Dr. Ambedkar Institute of Techonolgy
Department of Mechanical Engineering

The documents enclosed are verified and approved.

HOD
Dept. of Mechanical Engineering

HOD
Department of Mechanical Engineering
Dr. Ambedkar Institute of Technology
Bengaluru - 560 056.

Name of the Course	Course Code	Activities/Content with direct bearing on Employability/ Entrepreneurship/ Skill development	Nature of job oppurtunity
RAPID PROTOTYPING	ME731	Skill development	software
ENGINEERING ECONOMICS	ME733	Skill development	Industry oriented program
COMPUTER AIDED MODELING AND ANALYSIS LABORATORY	MEL74	Skill development	software
COMPUTATIONAL FLUID DYNAMICS	ME812	Skill development	software
SMART MATERIALS	ME813	Skill development	Industry oriented program
ADVANCED MANUFACTURING PROCESSES	ME552	Skill development	Industry oriented program
Mechatronics and Microprocessor	18ME554	Skill development	software
Principles of Metal Forming	18ME555	Skill development	Industry oriented program
PRODUCTION AND OPERATIONS MANAGEMENT	18ME644	Skill development	Industry oriented program
FLUID POWER CONTROL SYSTEMS	18ME646	Skill development	software
INDUSTRIAL MANAGEMENT	ME661	Skill development	Industry oriented program
ENGINEERING ECONOMICS	ME733	Skill development	Industry oriented program
COMPUTER INTEGRATED MANUFACTURING	ME811	Skill development	software
COMPUTATIONAL FLUID DYNAMICS	ME812	Skill development	software
SMART MATERIALS	ME813	Skill development	software
ADVANCED WELDING TECHNOLOGY	18ME642	Skill development	Industry oriented program
INTERNAL COMBUSTION ENGINES	18ME643	Skill development	software
PRODUCTION AND OPERATIONS MANAGEMENT	18ME644	Skill development	Industry oriented program
FINITE ELEMENT METHODS	18ME645	Skill development	software

FLUID POWER CONTROL SYSTEMS	18ME646	Skill development	software

ADMISSION YEAR : 2017-2018 ACADEMIC YEAR: 2020-21
SEMESTER : SEVENTH

COURSE TITLE: RAPID PROTOTYPING (PROFESSIONAL ELECTIVE - 5)		
Sub. Code: ME731	**No of Credits :3 L-T-P-SS::3:0:0:0**	**No. of lecture hours/week : 03 Total Number of Lecture hours:39**
Exam Duration : 3 hours	**CIE Marks: 50**	**Exam Marks : 100**
Pre-requisites	**Manufacturing process**	

COURSE OBJECTIVES:

1. Describe the manufacturing techniques of rapid prototyping process.
2. Successfully apply the following techniques in rapid prototyping process.
3. Analyze the different rapid tooling methods and its uses
4. Evaluate & optimization of different rapid manufacturing processes
5. Geared towards product design, prototyping, advancements and attractive applications

#	CONTENTS	Hrs
UNIT-1	**INTRODUCTION** (CLASS ROOM TEACHING)	**07**
	Additive Manufacturing, The Additive Manufacturing process, Uses, Time compression Engineering(TCE), Benefits of Additive Manufacturing, Rapid Prototyping, Origins of Rapid Prototyping, Rapid Prototyping Cycle, Rapid Prototyping Processes and Future of RP	
UNIT-2	**CLASSIFICATION OF RP SYSTEMS** (CLASS ROOM TEACHING)	**07**
	Classification of RP systems based upon the materials, Stereolithography: apparatus, Operation, process parameters, Applications of stereolithography parts, Advantages and Disadvantages, Solid ground Curing, Selective laser sintering: History, Mechanism, Materials of SLS, Data preparation for SLS, process parameters, Advantages and Disadvantages, Applications and Future of SLS**.**	
UNIT-3	**FUSED DEPOSITION MODELLING** (CLASS ROOM TEACHING)	**07**
	History, Principle, Machine Details, Process Parameters, Path Generation, Advantages and Disadvantages and Applications. **Laminated Object Manufacturing** (LOM): Principle of operation, LOM Materials, Process details, Techniques used in LOM, Applications and Typical uses, Advantages and Disadvantages, **Concept Modellers**: Introduction ,Thermal ink jet printer, Multi Jet Modelling, 3-D printers, Genesis Xs Printer HP System Object Quadra systems.	
UNIT-4	**RAPID TOOLING** (ONLINE TEACHING)	**09**
	Indirect tooling, silicon rubber tooling, Aluminium filled epoxy tooling, spray metal tooling, cast kirksite, 3Q keltool, Direct rapid tooling, Direct AIM (ACES Injection Moulding) Quick cast process, Copper polyamide, DMLS, ProMetal, Sand casting tooling, **Software for RP:** STL file, STL file Resolution, Solid View, Magics, Mimics, Mimics Z, Magics Communicator, **Process Optimization**: Factors influencing accuracy, Errors due to Tessellation: Errors due to slicing, Part building and part finishing.	
UNIT-5	**APPLICATIONS OF RAPID PROTOTYPING** (BLENDED TEACHING)	**09**
	Rapid Prototyping in Medical Field: Introduction, Prostheses and Implants, Surgical planning and scientific applications, Biologically active Implants and Tissue Engineering. RP medical materials**. Rapid Prototyping in Automotive Industry**: key benefits of Automotive Rapid Prototyping, Materials used in Automotive Prototypes, Examples of Automotive Rapid Prototypes**. Rapid Prototyping in Aeronautical Industry, Marine**	

	Applications, Industrial Prototyping, Industrial Rapid Prototypes: Examples**,** Benefits, and Materials used, Industrial prototyping services and Industrial Applications.	

TEXT BOOKS:

1. Stereolithography and other RP & M Technologies, Paul F, Jacob:SME,NY 1996
2. Rapid Manufacturing, Flham D.T & Dinjoy S S Verlog London 2001
3. Rapid Prototyping and Tooling, Hari prasad and K S Badarinarayan

REFERENCES:

1. Rapid Prototyping, Terry Wohler's Report 2000 " Wohler's " Association 2000
2. Rapid Prototyping Materials, Gurumurthy, IISc Bangalore
3. Rapid Automated, Lament Wood, Indus Press, New york

COURSE OUTCOMES: On completion of the course, student should be able to:

CO1: Describe the fundamentals of Rapid Prototyping technology and classification of RP techniques to prepare
prototypes for a different product.

