SYLLABUS
(WITH EFFECT FROM 2018-19)

ಪಠ್ಯಕ್ರಮ

(ಶೈಕ್ಷಣಿಕ ವರ್ಷ 2018–19)

VII to VIII Semester
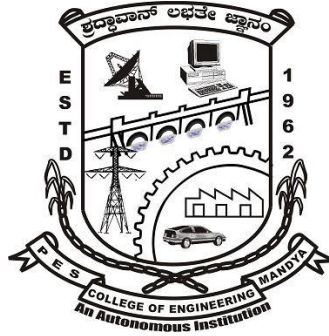### Bachelor Degree
In
Mechanical Engineering

OUT COME BASED EDUCATION
WITH
CHOICE BASED CREDIT SYSTEM

P.E.S. College of Engineering
Mandya - 571 401, Karnataka
(An Autonomous Institution Affiliated to VTU, Belagavi)
Grant -in- Aid Institution
(Government of Karnataka)
Accredited by NBA, New Delhi
Approved by AICTE, New Delhi.

ಪಿ.ಇ.ಎಸ್. ತಾಂತ್ರಿಕ ಮಹಾವಿದ್ಯಾಲಯ
ಮಂಡ್ಯ–571 401, ಕರ್ನಾಟಕ
(ವಿ.ಟಿ.ಯು, ಬೆಳಗಾವಿ ಅಡಿಯಲ್ಲಿನ ಸ್ವಾಯತ್ತ ಸಂಸ್ಥೆ)

Ph.: 08232- 220043, Fax: 08232 – 222075, Web: www.pescemandya.org

Preface

PES College of Engineering, Mandya, started in the year 1962, has become autonomous in the academic year 2008-09. Since, then it has been doing the academic and examination activities successfully. The college is running eight undergraduate and Eight Postgraduate programs. It consists of Six M.Tech programs, which are affiliated to VTU. Other postgraduate programs are MBA and MCA.

India has recently become a Permanent Member by signing 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 such as Taiwan, Hong Kong, Ireland, Korea, Malaysia, New Zealand, Russia, Singapore, South Africa, Turkey, Australia, Canada and Japan. Among other signatories to the international agreement are the US and the UK. Implementation of Outcome Based Education (OBE) has been the core issue for enabling the equivalence and of Indian degrees and their mobility across the countries.

Our Higher Educational Institution has adopted the CBCS based semester structure with OBE scheme and grading system.

The credit based OBE semester system provides flexibility in designing curriculum and assigning credits based on the course content and hours of teaching.

The OBE, emphasize setting clear standards for observable, measurable outcomes of programs in stages. There lies a shift in thinking, teaching and learning processes moving towards Students Centric from Teacher Centric education. OBE standards focus on mathematics, language, science, attitudes, social skills & moral values.

The key features which may be used to judge, if a system has implemented an outcome based education system is mainly Standard based assessments that determines whether students have achieved the stated standard. Assessments may take any form, so long as the process actually measure whether the student knows the required information or can perform the required task. Outcome based education is a commitment that all students of all groups will ultimately reach the same minimum standards. Outcome Based Education is a method or means which begins with the end in mind and constantly emphasizes continuous improvement.

Choice Based Credit System (CBCS) provides choice for students to select from the prescribed courses (core, Foundation, Foundation Elective, elective, open elective and minor or soft skill 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 to learning which enables integration of concepts, theories, techniques, and, perspectives from two or more disciplines to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline. These greatly enhance the skill/employability of students.

In order to increase the Industry/Corporate readiness, many Soft Skills and Personality Development modules have been added to the existing curriculum of the academic year 2015-16. Industry Interactions have been made compulsory to enhance the field experience. In order to enhance creativity and innovation Mini Project and Industrial visit & Interaction are included in all undergraduate programs.

Dr. Umesh D R
Deputy Dean (Academic)
Associate Professor,
Dept. of CS & Engg.

Dr. R Girisha
Dean (Academic)
Professor,
Dept. of CS & Engg.

PES College of Engineering

VISION

"PESCE shall be a leading institution imparting quality engineering and management Education, developing creative and socially responsible professionals"

MISSION

- 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.

Scheme of Teaching and Examination   <ins>**VII Semester B.E. (ME)**</ins>

Sl. No.	Course Code	Course Title	Teaching Dept.	Hrs/Week			Total Credit	Examination Marks		
				L	T	P		CIE	SEE	Total
1.	P18ME71	Automatic Control Engineering	ME	4	-	-	4	50	50	100
2.	P18ME72	Mechanical Vibrations	ME	4	-	-	4	50	50	100
3.	P18ME73	Production Management	ME	4	-	-	4	50	50	100
4.	P18ME74x	Professional Elective-III	ME	2	2	-	3	50	50	100
5.	P18MEO75x	Open Elective-II	ME	3	-	-	3	50	50	100
6.	P18MEL76	Design Laboratory	ME	-	-	3	1.5	50	50	100
7.	P18MEL77	Simulations Laboratory	ME	-	-	3	1.5	50	50	100
8.	P18ME78	Project Work Phase - I and seminar	ME	-	-	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   <ins>**VIII Semester B.E. (ME)**</ins>

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

Department of Mechanical Engineering

Course Title: Automatic Control Engineering			
Course Code: P18ME71	**Semester: VII**	**L-T-P-H: 4-0-0-4**	**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 continues-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, 5th Edition, 2010, ISBN: 9788120340107.
2. Rao V Dukkipati, "**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, 2nd Edition, 2003, ISBN: 9780070582880.
2. I. J. Nagarath and M. Gopal, "**Control systems**", New age International publishers, 4th Edition, 2006, ISBN: 9788122417753.

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.

