto graphic test, radiographic testing, ultrasonic testing and acoustic emission testing. **10 Hrs**

Self study component: Comparison of NDT methods, vacuum testing, halide testing, Helium test.

Text Books

1. O. P. Khanna, “**Foundry Technology**”, Dhanpat Rai Publication(p) Ltd, Revised edition, 2015, ISBN:9788189928346.
2. Parmar. R. S, ”**Welding Processes and Technology**”, 3rd Edition, Khanna Publishers, 2013, ISBN:9788174091260.

Reference Books

1. John Campbell, “**Casting**”, Butterworth Heinmann, 2nd Edition, 2004, ISBN: :9780750647915.
2. P.N.Rao, “**Manufacturing Technology Foundry, Forming and Welding**”, McGraw Hill, 4th Edition, volume 1, 2013, ISBN: 9789383286614.
3. Dr. K. Radha Krishna, “**Manufacturing process-I**”, Sapna Book House, Bangalore. 5th Edition, 2006, ISBN: 8128002074.
4. Carl R Loper and Philip C Rosenthal, Richard W Heine, “**Principles of Metal Casting**”, Tata McGraw Hill, 2001, ISBN: 9780070993488.

At the end of the course, students will be able to,

Course Outcomes		Bloom's Level
CO1	Apply the concepts of solidification and nucleation of metals in casting process.	III
CO2	Identify the different gating and riser systems to obtain sound casting.	III
CO3	Identify the different modern equipments and factors affecting in casting design .	III
CO4	Identify different types of welding techniques and factors contributing to weld cracks.	III
CO5	Identify the different welding defects using different non destructive testing methods.	III

Course Articulation Matrix

Course Outcomes	Program Outcomes												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	01	02	
CO1	Apply the concepts of solidification and nucleation of metals in casting process.	3													
CO2	Identify the different gating and riser systems to obtain sound casting.	3													
CO3	Identify the different modern equipments and factors affecting in casting design .	3	1												
CO4	Identify different types of welding techniques and factors contributing to weld cracks.	3													
CO5	Identify the different welding defects using different non destructive testing methods.	3													

Course Title: TRIBOLOGY			
Course Code: P18ME823	Semester: VIII	L-T-P: 4-0-0	Credits: 03
Contact Period - Lecture: 52 Hours	Exam: 3 Hours	Weightage % : CIE: 50, SEE:50	
Course Objectives: The course aims at strengthening the capability of students to integrate friction, wear and lubrication theories in design, manufacturing and operation of sustainable machine elements and their maintenance.			
Course Content			
Unit-1			
<p>Introduction to Tribology: Introduction, friction, laws of friction, friction theories, surface contaminants and frictional heating, wear- classification of wear, abrasive wear and adhesive wear, corrosive wear, fatigue and fretting wear, mechanisms of wear, basic wear testing methods- pin on disc wear tester and dry sand rubber wheel abrasion tester, wear resistant materials. Surface Roughness: Introduction, standardization of surface roughness, M and E system, center line average, root mean square roughness, probability distribution function, autocorrelation function, Abbott bearing area curve, surface roughness measurement techniques-stylus method, interferometric method, optical profilometer and pneumatic method. 10 Hrs</p> <p>Self Study Component: Industrial importance of tribology.</p>			
Unit-2			
<p>Lubricants and Lubrication: Types of bearing, lubricants, types of lubricants, lubrication, types of sliding lubrication-fluid-film lubrication, boundary lubrication and extreme boundary lubrication, properties of oils and equation of flow- viscosity, Newton's law of viscous flow, effect of temperature and pressure on viscosity, viscosity index, viscosity measuring apparatus-U-tube viscometer, Saybolt universal viscometer and Redwood viscometer, Hagen-Poiseuille law, flow through capillary tube, flow between parallel stationary plates. 10 Hrs</p> <p>Self Study component: Types of additives.</p>			
Unit-3			
<p>Hydrodynamic Lubrication: Friction forces and power loss in lightly loaded bearing, coefficient of friction for a lightly loaded bearing (Petroff's equation), limits of hydrodynamic lubrication, numerical examples of lightly loaded full-journal bearing, tower's experiments, Reynold's investigations, mechanism of pressure development in an oil film, application of converging oil film in thrust bearing, formation of a converging oil film in a partial and full journal bearings, Reynold's equation in two dimensions. 10 Hrs</p> <p>Self Study Component: Concept of Navier- Stokes.</p>			
Unit-4			
<p>Idealized Hydrodynamic Bearings: Definition of idealized bearings, idealized plane-slider bearing with a fixed shoe-pressure distribution, load carrying capacity, coefficient of friction, idealized slider bearing with a pivoted shoe-load carrying capacity, frictional resistance, coefficient of friction, location of the pivot point of a slider bearing with a pivot shoe, Numerical. 10 Hrs</p> <p>Self Study Component: Location of center of pressure of idealized slides bearing.</p>			
Unit-5			
<p>Hydrodynamic Journal Bearing: Idealized journal bearings- infinitely long-full journal bearing- oil film thickness, Sommerfeld substitution, pressure distribution (description only), load carrying capacity, Sommerfeld number, viscous friction, modified Sommerfeld solution. Infinitely short-full journal bearing- pressure distribution (description only), load capacity and friction force, numerical on idealized hydrodynamic journal bearing. Porous Bearings: Introduction to porous bearings, equations for porous bearings and working principle. Hydrostatic Lubrication: Introduction to hydrostatic lubrication, types of hydrostatic lubrication systems, hydrostatic step bearings, load carrying capacity and oil flow through the hydrostatic step bearing, numerical on hydrostatic lubrication. 12 Hrs</p> <p>Self Study Component: Advantages and disadvantages of magnetic bearing.</p>			
Text Books			
1. Basu S K., Sengupta S N.and Ahuja B. B., " Fundamentals of Tribology ", PHI, 1 st			