CO2: RP techniques such as SLA, SLS, FDM, SGC, and LOM based on their applicability, materials used and advantages.

CO3: Specifically designed concept modelers can adopt to create various models quickly and inexpensively.

CO4: Apply rapid tooling technique for the different specified product easily.

CO5: Create RP models using different software tools. Analyze advanced RP techniques for their suitability and merits.

MAPPING OF COs WITH POs												
COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	1	2	1	1	1	1	2	1	1
CO2	3	3	2	3	1	1	1	2	1	1	1	2
CO3	3	3	3	2	2	1	1	1	2	1	1	1
CO4	3	3	3	1	2	1	1	1	1	2	1	2
CO5	3	3	2	2	1	1	1	1	2	1	1	1
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2017-18 ACADEMIC YEAR: 2020-21
SEMESTER : SEVENTH

COURSE TITLE : ENGINEERING ECONOMICS (PROFESSIONAL ELECTIVE - 5)		
Sub Code: ME733	**No of Credits =03 L-T-P-SS::3:0:0:0**	**No. of lecture hours/week : 03 Total Number of Lecture hours : 39**
Exam Duration : 3 hours	**CIE Marks: 50**	**SEE Marks : 100**
Pre-requisites	**Engineering mathematics**	

COURSE OBJECTIVES:

1. Helping decision making
2. Calculation of interest
3. Arriving at break-even point
4. Feasibility study from economic point of view
5. Preparation of budget
6. Understanding financial statements
7. Arriving at the product cost.

UNIT	CONTENTS	Hrs.
UNIT-1	**INTRODUCTION** (CLASS ROOM TEACHING)	**07**
	Elements of engineering economics, engineering decision- makers, engineering and economics, problem solving and decision making, intuition and analysis, tactics and strategy. Engineering economic decision, maze. Law of demand and supply, law of returns, interest and interest factors: interest rate, simple interest, compound interest, cash - flow diagrams, personal loans and EMI payment, exercises and discussion.	
UNIT-2	**PRESENT-WORTH COMPARISONS** (CLASS ROOM TEACHING)	**08**
	Conditions for present worth comparisons, basic present worth comparisons, present-worth equivalence, net present-worth, assets with unequal lives, infinite lives, future-worth comparison, pay-back comparison, exercises, discussions and problems.	
UNIT-3	**RATE-OF-RETURN CALCULATIONS AND DEPRECIATION (**CLASSROOM TEACHING)	**07**
	Rate of return, minimum acceptable rate of return, IRR, IRR misconceptions, cost of capital concepts. Causes of depreciation, basic methods of computing depreciation charges, tax concepts, and corporate income tax.	
UNIT-4	**INTRODUCTION, SCOPE OF FINANCE, FINANCE FUNCTIONS** (CLASS ROOM TEACHING)	**08**
	Statements of financial information: introduction, source of financial information, financial statements, balance sheet, profit and loss account, relation between balance sheet and profit and loss account. Simple Numericals. **FINANCIAL RATIO ANALYSIS**: Introduction, nature of ratio analysis, liquidity ratios, leverage ratios, activity ratios, profitability ratios, evaluation of a firm's earning power. Comparative statements analysis. Simple Numericals.	
UNIT-5	**FINANCIAL AND PROFIT PLANNING** (BLENDED TEACHING)	**09**
	Introduction, financial planning, profit planning, objectives of profit planning, essentials of profit planning, budget administration, type of budgets, preparation of budgets, advantages, problems and dangers of budgeting. Introduction to bench marking of manufacturing operation. **ESTIMATING AND COSTING** Components of costs such as direct material costs, direct labor costs, fixed over-heads,	

	factory cost, administrative overheads, first cost, marginal cost, selling price, estimation for simple components.	

TEXT BOOKS:

1. Engineering Economy, Riggs J.L., McGraw Hill, 2002
2. Engineering Economy, Thuesen H.G. PHI , 2002

REFERENCE BOOKS:

1. Engineering Economy, Tarachand, 2000.
2. Industrial Engineering and Management, OP Khanna, Dhanpat Rai & Sons. 2000
3. Financial Management, Prasanna Chandra, TMH, 2004
4. Financial Management, IM PANDEY, Vikas Publisahing House, 2002

COURSE OUTCOMES: At the end of the course the student will be able to:

CO1: Take the right financial decision.
CO2: Help in calculating the financial factors.
CO3: Arrive at feasibility study of the project.
CO4: Training the students for preparing the budget.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	1	2	1	1	1	1	2	1	1
CO2	3	3	2	3	1	1	1	2	1	1	1	2
CO3	3	3	3	2	2	1	1	1	2	1	1	1
CO4	3	3	3	1	2	1	1	1	1	2	1	2
CO5	3	3	3	2	2	1	1	1	2	1	1	1
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2017-18 ACADEMIC YEAR: 2020-21
SEMESTER : SEVENTH

COURSE TITLE : COMPUTER AIDED MODELING AND ANALYSIS LABORATORY		
Sub Code: MEL74	**No of Credits =02** **L-T-P-SS::0:2:2:0**	**No. of practical hours/week: 02**
Exam Duration : 3 hours	**CIE Marks: 50**	**Exam Marks : 50**
Pre-requisites	**Engineering mathematics, MOM, DME**	

COURSE OBJECTIVES:

1. To be able to understand and handle design problems in systematic manner
2. To gain practical experience in 2D drafting and 3D modeling software systems.
3. To be able to apply CAD in real life applications.
4. 4.To be able to understand meaning and Usefulness of FEM
5. To be able to understand Various software used to solve the practical problems

#	Contents	Hrs
UNIT-1	**STUDY OF A FEA PACKAGE AND MODELING STRESS ANALYSIS OF**	**13**
	a. Bars of constant cross section area, tapered cross section area and stepped bar b. Trusses – (Minimum 2 exercises) c. Beams – Simply supported, cantilever, beams with UDL, beams with varying load etc (Minimum 6 exercises) d. Includes Theoretical problems and Introduction to meshing	
UNIT-2	**STRESS ANALYSIS OF**	**13**
	a) Stress analysis of a rectangular plate with a circular hole b) Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions(Minimum 4 exercises) c) Dynamic Analysis 1) Fixed – fixed beam for natural frequency determination 2) Bar subjected to forcing function 3) Fixed – fixed beam subjected to forcing function	

REFERENCE BOOKS:

1. A first course in the Finite element method, Daryl L Logan, Thomason, 3rd Ed.
2. Fundaments of FEM, Hutton – McGraw Hill, 2004
3. Finite Element Analysis, George R. Buchanan, Schaum Series.