After learning all the units of the course, the student will be able to:

Course Outcomes		Bloom's Level
CO1	**Classify** the different types of control systems. **Develop** mathematical model for the mechanical, electrical, servo mechanism and hydraulic systems.	II, III
CO2	**Make use of** block diagrams and signal flow graphs to represent the systems consisting of number of components, **Develop** mathematical models using reduction technique of these block diagrams and signal flow graphs.	III
CO3	**Analyze** the time response and steady-state error of the system. **Explain** different types of controllers.	II, IV
CO4	**Determine** stability of the various control systems by applying Routh's stability criterion. **Analyze** frequency response of control system using Nyquist stability criterion and Bode plot.	IV,V
CO5	**Construct** root loci from open loop transfer functions of control systems and Analyze the behavior of roots with system gain. **Analyze** complex systems having multi inputs and multi outputs using state-space method.	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	**Classify** the different types of control systems. **Develop** mathematical model for the mechanical, electrical, servo mechanism and hydraulic systems.	3	3	2	1								1		
CO2	**Make use of** block diagrams and signal flow graphs to represent the systems consisting of number of components, **Develop** mathematical models using reduction technique of these block diagrams and signal flow graphs.	3	3	2									2		
CO3	**Analyze** the time response and steady-state error of the system. **Explain** different types of controllers.	3	3	2	2								2		
CO4	**Determine** stability of the various control systems by applying Routh's stability criterion. **Analyze** frequency response of control system using Nyquist stability criterion and Bode plot.	3	3	3	2			2					2		
CO5	**Construct** root loci from open loop transfer functions of control systems and Analyze the behavior of roots with system gain. **Analyze** complex systems having multi inputs and multi outputs using state-space method.	3	3	3	2			1					2	1	

Course Title: Mechanical Vibrations			
Course Code: P18ME72	**Semester: VII**	**L-T-P-H: 4-0-0-4**	**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, 8th Edition, 2009, ISBN: 9788185240565.			
Reference Books			
1. Singiresu S Rao, **"Mechanical Vibrations"**, Pearson Education India, 4th Edition, 2003, ISBN: 978-8177588743. 2. S. Graham Kelly, Schaum's Outline Series, "**Mechanical Vibrations**", Tata McGraw Hill, Special Indian edition, 2007, ISBN: 9780070616790.			

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.

After learning all the units of the course, the student will be able to:

Course Outcomes		Bloom's Level
CO1	**Develop** mathematical models of single degree of freedom damped and undamped free vibratory systems and **Solve** their natural frequencies.	III
CO2	**Analyze** the response of simple single degree of freedom systems subjected to forced vibration.	IV
CO3	**Explain** the working principle of vibration measuring instruments. **Solve** the whirling speed of shafts and harmonics of general forcing functions using Fourier series.	II, III
CO4	**Develop** mathematical models and **Solve** natural frequencies, corresponding mode shapes of two degrees of freedom systems and **Explain** noise.	II, III
CO5	**Apply** numerical methods to **Solve** multi degree of freedom systems for their natural frequencies and mode shapes.	III

Course Articulation Matrix															
Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	**Develop** mathematical models of single degree of freedom damped and undamped free vibratory systems and **Solve** their natural frequencies.	3	3	2	2		1							3	
CO2	**Analyze** the response of simple single degree of freedom systems subjected to forced vibration.	3	3	3	2		2						2	3	
CO3	**Explain** the working principle of vibration measuring instruments. **Solve** the whirling speed of shafts and harmonics of general forcing functions using Fourier series.	3	3	3	2		2							3	
CO4	**Develop** mathematical models and **Solve** natural frequencies, corresponding mode shapes of two degrees of freedom systems and **Explain** noise.	3	3	3	2		2							2	
CO5	**Apply** numerical methods to **Solve** multi degree of freedom systems for their natural frequencies and mode shapes.	3	3	3	3		2						2	3	

Course Title: Production Management			
Course Code: P18ME73	**Semester: VII**	**L-T-P-H: 4-0-0-4**	**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., 8th Edition, 2007, ISBN: 9788126513727.
2. Joseph G.Monks, **"Operations Management"**, Tata McGraw-Hill, 2nd Edition, 2004, ISBN: 0070588708.

Reference Books

1. Barry Shore, **"Operations Management"**, McGraw Hill Inc., 1973, ISBN:

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.

After learning all the units of the course, the student will be able to:

Course Outcomes		Bloom's Level
CO1	**Define** production management, product life cycle, **Explain** process focused system, product focused system, product focused organization structure.	I, II
CO2	**Analyze** classification of forecasting methods, simple moving average, weighted moving averages, exponentially weighted moving averages, trend model with seasonal variation, Delphi technique.	IV
CO3	**Discuss** cost analysis and **Explain** objectives of good plant layout	II
CO4	**Compare** scheduling, scheduling strategies, **Apply** scheduling sequence operation standard scheduling techniques, Johnson's rule.	II, III
CO5	**Discuss** inventory control, inventory control terminology, deterministic model in inventory control, dispatching and expediting.	V

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	**Define** production management, product life cycle, **Explain** process focused system, product focused system, product focused organization structure.	1													
CO2	**Analyze** classification of forecasting methods, simple moving average, weighted moving averages, exponentially weighted moving averages, trend model with seasonal variation, Delphi technique.	1	2												
CO3	**Discuss** cost analysis and **Explain** objectives of good plant layout		2										1		
CO4	**Compare** scheduling, scheduling strategies, **Apply** scheduling sequence operation standard scheduling techniques, Johnson's rule.		2										1		
CO5	**Discuss** inventory control, inventory control terminology, deterministic model in inventory control, dispatching and expediting.	1											2		

Course Title: Power Plant Engineering			
Course Code: P18ME741	Semester: VII	L-T-P-H: 2-2-0-4	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

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**

Self Study Component: Thermionic and thermoelectric energy conversion.

Unit-2

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 Plan**t: 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**

Self Study Component: Applications, merits and demerits of thermal power plant.

Unit-3

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**

Self Study Component: Lancashire boiler and Babcock-Wilcox boiler.

Unit-4

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**

Self Study Component: Super heater controls, methods of reheaters and dust collectors.

Unit-5

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**

Self Study Component: Locations of nuclear power plants, express the various types of nuclear wastes.