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Edition, 2009, ISBN: 9788120327238.																											
2. B. C. Mujumdar, “ Introduction to Tribology of Bearings ”, S. Chand (G/L) and Company Ltd, 2 nd Edition, 2010, ISBN: 9788121929875.																											
Reference Books																											
1. E. I. Redzimonvskay, “ Lubrication of Bearings Theoretical Principles and Design ”, The Ronald Press Company, 1 st edition, 1959, ASIN: B0000EGL66.																											
2. Dudley D. Fuller, “ Theory and Practice of Lubrication for Engineers ”, John Wiley and Sons, 2 nd Edition, 1984, ISBN: 9780471047032.																											
3. Desmond F. Moore, “ Principles and Applications of Tribology ”, Pergamaon Press, 1 st edition, 1975, ISBN: 9780080179025.																											
4. Sushil Kumar Srivastava, “ Tribology in Industries ”, S Chand and Company Limited, 2004, ISBN: 9788121920452.																											
5. Prasanta Sahoo, “ Engineering Tribology ”, PHI, 2005, ISBN: 9788120327245.																											
At the end of the course, students will be able to,																											
Course Outcomes												Bloom's Level															
CO1	Apply the basics of friction, laws of friction and different types of wear and wear mechanisms and analyse surface texture and roughness characteristics using its measuring techniques.											III, IV															
CO2	Identify the properties of lubricants and develop Hagen-Poiseuille law.											III, V															
CO3	Apply the concept of lightly loaded bearings and develop Petroff's equation.											III, V															
CO4	Develop expressions for pressure distribution, load carrying capacity, coefficient of friction and frictional resistance in an idealized slider bearing.											V															
CO5	Develop expressions for pressure distribution, load carrying capacity and oil flow through the hydrodynamic journal bearing, hydrostatic step bearing.											V															
Course Articulation Matrix																											
Course Outcomes												Program Outcomes						PSO									
												1	2	3	4	5	6	7	8	9	10	11	12	01	02		
CO1	Apply the basics of friction, laws of friction and different types of wear and wear mechanisms and analyse surface texture and roughness characteristics using its measuring techniques.											3	3														
CO2	Identify the properties of lubricants and develop Hagen-Poiseuille law.											3		2													
CO3	Apply the concept of lightly loaded bearings and develop Petroff's equation.											3		3													
CO4	Develop expressions for pressure distribution, load carrying capacity, coefficient of friction and frictional resistance in an idealized slider bearing.												1	3													
CO5	Develop expressions for pressure distribution, load carrying capacity and oil flow through the hydrodynamic journal bearing, hydrostatic step bearing.												1	3													