COURSE OUTCOMES: On completion of the course, student should be able to:
CO1: Do 3D/2D Modelling and assign the material properties of the models.
CO2: Do proper meshing of the modelled component with different meshing techniques, mesh size control and mesh quality check.
CO3: Assign the required boundary condition, loading condition, types of loading and solve.
CO4: To analyse and evaluate the results obtained after analysis.

MAPPING OF COs WITH Pos												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	2	3	3	2	3	3	0	2
CO2	2	3	3	2	2	1	3	2	3	3	0	2
CO3	3	3	3	2	3	2	3	1	3	2	0	2
CO4	3	3	2	2	3	2	3	1	2	2	0	3
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

SCHEME OF EXAMINATION (SEE)					
Sl. No.	**Particulars**	**Max. Marks**	**Break Up of Max. Marks**		
			Write Up	**Conduction of experiment / Modelling Analysis**	**Expected Out Putt-Results (Different displacement, BM, Stress, Strain results. Etc. and Plotting deformation diagram, SFD,BMD, Graph if it's required)**
1	**Unit-1: Minor Experiment** (Any ONE from the list of experiments and it is purely individual Experiment) Q1	**20**	05	05	10
2	**Unit-2: Major Experiment** (Any ONE **Experiment** from the list of experiments and it is a Group Experiment) Q2	**20**	05	5	10
3	Viva Voce	**10**	--	--	--
TOTAL MARKS		**50**			

ADMISSION YEAR : 2017-18 ACADEMIC YEAR: 2020-21
SEMESTER : EIGHTH

COURSE TITLE : COMPUTATIONAL FLUID DYNAMICS (PROFESSIONAL ELECTIVE - 6)		
Sub Code: ME812	**No of Credits : L-T-P-SS 03:00:00:00 =03**	**No. of lecture hours/week : 03 Total Number of Lecture hours : 39**
Exam Duration : 3 hours	**CIE Marks: 50**	**SEE Marks : 100**
Pre-requisites	**Fluid dynamics, Mathematics**	

COURSE OBJECTIVES:

1. To understand the fundamentals of CFD and fluid flow equations in conservation forms.
2. To understand the various methods of solving linear algebraic equations.
3. To know the discretization methods and understand how it can be used in heat conduction problems.
4. To know the equations related to convection and diffusion and understand the methods to solve these equations.
5. To understand the Navier Stokes equations and turbulent modeling.

	CONTENTS	**Hrs**
UNIT-1	**INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS** (BLENDED MODE)	**07**
	Computational Fluid Dynamics: What, When, and Why?, CFD Applications, Experimental investigations, theoretical calculations, advantages and disadvantages of theoretical calculations, Fundamental principles of conservation, Reynolds transport theorem, Conservation of mass, Conservation of momentum, Conservation of Energy equations, Navier-Stokes equation, Time-average equations for turbulent flow, the turbulent kinetic energy equation, the general differential equations, Nature of coordinates : Independent variables, choice of coordinates, one way and two way coordinates.	
UNIT-2	**SOLUTION OF SYSTEMS OF LINEAR ALGEBRAIC EQUATIONS** (CLASSROOM MODE)	**08**
	Criteria for unique solution, infinite number of solutions and no solution, Solution techniques for systems of linear algebraic equations: Elimination, Iteration and Gradient Search method, Elimination method: Forward elimination and backward substitution, Assessment of number of computations, L-U decomposition technique, Tridiagonal matrix algorithm (TDMA): Thomas algorithm Iteration methods: Jacobi's method and Gauss Siedel method, Generalized analysis of the iterative methods, Sufficient condition for convergence, Rate of convergence, Scarborough criteria of sufficient condition for convergence in Gauss Siedel Method, Illustrative examples of Jacobi's method and Gauss Siedel method.	
UNIT-3	**DISCRETISATION METHODS AND HEAT CONDUCTION** (CLASSROOM MODE)	**08**
	The Discretization concept, The structure of Discretization equation, Methods of deriving the Discretization equation: Taylor series formulation, variation formulation, method of Weighted residuals, Control Volume formulations. Illustrative examples, Four basic rules, Numerical problems. Heat conduction: Steady one dimensional Conduction: The basic Equation, The grid Spacing, The interface conductivity, Non linearity, Source term Linearization, Boundary conditions, Unsteady one dimensional Conduction: the general Discretization equation,	

	Explicit, Crank Nicolson and fully implicit schemes, Two dimensional and three dimensional situation, Over relaxation and Under relaxation Methods. Problems.	
UNIT-4	**CONVECTION AND DIFFUSION** (CLASSROOM MODE)	**08**
	Steady one dimensional Convection and diffusion, the primary derivation, the upwind scheme, the exact solution, The Exponential scheme, The Hybrid scheme, The power law scheme, consequences of various scheme, Discretization equation for Two dimension, details of derivation, final Discretization equation, Discretization equation for Three dimension, one way space coordinates, outflow boundary conditions, False diffusion: common and proper view of False diffusion.	
UNIT-5	**NAVIER STOKES EQUATIONS AND TURBULENT MODELLING** (ONLINE MODE)	**08**
	Discretization of the Momentum Equation: Stream Function-Vorticity approach and Primitive variable approach, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorithm, Important features of turbulent flow, Vorticity transport equation, Statistical representation of turbulent flows: Homogeneous turbulence and isotropic turbulence, General Properties of turbulent quantities, Reynolds average Navier stokes (RANS) equation, Closure problem in turbulence: Necessity of turbulence modeling, Different types of turbulence model: Eddy viscosity 2 models, Mixing length model, Turbulent kinetic energy and dissipation, The κ-ε model, Advantages and disadvantages of κ -ε model.	