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.

After learning all the units of the course, the student will be able to:

Course Outcomes		Bloom's Level
CO1	**Analyze** economics of power plants and list factors affecting the power plants and **interpret** the performance of power plants based on load variations.	II, III
CO2	**Summarize** the working principle of hydro-electric power plant and different types of stokers and oil burners in thermal power plant.	III
CO3	**Explain** the elements and their functions of steam power plants.	II
CO4	**Identify** elements and their functions and operations of Diesel, gas and solar power plants.	III
CO5	**Explain** the principles of release in nuclear energy from reactors and **Identify** the social and economic issues of power plants.	II, III

Course Articulation Matrix															
Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	**Analyze** economics of power plants and list factors affecting the power plants and **interpret** the performance of power plants based on load variations.	3	3					1							
CO2	**Summarize** the working principle of hydro-electric power plant and different types of stokers and oil burners in thermal power plant.			2				1							
CO3	**Explain** the elements and their functions of steam power plants.	3	3					1		1			1		
CO4	**Identify** elements and their functions and operations of Diesel, gas and solar power plants.	3		1				1							
CO5	**Explain** the principles of release in nuclear energy from reactors and **Identify** the social and economic issues of power plants.		1					1							

Course Title: Hydraulics and Pneumatics			
Course Code: P18ME742	**Semester: VII**	**L-T-P-H: 2-2-0-4**	**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, 5th 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.

After learning all the units of the course, the student will be able to:

Course Outcomes		Bloom's Level
CO1	**Define** Pascal's law and **Explain** the different types of pumps.	I, II
CO2	**Explain** the various types of control components and **Analyze** the hydraulic circuits.	II, IV
CO3	**Understand** the maintenance of hydraulic control system and **Explain** the pneumatic control system.	II
CO4	**Illustrate** the pneumatic control valves.	II
CO5	**Identify** the multi-cylinder applications in various fields and **Explain** filters, regulators and lubricators.	III, II

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	**Define** Pascal's law and **Explain** the different types of pumps.	2	2												
CO2	**Explain** the various types of control components and **Analyze** the hydraulic circuits.	2	2	3											
CO3	**Understand** the maintenance of hydraulic control system and **Explain** the pneumatic control system.	2	2	2											1
CO4	**Illustrate** the pneumatic control valves.	2	2												
CO5	**Identify** the multi-cylinder applications in various fields and **Explain** filters, regulators and lubricators.	2	2												1

Course Title: Theory of Plasticity			
Course Code: P18ME743	Semester: VII	L-T-P-H: 2-2-0-4	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, recrystalization 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 filed, 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, 3rd Edition, 2015, ISBN: 9788174090509.
2. R. A. W. Slater, "**Engineering Plasticity: Theory and Application to Metal Forming Processes**", McMillan Press Ltd, 1st Edition, 1977, ISBN: 9780333157091.

Reference Books
1. J. Chakraborty, "**Theory of plasticity**", Butter-Heinemann publisher, 3rd Edition, 2007, ISBN: 9789380931715.
2. Jacob Lubliner, "**Plasticity Theory**", Dover publications Inc, 1st Edition, 2008, ISBN: 9780486462905.
3. Avitzur, B., "**Metal Forming Processes and Analysis**", McGraw Hill, 1st Edition, 1968, ISBN: 9780070025103.
4. L. M. Kachanov, "**Fundamentals of the Theory of Plasticity**", Dover Publication, 1st Edition, 2004, ISBN: 9780486435831.

After learning all the units of the course, the student will be able to:	

Course Outcomes		Bloom's Level
CO1	**Develop** the equation for stress transformation, spherical, deviator, octahedral stresses and strains, and Solve the same.	III
CO2	**Explain** factors affecting plastic deformation, strain hardening, recovery, recrystalization, cubical dilation and true stress and strain. **Solve** for Yield stress.	II, III
CO3	**Explain** St. Venant's theory of plastic flow and concept of plastic potential.	II
CO4	**Develop** basic equation for incompressible two dimensional flows, continuity equation and **Explain** geometry of slip line field and super position of slip line field, properties of the slip lines.	II, III
CO5	**Explain** Linear and non linear stress strain curve, shear stress distribution, residual stresses in plastic bending, and plastic torsion of circular bar and **Solve** residual stresses.	II, III

Course Articulation Matrix																
Course Outcomes		**Program Outcomes**													**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	**Develop** the equation for stress transformation, spherical, deviator, octahedral stresses and strains, and Solve the same.	3	2													
CO2	**Explain** factors affecting plastic deformation, strain hardening, recovery, recrystalization, cubical dilation and true stress and strain. **Solve** for Yield stress.	3	2													
CO3	**Explain** St. Venant's theory of plastic flow and concept of plastic potential.	3	2	1									1			
CO4	**Develop** basic equation for incompressible two dimensional flows, continuity equation and **Explain** geometry of slip line field and super position of slip line field, properties of the slip lines.	3	2	2	2								1			
CO5	**Explain** Linear and non linear stress strain curve, shear stress distribution, residual stresses in plastic bending, and plastic torsion of circular bar and **Solve** residual stresses.	3	3	2	3					1			2			

Course Title: Gas Turbines and Jet Propulsion			
CourseCode:P18ME744	Semester: VII	L-T-P-H: 2-2-0-4	Credits: 03
Contact Period -Lecture: 52 Hours; Exam: 3 Hours.		Weightage %: CIE: 50, SEE: 50	

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.

Course Content

Unit-1

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. **10 hrs**

Self Study Component: Carnot cycle, Sterling cycle with regenerator.

Unit-2

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. **12 hrs**

Self Study Component: Compressor stall and surge.

Unit-3

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.

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. **10 hrs**

Self Study Component: Requirement of combustion chamber, exchanger heat transfer effectiveness.

Unit-4

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.

Self Study Component: Turbine and nozzle efficiencies, degree of reaction- Impulse turbine. **10 hrs**

Unit 5

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.