Course Title: COMPUTATIONAL FLUID DYNAMICS			
Course Code: P18ME824	Semester: VIII	L-T-P-H: 4-0-0-4	Credits: 03
Contact Period - Lecture: 52 Hours	Exam: 3 Hours	Weightage %: CIE: 50 SEE: 50	
<p>Course Objectives: This course will prepare students in the fundamentals of the computational approach to study fluid flow and heat transfer problems and will provide a deeper understanding of the physical models and governing equations of fluid dynamics. It will also impart the knowledge of numerical techniques to the solution of fluid dynamics and heat transfer problems.</p>			
Course Content			
Unit-1			
<p>Governing Equations: Basics of Computational Fluid Dynamics (CFD), comparison of experimental, theoretical and computational approaches, 3-D general mass conservation, momentum and energy equations in differential form, integral form. Partial Differential Equations (PDE): classification of PDE, hyperbolic, parabolic and elliptic forms of equations and their physical behavior, physical boundary conditions. 11 Hrs</p> <p>Self Study Component: Forms of the governing equations particularly suited for CFD work, generic form of equations, impact of CFD on automobile, engine and manufacturing applications.</p>			
Unit-2			
<p>Finite Difference Method: Derivation of finite difference equations for first and second order accuracy, different numerical schemes-explicit and implicit approach-upwind, downwind, FTCS, etc., truncation error, round-off and discretization errors and analysis of stability, error propagation, application of numerical methods to selected model equations; wave equation, heat equation, Laplace equation. 10 Hrs</p> <p>Self Study Component: Stability properties of explicit and implicit methods, numerical dissipation and numerical dispersion.</p>			
Unit-3			
<p>Finite Volume Method for Diffusion: Finite volume formulation of steady state one dimensional diffusion problems, finite volume methods for diffusion equation-one dimensional unsteady heat conduction through explicit, Crank-Nicolson and fully implicit. Finite Volume Method for Convection Diffusion: Finite volume formulation of steady state one dimensional convection-diffusion problems- central, upwind, hybrid, power-law, QUICK differencing schemes. 11 Hrs</p> <p>Self Study Component: Properties of discretization schemes-conservativeness, boundedness, transportive.</p>			
Unit-4			
<p>Overview of Ansys Workbench: (Teaching by Industry Experts) Introduction, mechanical overview, starting mechanical, working with units, basic analysis procedure, mechanical interface, menus, toolbars, graphics controls and selection, outline tree and details, tagging and tree filtering, graphics window, mechanical application wizard, scoping loads and supports, engineering data application. General pre-processing: Geometry, connections, co-ordinate systems, named selections, object generator, selection information. Meshing: Global, local meshing controls, mesh troubleshooting, virtual topology, submodelling. 10 Hrs</p> <p>Self Study Component: Need for CFD, applications of CFD, Convergence criteria</p>			
Unit-5			
<p>Introduction to Analysis: (Teaching by Industry Experts) Vibration Analysis (Free Vibration): Basics of free vibration, geometry, contact, solution setup, modal results, vibration with pre-stress. Thermal Analysis (Steady State Thermal Analysis): Basics of steady state heat transfer, geometry, material property, thermal contact, thermal boundary conditions, solution options, and results post-processing. Results and Post Processing: Viewing results, legend controls, contour controls, post processing utilities, exporting results, convergence and scoping. 10 Hrs</p> <p>Self Study Component: Numerical stability, turbulence modeling.</p>			

Text Books

1. John C. Tannehill, Dule A Anderson and Richard H Pletcher, “**Computational Fluid Mechanics and Heat Transfer**”, CRC press, 3rd Edition, 2011, ISBN: 139781591690375.
2. SuhasV Patankar, “**Numerical Heat Transfer and Fluid Flow**”, CRC Press, 1980, ISBN: 139780891165224.

Reference Books

1. T.J. Chung, “**Computational Fluid Dynamics**”, Cambridge University Press, 2nd edition, 2010, ISBN: 139780521769693.
2. John D. and Anderson, Jr., “**Computational fluid Dynamics- The basics with applications**”, McGraw-Hill, Inc.1995, ISBN:139780070016859.
3. Muralidhar, K., and Sundararajan, T., “**Computational Fluid Flow and Heat Transfer**”, Narosa Publishing House, New Delhi, 2ndedition, 2009, ISBN: 139788173195228.
4. Versteeg, H.K., and Malalasekera, W., “**An Introduction to Computational Fluid Dynamics-The finite volume Method**”, Pearson, 2nd edition, 2007, ISBN: 139780131274983.