TEXT BOOKS:

1. **Computational Fluid Dynamics: The Basics with Applications,** John D. Anderson, Jr., McGraw-Hill International Editions, 1995.
2. **Computational Fluid Flow and Heat Transfer,** K. Muralidhar and T.Sundararajan (Editors), 2nd Edition, Narosa Publishing House, 2003.
3. **Introduction to Computational Fluid Dynamics:** H.K. Versteeg and W. Malalasekera, Pearson Education Limited, 2nd Edition, 2007.

REFERENCE BOOKS:

1. **Computational Fluid Methods for Fluid Dynamics**, J.H. Ferziger and M. Peric, Springer (India) Pvt. Ltd., 3rd Edition, 2002.
2. **Introduction to Computational Fluid Dynamics**, Pradip Niyogi, S.K. Chakrabartty, M.K. Laha, Pearson Education, 2011.
3. **Numerical Heat Transfer and Fluid Flow**, Suhas V. Patankar, Hemisphere Publishing Corporation, 1980.

e-LEARNING RESOURCES

Videos, Lecture notes: http://www.nptel.ac.in

COURSE OUTCOME (CO)

After completion of the course, students will be able to:

CO1: Understand the fundamental concepts of computational fluid dynamics and explain Reynolds transport theorem.

CO2: Demonstrate the different methods of solving a system of linear algebraic equations.

CO3: Understand the concept of Discretization and its methods; Discretize the heat conduction equations and solve numerical problems.

CO4: Derive the one dimensional steady convection and diffusion equation; Discretize these equations using different methods.

CO5: Discretize the momentum equation and understand the various turbulent models.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	1	1	1	1	1	1	1	1	1
CO2	3	3	2	1	1	1	1	1	1	1	1	1
CO3	3	3	3	1	1	1	1	1	1	1	1	1
CO4	3	3	2	1	1	1	1	1	1	1	1	1
CO5	3	3	3	1	1	1	1	1	1	1	1	1
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										
3. Each full question shall have maximum of 3 sub-divisions.										

ADMISSION YEAR : 2017-18 ACADEMIC YEAR: 2020-21
SEMESTER : EIGHTH

COURSE TITLE : SMART MATERIALS (PROFESSIONAL ELECTIVE - 6)		
Sub Code: ME813	**No of Credits =03** **L-T-P-SS::3:0:0:0**	**No. of lecture hours/week : 03** **Total Number of Lecture hours : 39**
Exam Duration : 3 hours	**CIE Marks: 50**	**SEE Marks : 100**
Pre-requisites	**Material science, Composite materials**	

COURSE OBJECTIVES:

1. The aim of this course is to integrate research results with curriculum development for the benefit of the students in physics, materials science and engineering civil and structural engineering, mechanical and aerospace engineering, industrial and systems engineering, as well as electrical and electronic engineering.
2. The fundamentals of smart materials, device and electronics, in particular those related to the development of smart structures and products.
3. The skills, knowledge and motivation in the design, analysis and manufacturing of smart structures and products.

#	CONTENTS	Hrs
UNIT-1	**INTRODUCTION TO SMART MATERIALS (Classroom Teaching)**	**07**
	Characteristics of composites and ceramic materials, Smart materials and their types, dynamics and controls, concepts, Electro-magnetic materials and shape memory alloys-processing and characteristics.	
UNIT-2	**SMART STRUCTURES (Blended Learning)**	**08**
	Types of smart Structures, potential feasibility of smart structures, key elements of smart structures, applications of smart structures. Piezoelectric materials, properties, piezoelectric constitutive relations, poling and coercive field, field strain relation. Hysteresis, creep and strain rate effects, inchworm linear motor.	
UNIT-3	**SENSING AND ACTUATION (Blended Learning)**	**08**
	Principles of electromagnetic, acoustics, chemical and mechanical sensing and actuation, Types of sensors and their applications, signal processing, principals and characterization of sensors.	
UNIT-4	**SHAPE MEMORY ALLOY (Blended Learning)**	**08**
	Experimental Phenomenology, Shape Memory Effect, phase transformation, super elasticity, Tanaka's constitutive model, SME testing of SMA wires, vibration control through SMA, Testing of super elasticity, Applications Of SMA. **ER AND MR FLUIDS** Mechanisms and properties, fluid composition and behavior, The Bingham plastic and related models, pre-yield response. Post-yield flow applications in clutches, dampers and others.	
UNIT-5	**VIBRATION ABSORBERS and MEMS (Blended Learning)**	**08**
	VIBRATION ABSORBERS: Series and parallel damped vibrations (overview), active vibration absorbers, fiber optics, physical phenomena, characteristics, sensors, fiber optics in crack detection, applications, biomimetics. **MEMS:** Mechanical properties of MEMS materials, scaling of mechanical systems, fundamentals of theory, the intrinsic characteristics of MEMS, miniaturization, microelectronics integration.	

TEXT BOOKS:

1. **'Analysis and Design',** A. V. Srinivasan, 'Smart Structures –Cambridge University Press, New York, 2001, (ISBN : 0521650267)
2. **'Smart Materials and Structures',** M V Gandhi and B S Thompson Chapmen & Hall, London, 1992 (ISBN : 0412370107)

REFERENCE BOOKS:

1. **'Smart Materials and Structures',** Banks HT, RC Smith, Y Wang, Massow S A, Paris 1996
2. **G P Gibss'Adaptive Structres',** Clark R L, W R Saunolers, Jhon Wiles and Sons, New York, 1998
3. **An introduction for scientists and Engineers',**EsicUdd, Optic Sensors :Jhon Wiley & Sons, New York, 1991 (ISBN : 0471830070).