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

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

Self Study Component: Types of propellers, combustion processes in solid and liquid propellant rockets. **10 hrs**

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, 3d 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.

After learning all the units of the course, the student will be able to:

Course Outcomes	Bloom's Level
CO1	**Analyze** the performance of centrifugal compressors.	IV
CO2	**Analyze** the performance of axial flow compressors.	IV
CO3	**Analyze** the performance of combustion chambers and regenerators.	IV
CO4	**Analyze** the performance axial flow turbines.	IV
CO5	**Understand** the working of aircraft and chemical rocket engines.	II

Course Articulation Matrix															

Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	**Analyze** the performance of centrifugal compressors.	2	2	2										1	
CO2	**Analyze** the performance of axial flow compressors.	2	2	2										1	
CO3	**Analyze** the performance of combustion chambers and regenerators.	2	2	2										1	
CO4	**Analyze** the performance axial flow turbines.	2	2	2										1	
CO5	**Understand** the working of aircraft and chemical rocket engines.	2	2											1	

Course Title: Total Quality Management (Open Elective-II)			
Course Code: P18MEO751	Semester: VII	L-T-P-H: 3-0-0-3	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.

After learning all the units of the course, the student will be able to:

Course Outcomes		Bloom's Level
CO1	**Define** quality, quality statements, strategic planning, communications and decision making.	I
CO2	**Explain** customer, customer perception of quality, Juran Trilogy, PDSA cycle and **Illustrate** SPC tools.	II
CO3	**Outline** Benchmarking process. **Identify** ISO registration in quality management systems.	II, III
CO4	**Illustrate** TPM and EMS systems. **Explain** latest TQM Tools including Six Sigma.	II
CO5	**Build** QFD team and **Explain** quality by design.	II, III

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	**Define** quality, quality statements, strategic planning, communications and decision making.	2	1							1		3	1		
CO2	**Explain** customer, customer perception of quality, Juran Trilogy, PDSA cycle and **Illustrate** SPC tools.	2	1			3						2			
CO3	**Outline** Benchmarking process. **Identify** ISO registration in quality management systems.	2	1				1					2			
CO4	**Illustrate** TPM and EMS systems. **Explain** latest TQM Tools including Six Sigma.	2	1	1	2		2		3				1		
CO5	**Build** QFD team and **Explain** quality by design.	2								3	2				

Course Title: Operations Research (Open Elective-II)				
Course Code: P18MEO752	**Semester: VII**	**L-T-P-H: 3-0-0-3**		**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 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.
Self Study Component: Dual simplex method. **12 hrs**

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, 10th Edition, 2014, ISBN: 9780134444017.
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, 5th Edition 2001, ISBN: 8131700003.
3. Ravindran, Phillips and Solberg, "**Operations Research: Principles and Practice"**, Wiley India, 2nd Edition 2007, ISBN: 9780471086086.
4. S.D. Sharma, "**Operations Research"**, Kedarnath Ramnath and Co. 2002, 2nd Edition, 2002, ISBN: 9789385935145.

After learning all the units of the course, the student will be able to:

Course Outcomes		Bloom's Level
CO1	**Define** operation research **Develop** operation research models from the verbal description of real life.	I, III
CO2	**Analyze** the problem using mathematical tools and simple queue system.	IV
CO3	**Solve** transportation and assignment problem using different methods.	III
CO4	**Describe** the model project and **Solve** different model techniques.	II,III
CO5	**Explain** the Inventory and different models with their characteristics and solve problems.	II

Course Articulation Matrix															
Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	**Define** operation research **Develop** operation research models from the verbal description of real life.	2	2										1		
CO2	**Analyze** the problem using mathematical tools and simple queue system.	2	2										1		
CO3	**Solve** transportation and assignment problem using different methods.	2	2										1	2	
CO4	**Describe** the model project and **Solve** different model techniques.	2	2										1	2	
CO5	**Explain** the Inventory and different models with their characteristics and solve problems.	2	2										1		

Course Title: Renewable Energy Technology (Open Elective-II)			
Course Code:P18MEO753	Semester: VII	L-T-P-H: 3-0-0-3	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

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**

Self Study Component: Hydrogen energy, depletion of solar radiation and thermionic converter.

Unit-2

Solar Radiation Measurement: Introduction, principles of working of solar radiation measuring devices - pyranometer, shading ring, pyrheliometer, 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**

Self Study Component: Solar radiation geometry, solar radiation measuring angles, the slope, angstrom pyrheliometer.

Unit-3

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**

Self Study Component: Photovoltaic module I-V characteristics, efficiency and quality of the cell, heat pump and binary fluid geothermal power system.

Unit-4

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**

Self Study Component: power in the wind, OTEC cycle, bio fouling.

Unit-5

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

Self Study Component: Deenbhandhu bio gas plant and Iodine sulphur cycle.

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.

After learning all the units of the course, the student will be able to:

Course Outcomes		Bloom's Level
CO1	**Explain** renewable energy sources and their utilization and discuss the availability of solar radiation.	II
CO2	**Discuss** solar energy with the help of solar radiation measuring instruments and solar collectors for harnessing solar energy.	II
CO3	**Discuss** characteristics of geothermal energy and elucidate solar photovoltaic systems for harnessing solar energy.	II, III
CO4	**Explain** different types of wind mills and their design principles. **Discuss** characteristics of tidal energy, ocean thermal energy.	II, III
CO5	**Discuss** characteristics of biomass energy and describe the methods of production of hydrogen for utilization as a renewable form of source of energy.	II

Course Articulation Matrix															
Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	**Explain** renewable energy sources and their utilization and discuss the availability of solar radiation.	3	1	2				2					2		
CO2	**Discuss** solar energy with the help of solar radiation measuring instruments and solar collectors for harnessing solar energy.	3	3	2				1					2		
CO3	**Discuss** characteristics of geothermal energy and elucidate solar photovoltaic systems for harnessing solar energy.	3	1	3				2					2		
CO4	**Explain** different types of wind mills and their design principles. **Discuss** characteristics of tidal energy, ocean thermal energy.	3	2	3				1					2		
CO5	**Discuss** characteristics of biomass energy and describe the methods of production of hydrogen for utilization as a renewable form of source of energy.	3	1	2				2					2		

Course Title: Finite Element Method in Engineering (Open Elective-II)			
Course Code: P18MEO754	**Semester: VII**	**L-T-P-H: 3-0-0-3**	**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, 1st Edition, 2005, ISBN: 9788123908953.