At the end of the course, students will be able to,

Course Outcomes		Bloom's Level
CO1	Apply the concepts of partial differential equations to understand behavior of the equation with suitable boundary conditions.	III
CO2	Develop finite difference discretization methods and implement them to analyse engineering problems.	IV, V
CO3	Develop finite volume discretization methods and implement them to analyse engineering problems.	IV, V
CO4	Identify the modern CFD tool to build flow geometries, generate mesh and select suitable solvers to obtain the solutions.	III
CO5	Develop the numerical solutions for free vibration and steady state thermal problems.	V

Course Articulation Matrix

Course Outcomes	Program Outcomes												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	01	02
	CO1	3												
CO2		2	3											
CO3		2	3											
CO4	3				2								2	
CO5			3											

Department of Mechanical Engineering

Course Title: INTERNSHIP															
Course Code: P18ME83			Semester: VIII			L-T-P: 0-0-0			Credits: 02						
Exam: 3 Hours						Weightage % : CIE: 50, SEE:50									
Course Objectives: All students have to undergo mandatory internship of 8 weeks during the vacation of VI and VII Semesters.															
Course Content															
The area for internship shall be a mechanical industry/ consultancy / service firms related to mechanical engineering. An examination should be conducted during VIII semester and the prescribed credit shall be counted for the same semester. Internship shall be considered as a head of passing and shall be consider for the award of degree. Those, who do not take-up / complete the internship shall be declared as failed and have to complete during the subsequent examination after satisfying the internship requirements.															
At the end of the course, students will be able to,															
Course Outcomes													Bloom's Level		
CO	Adapt the industrial knowledge in the appropriate field related to mechanical engineering.												III, VI		
Course Articulation Matrix															
Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO	Adapt the industrial knowledge in the appropriate field related to mechanical engineering.	2	1	2		1	2	2	2		1	2		1	

Course Title: PROJECT WORK PHASE-II															
Course Code: P18ME84			Semester: VIII			L-T-P: 0-0-4			Credits: 06						
Exam: 3 Hours					Weightage %: SEE:100, CIE: 100										
Course Objectives: Course Objectives: This course enables the students to conduct a project work on topics related to mechanical engineering or interdisciplinary topics integrated with mechanical engineering.															
Course Content : The Project Work Phase - II shall be of CIE for 100 marks and SEE for 100 marks. It is based on the submission of report consisting title, abstract, introduction, literature survey, objectives and methodology, experimentation, analysis, results, discussions and conclusions for 100 marks and presentation for 100 marks.															
Course Outcomes													Bloom's Level		
CO	Identify title, introduction, literature survey and objectives and methodology.										Formulation of		III, IV		
Course Articulation Matrix															
Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO	Identify title, introduction, literature survey and objectives and methodology.	2	3	2	2	1	2		2	2	2	1	1	1	2

Course Title: SELF STUDY COURSE AND SEMINAR			
Course Code: P18ME85	Semester: VIII	L-T-P: 0-0-4	Credits: 02
Weightage % : CIE: 50			
<p>In the self-study course and seminar, the student has to choose and study the courses related to the program discipline with her/his own efforts under the guidance of a course instructor/project guide, using study materials available in open sources i.e. Massive open online course (MOOC) NPTEL courses.</p> <p>Further, in addition to the above, the department has to release the pool of courses from the list of available 8 weeks NPTEL online courses. The student has to register for the course from the available pool during VII/VIII semester and the same will be reflected in the grade card of the VIII semester. The 50 marks CIE assessment is based on the final NPTEL score (i.e. Online assignments: 25% + Proctored exam: 75%). The NPTEL score will be mapped directly to the CIE marks as per the calculation below only if he /she has completed the NPTEL course (i.e. Certification).</p> <p style="text-align: center;">CIE = (NPTEL Score X 1.5)/2=[Maximum CIE should be 50 marks]</p> <p style="text-align: center;">[Ex.-1: If NPTEL score is 60 then the CIE will be = (60 X 1.5)/2=45</p> <p style="text-align: center;">Ex.-2: If NPTEL score is 80 then the CIE will be= (80X 1.5)/2=50 (Maximum CIE should be 50 Marks)]</p> <p>If the student fails to complete the NPTEL course at the end of the VIII semester, then the department has to constitute a committee consisting of the head of the department, two senior faculty members of the department, one of them may be the internal guide. The evaluation is based on a report, presentation, and viva voce and the assessment is a relative evaluation in context to the student completed NPTEL course (i.e. the CIE score should be less than the score of the student cleared NPTEL course).</p>			