COURSE OUTCOMES: On completion of this COURSE, students should be able to:
CO1: Understand the physical principles underlying the behaviour of smart materials;
CO2: Analyze the properties of smart structures, Piezo electric materials with the applications and select suitable procedure for fabrication.
CO3: Understand the engineering principles in smart sensor, actuator and technologies
CO4: Explain the principle concepts of ER & MR Fluids and shape memory alloys with principles of working.
CO5: Describe the methods of controlling vibration using smart systems and fabrication methods of MEMS. Explain the principle concepts of Biomimetic, Fibre optics and actuation with principles of working.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	2	1	1	1	1	1	2	1
CO2	3	3	2	3	2	1	1	1	1	1	2	1
CO3	3	3	2	3	3	1	1	1	1	1	2	1
CO4	3	3	3	3	2	1	1	1	1	1	2	1
CO5	3	3	3	3	2	1	1	1	1	1	2	1
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2018-19 ACADEMIC YEAR: 2020-21
SEMESTER : FIFTH

COURSE TITLE : MECHATRONICS AND MICROPROCESSORS (PROFESSIONAL ELECTIVE – 1)		
Sub Code: 18ME554	**No of Credits =03** **L-T-P-SS:3:0:0:0**	**No. of lecture hours/week : 03** **Total Number of Lecture hours : 39**
Exam Duration : 3 hours	**CIE Marks: 50**	**Exam Marks : 100**
Pre-requisites		

Course objective:

1. Substantiate the need for interdisciplinary study in technology education.
2. Understand the evolution and development of Mechatronics as a discipline.
3. Define various types of transducers used and understand analog to digital converter and vice versa.
4. Applications of microprocessors in various systems and to know the functions of each Element.
5. Describe the operation of mechanical, electrical pneumatic and hydraulic actuators.
6. Identify main parts, hardware forms and internal architecture of PLC.

#	CONTENTS	Hrs
UNIT-1	**INTRODUCTION TO MECHATRONIC SYSTEMS** (ONLINE TEACHING)	**08**
	Measurement and control systems Their elements and functions, Microprocessor based controllers-engine management system, automatic camera and automatic washing machine, Mechanical components in mechatronics, force, friction and lubrication, materials, mechanical behaviour of materials, mechanisms used in mechatronics, lever and four bar mechanisms, bearing, belt, chain, cam, slider crank, clutches etc.	
UNIT-2	**REVIEW OF TRANSDUCERS AND SENSORS** (BLENDED MODE TEACHING)	**08**
	Definition and classification of transducers. Definition and classification of sensors. Principle of working of and applications of light sensors, proximity sensors – magnetic switch, eddy current type, pneumatic type, ultrasonic type and Hall effect sensors, Computing elements in mechatronics, analog computer, timer, analog to digital converter, digital to analog converter, digital computer, microprocessor and its architecture, micro-controllers, programming logic controllers, their basic structures, mnemonics.	
UNIT-3	**ELECTRICAL ACTUATION SYSTEMS:** (CLASS ROOM TEACHING)	**08**
	Electrical systems, Mechanical switches, solid-state switches, solenoids, DC & AC motors, Stepper motors and their merits and demerits. Signal Conditioning: Introduction to signal conditioning. The operational amplifier.	
UNIT-4	**INTRODUCTION TO MICROPROCESSORS** (CLASS ROOM TEACHING)	**08**
	Evolution of Microprocessor, Organization of Microprocessors (Preliminary concepts), basic concepts of programming of microprocessors. Review of concepts - Boolean algebra, Logic Gates and Gate Networks, Binary & Decimal number systems, memory representation of positive and negative integers, maximum and minimum integers. Conversion of real, numbers, floating point notation, representation of floating point numbers, accuracy and range in floating point representation, overflow and underflow, addition of floating point numbers, character representation. Central Processing Unit of Microprocessors**:** Introduction, timing and control unit basic concepts, Instruction and data flow, system timing, examples of INTEL 8085 and 4004 register organization.	
UNIT-5	**DATA WORD REPRESENTATION** (CLASS ROOM TEACHING)	**07**

	Data word representation. Basic elements of control systems 808SA processor architecture terminology such as CPU, memory and address, ALU, assembler data registers, Fetch cycle, write cycle, state, bus, interrupts. Micro Controllers. Difference between microprocessor and micro controllers. Requirements for control and their implementation in microcontrollers. Classification of micro controllers. Organization & Programming of Microprocessors**:** Introduction to organization of INTEL 808S-Data and Address buses, Instruction set & programming of 8085.	

TEXTBOOKS:

1. A Kuttan, "Introduction to Mechatronics, Oxford University Press, 2010.
2. Alciatore & Histand, "Introduction to Mechatronics & Measurement Systems, 4e", McGrawHill Education, 2014.
3. M Jouaneh, "Fundamentals of Mechatronics", Cengage Learning, 2013.
4. W. Bolton, "Mechatronics", Pearson Education, Second Edition, 1999.Bradley
5. D. A., Dawson D., Buru N.C. and. Loader A.J, "Mechatronics", Chapman and Hall, 1993

REFERENCE BOOKS:

1. Dan Necsulesu, "Mechatronics", Pearson Education Asia, 2002 (Indian Reprint).
2. NitaigourPremchandMahadik, "Mechatronics", McGraw-Hill Education, 2015.
3. Lawrence J. Kamm, "Understanding Electro – Mechanical Engineering, An Introduction to Mechatronics", Prentice – Hall of India Pvt., Ltd., 2000.
4. Ramachandran K. P., Vijayaraghavan G. K., Balasundaram M.S. "Mechatronics: Integrated Mechanical Electronic Systems", Wiley

CO1:
CO2:
CO3:
CO4:
CO5:

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	1	1	1	2	0	0	1	0	3
CO2	3	3	2	1	1	0	2	0	0	1	0	2
CO3	3	3	2	1	1	0	2	0	0	1	0	2
CO4	3	3	3	2	1	0	2	0	0	1	0	3
CO5	3	3	2	2	1	0	2	0	0	1	0	3
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2018-19 ACADEMIC YEAR: 2020-21
SEMESTER : FIFTH

COURSE TITLE : PRINCIPLES OF METAL FORMING (PROFESSIONAL ELECTIVE - 1)		
Sub Code: 18ME555	**No of Credits =03** **L-T-P-SS::3:0:0:0**	**No. of lecture hours/week : 03** **Total Number of Lecture hours : 39**
Exam Duration : 3 hours	**CIE Marks: 50**	**SEE Marks : 100**
Pre-requisites	**Metallurgy, Strength of Materials, Manufacturing process**	

COURSE OBJECTIVES

1. Express and analyze the concept of different metal forming process, concepts of stress and Strain and its elastic relationships.
2. Express and analyze the concept of Plasticity, flow curve, yield criteria, plastic stress-strain relationship and effects of various parameters on flow properties.
3. Analyze and demonstrate hot and cold metal working, metallurgical consideration in metal working -forging and rolling process.
4. Analyze and demonstrate extrusion process.
5. Analyze and demonstrate sheet metal forming and powder metallurgy.