2 T. R. Chandrupatla and A. D. Belegundu, **"Introduction to Finite Elements in Engineering"**, Pearson, 4th Edition, 2011, ISBN: 9780132162746.

Reference Books

1 Singiresu S Rao, **"The Finite Element Method in Engineering"**, Elsevier Publisher, 5th Edition, 2008, ISBN: 9789380931555.

2 O. C. Zienkiewicz, **"The FEM its Basics and Fundamentals"**, Elsevier Publisher, 6th

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 5th Edition, 2011, ISBN: 9780495668251.

5 David V. Hutton, **"Fundamentals of Finite Element Analysis"**, Tata McGraw Hill Publishing Co. Ltd, 2005, ISBN: 978-0070601222.

After learning all the units of the course, the student will be able to:

Course Outcomes		Bloom's Level
CO1	**Understand** the basic concepts and mathematical preliminaries of FEM required to solve basic field problems.	II
CO2	**Develop** interpolation models for 1D and 2D elements that satisfy convergence criteria and geometric isotropy and **Make use of** parametric concept in the finite element analysis.	III
CO3	**Formulate** element stiffness matrices and load vectors for different elements using variational principle and **Analyze** axially loaded bars.	II,III
CO4	**Use** finite element formulations to **Determine** displacements, stresses, and support reactions of trusses.	II,III
CO5	**Make use of** finite element methods to solve beam problems and 1D steady state heat transfer problems.	II,III

Course Articulation Matrix														
Course Outcomes	**Program Outcomes**												**PSO**	
	1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1 **Understand** the basic concepts and mathematical preliminaries of FEM required to solve basic field problems.	3	2	2	2	1							1	2	
CO2 **Develop** interpolation models for 1D and 2D elements that satisfy convergence criteria and geometric isotropy and **Make use of** parametric concept in the finite element analysis.	3	3	3	2	2							2	2	
CO3 **Formulate** element stiffness matrices and load vectors for different elements using variational principle and **Analyze** axially loaded bars.	3	3	3	2	3							2	2	
CO4 **Use** finite element formulations to **Determine** displacements, stresses, and support reactions of trusses.	3	3	3	2	3							3	2	
CO5 **Make use of** finite element methods to solve beam problems and 1D steady state heat transfer problems.	3	3	3	3	3					-		3	2	

Course Title: Design Laboratory			
Course Code: P18MEL76	**Semester: VII**	**L-T-P-H: 0-0-3-3**	**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, 4th Edition, 2015, ISBN: 9789351343479.

After learning all the units of the course, the student will be able to:

Course Outcomes		Bloom's Level
CO1	**Apply** principles of vibration and **Determine** vibration characteristics of simple single degree of freedom systems experimentally.	III,V
CO2	**Test for** critical speed of shaft. **Demonstrate** experimentally, the vibration characteristics of rotor.	IV, II
CO3	**Demonstrate** the basic principles of photo elasticity. **Determine** experimentally, stress concentration using polariscope.	II, V
CO4	**Examine** experimentally pressure distribution in journal bearings.	IV
CO5	**Analyze** performance parameters of governors, **Determine** gyroscopic torque in a Gyroscope	IV,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** principles of vibration and **Determine** vibration characteristics of simple single degree of freedom systems experimentally.	1	2	1	3					2	2			1	
CO2	**Test for** critical speed of shaft. **Demonstrate** experimentally, the vibration characteristics of rotor.	1	2	1	3					2	2			1	
CO3	**Demonstrate** the basic principles of photoelasticity**. Determine** experimentally, stress concentration using polariscope.	2	2	1	3					2	2			1	
CO4	**Examine** experimentally pressure distribution in journal bearings.		2	1	3					2	3			1	
CO5	**Analyze** performance parameters of governors, **Determine** gyroscopic torque in a Gyroscope		2	1	3					1	1			1	

Course Title: Simulations Laboratory				
Course Code: P18MEL77	**Semester: VII**	**L-T-P-H: 0-0-3-3**		**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, 3rd edition, 2010, ISBN: 0070681937.
2. Groover, **"Computer Aided Design/Computer Aided Manufacturing"**, Tata McGraw Hill. 2003.
3. Rao V Dukkipati, **"Control Systems",** Narosa Publishing House, 2008, ISBN: 978-8173195549.

After learning all the units of the course, the student will be able to:

Course Outcomes		Bloom's Level
CO1	**Build** solid model of simple machine parts using Master CAM package.	III
CO2	**Demonstrate** simulation of Turning, Drilling, Milling using software	II
CO3	**Develop** MATLAB programs to plot step-response curve and determine transient response specifications.	III
CO4	**Compile** MATLAB programs to draw root locus, Nyquist and Bode plots of control systems.	VI

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	**Build** solid model of simple machine parts using Master CAM package.		2	1	3	2				3	1		1	2	
CO2	**Demonstrate** simulation of Turning, Drilling, Milling using software		2		1	2				2	1			2	
CO3	**Develop** MATLAB programs to plot step-response curve and determine transient response specifications.	1	2	3		1				2	2			2	
CO4	**Compile** MATLAB programs to draw root locus, Nyquist and Bode plots of control systems.	1	2	3		1				2	2			2	

Course Title: Project Work Phase – I and Project Seminar			
Course Code: P18ME78	**Semester: VII**	**L:T:P:H: 0:0:0:4**	**Credits :02**
Weight age: CIE:100			

Project Work: The Project Work (Phase I + Phase II) carries 8 credits (2 credits+6 credits) and spreads over TWO semesters, i.e. during 7th and 8th semesters.

 I. Project Phase – I and Project seminar Comprises of Literature Survey, Problem identification, Objectives and Methodology. CIE marks shall be based on the report covering Literature Survey, Problem identification, Objectives and Methodology and seminar presentation skill.

 II. The Assessment marks (CIE) in the case of Project Work - Phase I, shall be based on the evaluation at the end of the 7th semester by a committee consisting of Head of the concerned department, two senior faculty members of the department, one of them may be the internal guide. The work may be evaluated by the committee for award of Assessment marks (CIE) based on a Report [comprising of synopsis, Introduction, Literature survey, Objective and Methodology], presentation and viva voce.

 III. The project work shall be carried out by candidate(s) independently/in a group (maximum of four) during the seventh and eighth semester under the guidance of one of the faculty members of the Department of study. If the project work is of inter-disciplinary nature, a co-guide shall be taken from the same or any other relevant Department. If a project work has to be carried out in any industry / factory / organization, outside the campus, the permission for the same and the name of co-guide at any of these organizations shall be intimated to the authorities at the beginning of seventh semester by the Head of the Department.

Course Title: Industrial Robotics				
Course Code: P18ME81	Semester: VIII	L-T-P-H: 4-0-0-4		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 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.

Course Content

Unit-1

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**

Self Study Component: Latest developments in robots**.**

Unit-2

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**

Self Study Component: Applications of hydraulic, electric and pneumatic drive system.

Unit-3

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

Self Study Component: Applications of DH method in three axis robot arm and wrist.

Unit-4

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**

Self Study Component: Capabilities and limitations of lead through methods.

Unit-5

Autonomous Mobile Robots: Locomotion, key issues for locomotion, legged mobile robots, leg-types and configurations and stability, examples of legged robot locomotion, gaits-biped, quadraped 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

Self Study Component: Applications of robots in processing operations.

Text Books

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

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: 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.

After learning all the units of the course, the student will be able to:

Course Outcomes		Bloom's Level
CO1	**Classify** robots based on geometrical configuration. **Define** work volume, resolution, and accuracy of various configurations of robot.	I, II
CO2	**Identify** different types of drive system and sensors required for specific applications.	III
CO3	**Explain** the forward kinematics of robots using DH method.	II
CO4	**Develop** robot task program using robot language.	III
CO5	**Distinguish** the requirements of robot systems for various industrial applications.	IV

Course Articulation Matrix															
Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	**Classify** robots based on geometrical configuration. **Define** work volume, resolution, and accuracy of various configurations of robot.	2	2	1	1								1		
CO2	**Identify** different types of drive system and sensors required for specific applications.	2	2	1	1								1		1
CO3	**Explain** the forward kinematics of robots using DH method.	3	2	1	2						1		1	1	
CO4	**Develop** robot task program using robot language.	2	2	1	1						1		1		
CO5	**Distinguish** the requirements of robot systems for various industrial applications.	2	2	1							2		2		3

Course Title: Operations Research			
Course Code: P18ME821	**Semester: VIII**	**L-T-P-H: 2-2-0-4**	**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, 10th Edition, 2014, ISBN No.9780134444017.
2. S.D. Sharma **"Operations Research"**, Kedarnath Ramnath and Co., 2nd 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, 5th Edition, 2001, ISBN: 8131700003.
3. Ravindran, Phillips and Solberg **"Operations Research"**, Principles and practice Wiley India, 2nd Edition, 2007, ISBN: 9780471086086.
4. Prem Kumar Gupta, D.S. Hira S **"Operation Research",** Chand Publication, 2011, ISBN: 9788121902816.

After learning all the units of the course, the student will be able to:

Course Outcomes		Bloom's Level
CO1	**Define** operation research and **Develop** mathematical models of LPP from the verbal description of real life.	I, III
CO2	**Analyze** the problem using mathematical tools and simple queue system.	IV
CO3	**Solve** transportation and assignment problem using different methods.	III
CO4	**Describe** the model and the solving technique to analyze the results and propose recommendation.	II
CO5	**Explain** the game and queuing theory with their characteristics and **Solve** problems.	II, III

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	**Define** operation research and **Develop** mathematical models of LPP from the verbal description of real life.	2	2										1		
CO2	**Analyze** the problem using mathematical tools and simple queue system.	2	2										1		
CO3	**Solve** transportation and assignment problem using different methods.	2	2										1		
CO4	**Describe** the model and the solving technique to analyze the results and propose recommendation.	2	2										1		2
CO5	**Explain** the game and queuing theory with their characteristics and **Solve** problems.	2	2										1		

Course Title: Foundry and Welding Technology			
Course Code: P18ME822	Semester: VIII	L-T-P-H: 2-2-0-4	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

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.

Self study component: Alloy steels, measurement of hardenability and its significance, production heat treating. **10 hrs**

Unit-2

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 Risering**: 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, Chvorinove's rule, riser location and riser feeding distance. **10 hrs**

Self study component: Risering practice for alloys- heat loss from risers.

Unit-3

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**

Self study component: Surface treatment of castings.

Unit-4

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

Self study component: Specific weld cracks: Chevron cracks, lamellar cracks, reheat cracking, stress corrosion cracking.

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 Heinnmann, 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.