UNIT	**CONTENTS**	**Hrs.**
UNIT-1		**08**
	Introduction to metal Forming, classification of metal working process, behaviour of materials and its failure. Concept of stress-strain, description and state of stress in 3 dimension, description of strain, hydrostatic and deviator components of stress and strain. Elastic stress-strain relationships.	
UNIT-2		**08**
	Introduction to theory of plasticity and flow curve, true stress and true strain, yield criteria for ductile materials, plastic stress-strain relationships. Measure of yielding and ductility in tensile testing, instability in tension, strain rate and temperature effects on flow properties, influence of parameters on flow properties.	
UNIT-3		**08**
	Mechanics of metal working and analysis method, determination of flow stress in metal working, hot working and cold working, metallurgical consideration in metal forming. introduction and classification of forging process, forging in plane strain, Introduction and classification of rolling process, analysis of rolling load calculation	
UNIT-4	(**For Online class**)	**08**
	Introduction and classification of extrusion process, analysis of extrusion process, extrusion of tubes and pipes, introduction of rod and wire drawing, analysis of wire and tube drawing process.	
UNIT-5	Introduction and classification of sheet metal working operations and powder metallurgy forming.	**07**

Course Outcomes: At the end of the course, student will able to:

CO1: Ability to define Metal forming process and classification, concepts of stress-strain and its elastic relationships.
CO2: Concept of Plastic deformation in Metals and its flow characteristics with certain phenomenon.
CO3: The difference between Hot and cold forming, its associated metallurgical behavior and working principles of Forging and Rolling process.
CO4: Working principles of Extrusion, various classification of it. Wire drawing principle
CO5: Sheet Metal forming operations and its application and Powder metallurgy and its application

TEXT BOOKS:

1. Mechanical metallurgy (SI Units), G.E.Dieter, McGraw hill Pub-2001.
2. Ghosh A. Mallik A K Manufacturing science, Affiliated East-West press Pvt Ltd
3. Rowe, Geoffrey W. An Introduction to the principles of Metal working, TMH

REFERENCE BOOKS:

1. Materials & Process in Manufacturing – E.Paul, Degramo, J.T.Black, Ranold, A.K.Prentice-hall of India 2002
2. Fundamentals of Manufacturing Processes by Lal G K, Narosa
3. Textbook of Production Engineering by P. C. Sharma, S Chand & Company Ltd

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3										
CO2	2	3										
CO3	2	3	3	3	3				1	1	1	1
CO4	2	3	3	3	3				1	1	1	1

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2018-19 ACADEMIC YEAR: 2020-21
SEMESTER : SIXTH

COURSE TITLE : PRODUCTION AND OPERATIONS MANAGEMENT (PROFESSIONAL ELECTIVE - 2)		
Sub Code: 18ME644	**No of Credits =03** **L-T-P-SS::3:0:0:0**	**No. of lecture hours/week : 03** **Total Number of Lecture hours : 39**
Exam Duration : 3 hours	**CIE Marks: 50**	**SEE Marks : 100**
Pre-requisites	Elementary knowledge of calculus and probability	

Course Objective:

1. Develop an understanding of and an appreciation for the production and operations management function in any organization.
2. To understand the importance of productivity and competitiveness to both organizations and nations.
3. To understand the importance of an effective production and operations strategy to an organization.
4. To understand the various production and operations design decisions and how they relate to the overall strategies of organizations.
5. To understand the relationship of the various planning practices of capacity planning, aggregate planning, project planning and supply management.

UNITS	CONTENTS	Hrs.
UNIT- 1	**PRODUCTION & OPERATIONS MANAGEMENT CONCEPTS** (ONLINE TEACHING)	**08**
	Introduction, Historical Development, Operations Management Definition, Production and Manufacturing Systems, Products v/s Services, Productivity, Factors affecting Productivity, International Dimensions of Productivity, The environment of operations, Operational excellence and world class manufacturing practices. OPERATIONS DECISION MAKING: Introduction, Characteristics of decisions, framework for Decision Making, Decision methodology, Decision supports systems, Economic models, Statistical models. (Simple numericals)	
UNIT- 2	**SYSTEM DESIGN & CAPACITY PLANNING**(BLENDED TEACHING)	**08**
	Design capacity, System capacity, and Determination of Equipment requirement. Facility Location and Facility Layout, Location Planning for Goods and Services, Foreign locations and facility layout. (Simple numericals)	
UNIT- 3	**FORECASTING**, **AGGREGATE PLANNING AND MASTER SCHEDULING**(ONLINE TEACHING)	**08**
	Forecasting: Forecasting Objectives and Uses, Forecasting Variables, Opinion and Judgmental methods, Time Series methods, Exponential smoothing, Regression and Correlation methods, Application and Control of Forecasts. (Simple numericals) **Aggregate Planning And Master Scheduling:** Introduction, Planning and Scheduling, Objectives of Aggregate Planning, Aggregate Planning Methods, Master Scheduling Objectives, Master Scheduling Methods. (Simple numericals)	
UNIT- 4	**INVENTORY CONTROL AND MATERIALS MANAGEMENT** (ONLINE TEACHING)	**08**
	Definition and Need, Components Inventory, inventory control. Scope of Materials	

	Management, Material handling, storage and retrieval, purpose of inventories, Dependent and Independent demand, Inventory cost and Order quantities, Inventory classification and counting (Simple numericals)	
UNIT- 5	**MATERIAL, CAPACITY REQUIREMENTS PLANNING AND PURCHASING & SUPPLY MANAGEMENT** (CLASS ROOM TEACHING)	**07**
	Material and Capacity Requirements Planning: Overview: MRP and CRP, MRP: Underlying Concepts, System Parameters, MRP Logic, System refinements, Capacity Management, CRP activities. Concept of continuous improvement of process. (Simple numericals) **Purchasing & Supply Management**: Purchase and supply chain management. Approaches to purchase and supply chain management, make or buy decision, eProcurement, Vender development, rating, and certification.	

TEXT BOOKS:

1. Operations Management, I. B. Mahadevan. Theory and practice, Pearson, 2007.
2. Operations Management, Monks, J.G., McGraw-Hili International Editions, 1987.

REFERENCE BOOKS:

1. Modern Production/Operations Management, Buffa, Wiley Eastern Ltd.2001
2. Production and Operations Management, Pannerselvam. R., PHI. 2002
3. Productions & Operations Management, Adam & Ebert. 2002
4. Production and Operations Management, Chary, S. N., Tata-McGraw Hill. 2002

COURSE OUTCOMES: On completion of the course, student should be able to:

CO1: Appreciate the production and operations management function in any organization.