After learning all the units of the course, the student will be able to:

Course Outcomes		**Bloom's Level**
CO1	**Define and Explain** concept of solidification of metals- solidification of pure metals- nucleation, homogeneous or self nucleation.	I, II
CO2	**Describe** gating System- Requirements, purposes of functions of the gating system- pouring cups and basins- spruers- gates, their characteristics and different types.	II
CO3	**Explain** shakeout- modern developments, punchout machines, shakeout tables and decks, high frequency shakeouts, vibrating shakeout conveyors.	II
CO4	**Describe** Special Welding Processes, Electron beam welding, Laser beam welding, Friction Stir welding, **Identify** cracks in welding.	II, III
CO5	**Classify** Weld defects in other arc welding processes: Resistance welding defects, defects in friction welding, defects in welds of other welding processes.	II

Course Articulation Matrix															
Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	**Define and Explain** concept of solidification of metals- solidification of pure metals- nucleation, homogeneous or self nucleation.	1				2				3					
CO2	**Describe** gating System- Requirements, purposes of functions of the gating system- pouring cups and basins- spruers- gates, their characteristics and different types.	2		3			2		1						
CO3	**Explain** shakeout- modern developments, punchout machines, shakeout tables and decks, high frequency shakeouts, vibrating shakeout conveyors.	1				2				3					
CO4	**Describe** Special Welding Processes, Electron beam welding, Laser beam welding, Friction Stir welding, **Identify** cracks in welding.	2	2		1			3							2
CO5	**Classify** Weld defects in other arc welding processes: Resistance welding defects, defects in friction welding, defects in welds of other welding processes.	3		2							1				

Course Title: Tribology			
Course Code: P18ME823	Semester: VIII	L-T-P-H: 2-2-0-4	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

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.
Self Study Component: Industrial importance of tribology.   **10 hrs**

Unit-2

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**
Self Study component: Types of additives.

Unit-3

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**
Self Study Component: Concept of Navier- Stokes.

Unit-4

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**
Self Study Component: Location of center of pressure of idealized slides bearing.

Unit-5

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**
Self Study Component: Advantages and disadvantages of magnetic bearing.

Text Books

1. Basu S K., Sengupta S N.and Ahuja B. B., "**Fundamentals of Tribology**", PHI, 1st

Edition, 2009, ISBN: 9788120327238.

2. B. C. Mujumdar, "**Introduction to Tribology of Bearings**", S. Chand (G/L) and Company Ltd, 2nd Edition, 2010, ISBN: 9788121929875.

Reference Books

1. E. I. Redzimovskay, "**Lubrication of Bearings Theoretical Principles and Design**", The Ronald Press Company, 1st edition, 1959, ASIN: B0000EGL66.

2. Dudley D. Fuller, "**Theory and Practice of Lubrication for Engineers**", John Wiley and Sons, 2nd Edition, 1984, ISBN: 9780471047032.

3. Desmond F. Moore, "**Principles and Applications of Tribology**", Pergamaon Press, 1st 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.

After learning all the units of the course, the student will be able to:

Course Outcomes		Bloom's Level
CO1	**Define** friction, laws of friction and different types of wear and wear mechanisms. **Explain** surface texture and roughness characteristics using its measuring techniques.	I, II
CO2	**Explain** the properties of lubricants and classify them. **Develop** Hagen-Poiseuille law.	II, III
CO3	**Explain** the concept of lightly loaded bearings and **Develop** Petroff's equation and limits of hydrodynamic lubrication.	II, III
CO4	**Develop** expressions for pressure distribution, load carrying capacity, coefficient of friction, frictional resistance in an idealized slider bearing.	III
CO5	**Develop** expressions for pressure distribution, load carrying capacity and oil flow through the hydrodynamic journal bearing, hydrostatic step bearing. **Explain** working of porous bearing with equation and types of hydrostatic lubrication systems.	II, III

	Course Articulation Matrix														
Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	01	02
CO1	**Define** friction, laws of friction and different types of wear and wear mechanisms. **Explain** surface texture and roughness characteristics using its measuring techniques.	3	3	2	3			1							1
CO2	**Explain** the properties of lubricants and classify them. **Develop** Hagen-Poiseuille law.	3	3	2				1							1
CO3	**Explain** the concept of lightly loaded bearings and **Develop** Petroff's equation and limits of hydrodynamic lubrication.	3	3	3											1
CO4	**Develop** expressions for pressure distribution, load carrying capacity, coefficient of friction, frictional resistance in an idealized slider bearing.	3	3	1											1
CO5	**Develop** expressions for pressure distribution, load carrying capacity and oil flow through the hydrodynamic journal bearing, hydrostatic step bearing. **Explain** working of porous bearing with equation and types of hydrostatic lubrication systems.	3	3	1											1

Course Title: Computational Fluid Dynamics			
Course Code: P18ME824	Semester: VIII	L-T-P-H: 2-2-0-4	Credits: 03
Contact Period - Lecture: 52 Hours; Exam: 3 Hours.		Weightage %: CIE: 50 SEE: 50	

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.

Course Content

Unit-1

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.

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. **11 hrs**

Unit-2

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.

Self Study Component: Stability properties of explicit and implicit methods, numerical dissipation and numerical dispersion. **10 hrs**

Unit-3

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.

Self Study Component: Properties of discretization schemes-conservativeness, boundedness, transportive. **11 hrs**

Unit-4

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**

Self Study Component: Need for CFD, applications of CFD, Convergence criteria

Unit-5

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**

Self Study Component: Numerical stability, turbulence modeling.

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.

After learning all the units of the course, the student will be able to:

Course Outcomes		Bloom's Level
CO1	**Understand** the behavior of the differential equations and partial differential equations with suitable boundary conditions.	II
CO2	**Understand and develop** finite difference discretization schemes and implement them to solve engineering problems.	II,IV
CO3	**Understand and develop** finite volume discretization schemes and implement them to solve engineering problems.	II,IV
CO4	**Study** the modern CFD tool ANSYS to build flow geometries, generate mesh and select suitable solvers to obtain the solutions.	II,III
CO5	**Develop** the numerical solutions for simple free vibration and steady state thermal 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	**Understand** the behavior of the differential equations and partial differential equations with suitable boundary conditions.	2	2	3	2									2	
CO2	**Understand and develop** finite difference discretization schemes and implement them to solve engineering problems.	2	2	3										3	
CO3	**Understand and develop** finite volume discretization schemes and implement them to solve engineering problems	2	2	1	2									1	
CO4	**Study** the modern CFD tool ANSYS to build flow geometries, generate mesh and select suitable solvers to obtain the solutions	2	2	2		2								2	
CO5	**Develop** the numerical solutions for simple free vibration and steady state thermal problems.	2		2	1	2	2								1

Course Title: Internship		
Course Code: P18ME83	**Semester: VIII**	**Credits :02**
Exam Hours : 03 Hr	**Weight age: CIE:50; SEE:50**	

Guidelines for Internship:

I. Internship is of minimum eight weeks duration and to be completed between the vacation period of VI & VII semester and VII & VIII semester.

II. The internship can be carried out in any industry/ R & D Organization/ Research/ Institute/ Educational institute of repute/ Internshala (ACITE MoU Internship).

III. The Department/college shall nominate staff member/s to facilitate, guide and supervise students under internship.

IV. The Internal Guide has to visit place of internship at least once during the student's internship.

V. The students shall report the progress of the internship to the guide in regular intervals and seek his/her advice.

VI. After the completion of Internship, students shall submit a report with completion and attendance certificates to the Head of the Department with the approval of both internal and external guides.

VII. There will be 50 marks CIE (Seminar: 25, Internship report: 25) and 50 marks for Viva Voce conducted during Semester End Examination (SEE) of VIII Semester. For the conduction of Internship Semester End Examination following instructions are issued:

    a. The Semester End Examination (SEE) for 50 marks shall be conducted similar to final semester project work / lab examination.

    b. Internal & External Examiners shall be appointed by the BoE – Chairperson in consultation with HoD and approval of the same by the Principal & Controller of Examination.

    c. External Examiner may be from the Industry. If the external examiner from the industry is not available, alternative arrangement shall be made by the BoE - Chairperson by appointing a faculty from out of the available faculty in the department, wherein the student is studying.

VIII. The students are permitted to carry out the internship anywhere in India or abroad. The Institution will not provide any kind of financial assistance to any student for carrying out the Internship.

IX. Failing to undergo Internship: Internship is one of the head for obtaining degree, therefore completion of internship is mandatory.

Course Title: Project Work Phase – II		
Course Code: P18ME84	Semester: VIII	Credits :06
Weight age: CIE:100 SEE:100		

Project Work: The Project Work (Phase I + Phase II) carries 8 credits (2 credits+6 credits) and spreads over TWO semesters, i.e. during 7th and 8th semesters.

I.   Project Phase – I and Project seminar Comprises of Literature Survey, Problem identification, Objectives and Methodology. CIE marks shall be based on the report covering Literature Survey, Problem identification, Objectives and Methodology and seminar presentation skill.

II.   The Assessment marks (CIE) in the case of Project Work - Phase I, shall be based on the evaluation at the end of the 7th semester by a committee consisting of Head of the concerned department, two senior faculty members of the department, one of them may be the internal guide. The work may be evaluated by the committee for award of Assessment marks (CIE) based on a Report [comprising of synopsis, Introduction, Literature survey, Objective and Methodology], presentation and viva voce.

III.   The project work shall be carried out by candidate(s) independently/in a group (maximum of four) during the seventh and eighth semester under the guidance of one of the faculty members of the Department of study. If the project work is of inter-disciplinary nature, a co-guide shall be taken from the same or any other relevant Department. If a project work has to be carried out in any industry / factory / organization, outside the campus, the permission for the same and the name of co-guide at any of these organizations shall be intimated to the authorities at the beginning of seventh semester by the Head of the Department.

IV.   The weekly progress of the Project work shall be monitored and reviewed by the Project Guide assigned by DUGC. The method of evaluation, including intermediate assessment shall be evolved by the pertinent DUGC.

V.   A candidate shall submit N+3 (No. of candidates+3) copies of the Report of the Project Work to Head, DUGC on or before the specified date. The report shall be in the format prescribed by the Institute. The candidate shall submit a report of the project work (dissertation) duly approved by the guide and co-guide. The project report shall be countersigned by the guide, co-guide (if any) and the Head of the Department

VI.   The last date for the submission of Report shall be Two weeks before the closure of the semester in which the project work credits have been registered for and is expected to be completed or as announced by the COE. The date of submission of the dissertation may be extended up to a maximum of eight academic years, from the date of commencement of the first semester in which the candidate has taken admission to the course.

VII.   The final evaluation (CIE & SEE) for Project Work - Phase II is done by a Project Work Evaluation Committee (PWEC) constituted by the pertinent DUGC. There shall be an open seminar followed by a viva – voce examination as part of the final evaluation. After the final evaluation, appropriate letter grade is awarded.

VIII. If in the opinion of the PWEC, the Project Report is acceptable with minor modifications for the minimum passing grade 'E' (Fair) in the case of project, the PWEC shall value and instruct the candidate suitably to incorporate the necessary modifications and to resubmit it to the Chairman, PWEC. After such

resubmission, the Chairman, PWEC will certify that the necessary modification has been incorporated.

IX. The Assessment marks in case of Project Work - Phase II and seminar shall be based on the evaluation, as per the guidelines, at the end of the 8th semester by a committee consisting of Head of the concerned department, two senior faculty members of the department (one of them may be the internal guide).

X. The Assessment marks sheet shall bear the signature of all those concerned, along with the date and seal of the Principal.

Course Title: Self-Study Course & Seminar			
Course Code: P18ME85	**Semester: VIII**	**L:T:P:H: 0:0:4:4**	**Credits :02**
Weight age: CIE: 50			

In the Self-Study course & Seminar, the student has to choose & 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. The intention of the course is to encourage the habit of self-learning.

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).

CIE = (NPTEL Score X 1.5) / 2 = [Maximum CIE should be 50 Marks]

[Ex. – 1: If NPTEL Score is 60 then the CIE will be = (60 X 1.5)/2 = 45

Ex. – 2: If NPTEL Score is 80 then the CIE will be = (80 X 1.5)/2 = 50 (Max. CIE should be 50 Marks)]

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 Certification (i.e. the CIE Score should be less than the score of the student cleared NPTEL Course).