CO2: Explain importance of productivity and competitiveness to both organizations and nations.

CO3: Explain importance of an effective production and operations strategy to an organization.

CO4: Explain various production and operations design decisions and how they relate to the overall strategies of organizations.

CO5: Explain relationship of the various planning practices of capacity planning, aggregate planning, project planning and supply management.

MAPPING OF COs WITH POs												
COs/POs	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	0	2	0	0	0	0	0	0	2
CO2	3	3	2	1	2	0	2	0	0	0	0	2
CO3	3	3	2	1	2	0	0	0	0	0	0	2
CO4	3	3	3	3	2	2	0	0	0	2	0	2
CO5	3	3	2	1	3	3	3	0	0	2	0	2
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2018-19 ACADEMIC YEAR: 2020-21
SEMESTER : SIXTH

COURSE TITLE : FLUID POWER CONTROL SYSTEMS (PROFESSIONAL ELECTIVE – 1)		
Sub Code: 18ME646	**No of Credits : L-T-P-SS 3:0:0:0 =3**	**No. of lecture hours/week : 03 Total Number of Contact Hours : 39**
Exam Duration : 3 hours	**CIE Marks: 50**	**Exam Marks : 100**
Pre-requisites	**Fluid mechanics**	

COURSE OBJECTIVES:

1. To outline the introductory concepts on fluid power control systems.
2. To explain various types of hydraulic pumps and actuators, and their classification and application.
3. To describe the operation of a complete hydraulic circuit drawn with symbols for all components.
4. To outline the basics of a pneumatic system with its components.
5. To describe the pneumatic control system and various logic devices and pneumatic circuits.

#	CONTENTS	Hrs.
UNIT-1	**INTRODUCTION TO FLUID POWER CONTROL** (BLENDED MODE)	**06**
	Review of fluid mechanics (Pascal's law, continuity equation, Bernoulli's equation, Torricelli theorem, Air-to-hydraulic pressure booster, the siphon); Introduction to fluid power: advantages and applications; Types of fluid power control systems: Environmental issues; Fluids in hydraulic system: fluid properties, general types of fluids; Seals, sealing materials and compatibility with fluids; pipe sizing for flow rate and pressure rating requirement, different pipes, tubing and hoses, quick disconnect couplings; Flow through pipes: Laminar and turbulent, Reynolds number, Darcy equation, frictional losses, equivalent thickness technique; Numerical problems.	
UNIT-2	**HYDRAULIC PUMPS AND ACTUATORS** (CLASSROOM MODE)	**09**
	Introduction, Pumping theory, Classification of pumps, construction and working of Gear pumps, Vane pumps, Piston pumps, fixed and variable displacement pumps, Pump performance characteristics, pump noise, pump selection factors; Accumulators: Types, and applications of accumulators; Types of Intensifiers; Pressure switches /sensor, Temperature switches/sensor, Level sensor; Actuators: Classification, cylinder and hydraulic motors, Hydraulic cylinders, single and double acting cylinder, mounting arrangements, cushioning, special types of cylinders; Construction and working of rotary actuators such as gear, vane, piston motors, and Hydraulic Motor. Theoretical torque, power, flow rate, and hydraulic motor performance; Symbolic representation of hydraulic actuators (cylinders and motors); Numerical problems.	
UNIT-3	**HYDRAULIC CIRCUIT DESIGN AND ANALYSIS** (CLASSROOM MODE)	**09**
	Components and hydraulic circuit design Components: Classification of control valves, Directional Control Valves-symbolic representation, constructional features of poppet, sliding spool, rotary type valves solenoid and pilot operated DCV, shuttle valve, and check valves; Pressure control valves - types, direct operated types and pilot operated types; Flow Control Valves -compensated and non-compensated FCV, needle valve, temperature compensated, pressure compensated, pressure and temperature compensated FCV, symbolic representation; Hydraulic Circuit Design: Control of single and Double -acting hydraulic cylinder, regenerative circuit, pump unloading circuit, counter balance valve application,	

	hydraulic cylinder sequencing circuits, hydraulic circuit for force multiplication; speed control of hydraulic cylinder- metering in, metering out and bleed off circuits. Pilot pressure operated circuits; Hydrostatic transmission; Numerical problems.	
UNIT-4	**INTRODUCTION TO PNEUMATIC CONTROL** (CLASSROOM MODE)	**09**
	Definition of pneumatic system, advantages, limitations, applications, Choice of working medium. Characteristic of compressed air. Structure of Pneumatic control System, fluid conditioners and FRL unit. **PNEUMATIC ACTUATORS:** Linear cylinder - types, conventional type of cylinder r-working, end position cushioning, seals, mounting arrangements- applications. Rod - less cylinders types, working, advantages, rotary cylinders- types construction and application, symbols. **COMPRESSED AIR:** Production of compressed air- preparation of compressed air-driers, filters, regulators, lubricators, distribution of compressed air piping layout.	
UNIT-5	**PNEUMATIC CONTROL VALVES AND CIRCUITS** (ONLINE MODE)	**06**
	DCV such as poppet, spool, suspended seat type slide valve, 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. **SIGNAL PROCESSING ELEMENTS:** Use of Logic gates - OR and AND gates in pneumatic applications. Practical Examples involving the use of logic gates, Pressure dependant controls- types - construction - practical applications, Signal elimination and cascading methods, Time dependent controls principle. Construction, practical applications. **ELECTRO-PNEUMATIC CONTROL:** Principles - signal input and output, pilot assisted solenoid control of directional control valves, relay and contactors. Control circuitry for simple signal cylinder application. Numerical problems on pneumatic circuits.	

TEXT BOOKS

1. **Fluid Power with Applications,** Anthony Esposito, Pearson, 7th Edition, 2013**.**
2. **Hydraulics and Pneumatics,** Andrew Par, Jaico Publishing House, 2005.
3. **Fluid Power: Theory and Applications**, James Sullivan, 3rd Edition, Prentice Hall, 1989.

REFERENCE BOOKS

1. **Oil Hydraulics,** Majumdar, S.R., Tata McGraw-Hill Publications, 2002.
2. **Pneumatic Systems: Principles and Maintenance,** Majumdar, S.R., Tata McGraw-Hill Publications, 2005
3. **Fundamentals of Fluid Power Control,** John Watton, Cambridge University Press, 2012..

COURSE OUTCOMES: On completion of the course, students will be able to:

CO1: *Understand* the fundamental theoretical concepts governing the fluid power. (RBTL: 1, 2, 3)

CO2: *Familiarize* with common hydraulic components (such as pumps, actuators, motors, and valves), their use, symbols and their performance characteristics. (RBTL: 1, 2, 3)

CO3: *Formulate* and *analyse* mathematical models of hydraulic circuits and design them for directional, speed, pressure, force and flow control. (RBTL: 1, 2, 3)

CO4: *Understand* the basics of the structure of a pneumatic system and its components. (RBTL: 1, 2, 3)

CO5: *Familiarize* with the pneumatic control valves and circuits, signal processing elements and electro-pneumatic control circuits. (RBTL: 1, 2, 3)
(RBTL: Revised Bloom's Taxonomy Levels; 1 – Remembering, 2 – Understanding, 3 – Applying, 4 - Analyzing, 5 - Evaluating, 6 - Creating)

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	0	2	0	0	0	0	0	0	2
CO2	3	3	2	0	2	0	2	0	0	0	0	2
CO3	3	3	2	0	2	0	0	0	0	0	0	2
CO4	3	3	3	3	3	0	0	0	0	2	0	2
CO5	3	3	2	1	3	3	3	0	0	2	0	2
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										
3. Each full question shall have maximum of 3 sub-divisions										

ADMISSION YEAR : 2017-18 ACADEMIC YEAR: 2020-21
SEMESTER : SEVENTH

COURSE TITLE : ENGINEERING ECONOMICS (PROFESSIONAL ELECTIVE - 5)		
Sub Code: ME733	**No of Credits =03 L-T-P-SS::3:0:0:0**	**No. of lecture hours/week : 03 Total Number of Lecture hours : 39**
Exam Duration : 3 hours	**CIE Marks: 50**	**SEE Marks : 100**
Pre-requisites	**Engineering mathematics**	

COURSE OBJECTIVES:

1. Helping decision making
2. Calculation of interest
3. Arriving at break-even point
4. Feasibility study from economic point of view
5. Preparation of budget
6. Understanding financial statements
7. Arriving at the product cost.

UNIT	CONTENTS	Hrs.
UNIT-1	**INTRODUCTION** (CLASS ROOM TEACHING)	**07**
	Elements of engineering economics, engineering decision- makers, engineering and economics, problem solving and decision making, intuition and analysis, tactics and strategy. Engineering economic decision, maze. Law of demand and supply, law of returns, interest and interest factors: interest rate, simple interest, compound interest, cash - flow diagrams, personal loans and EMI payment, exercises and discussion.	
UNIT-2	**PRESENT-WORTH COMPARISONS** (CLASS ROOM TEACHING)	**08**
	Conditions for present worth comparisons, basic present worth comparisons, present-worth equivalence, net present-worth, assets with unequal lives, infinite lives, future-worth comparison, pay-back comparison, exercises, discussions and problems.	
UNIT-3	**RATE-OF-RETURN CALCULATIONS AND DEPRECIATION (**CLASSROOM TEACHING)	**07**
	Rate of return, minimum acceptable rate of return, IRR, IRR misconceptions, cost of capital concepts. Causes of depreciation, basic methods of computing depreciation charges, tax concepts, and corporate income tax.	
UNIT-4	**INTRODUCTION, SCOPE OF FINANCE, FINANCE FUNCTIONS** (CLASS ROOM TEACHING)	**08**
	Statements of financial information: introduction, source of financial information, financial statements, balance sheet, profit and loss account, relation between balance sheet and profit and loss account. Simple Numericals. **FINANCIAL RATIO ANALYSIS**: Introduction, nature of ratio analysis, liquidity ratios, leverage ratios, activity ratios, profitability ratios, evaluation of a firm's earning power. Comparative statements analysis. Simple Numericals.	
UNIT-5	**FINANCIAL AND PROFIT PLANNING** (BLENDED TEACHING)	**09**
	Introduction, financial planning, profit planning, objectives of profit planning, essentials of profit planning, budget administration, type of budgets, preparation of budgets, advantages, problems and dangers of budgeting. Introduction to bench marking of manufacturing operation. **ESTIMATING AND COSTING** Components of costs such as direct material costs, direct labor costs, fixed over-heads,	

	factory cost, administrative overheads, first cost, marginal cost, selling price, estimation for simple components.	

TEXT BOOKS:

1. Engineering Economy, Riggs J.L., McGraw Hill, 2002
2. Engineering Economy, Thuesen H.G. PHI , 2002

REFERENCE BOOKS:

1. Engineering Economy, Tarachand, 2000.
2. Industrial Engineering and Management, OP Khanna, Dhanpat Rai & Sons. 2000
3. Financial Management, Prasanna Chandra, TMH, 2004
4. Financial Management, IM PANDEY, Vikas Publisahing House, 2002

COURSE OUTCOMES: At the end of the course the student will be able to:

CO1: Take the right financial decision.
CO2: Help in calculating the financial factors.
CO3: Arrive at feasibility study of the project.
CO4: Training the students for preparing the budget.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	1	2	1	1	1	1	2	1	1
CO2	3	3	2	3	1	1	1	2	1	1	1	2
CO3	3	3	3	2	2	1	1	1	2	1	1	1
CO4	3	3	3	1	2	1	1	1	1	2	1	2
CO5	3	3	3	2	2	1	1	1	2	1	1	1
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2017-18 ACADEMIC YEAR: 2020-21
SEMESTER : EIGHTH

COURSE TITLE : COMPUTER INTEGRATED MANUFACTURING (PROFESSIONAL ELECTIVE - 6)		
Sub Code: ME811	**No of Credits =03 L-T-P-SS::3:0:0:0**	**No. of lecture hours/week : 03**
Exam Duration : 3 hours	**CIE Marks: 50**	**SEE Marks : 100**
Pre-requisites	**Manufacturing process I and II, CAD/CAM**	

Course Objectives:

1. To impart knowledge of CIM and Automation and different concepts of automation by developing mathematical models.
2. To expose students to automated flow lines, assembly lines, Line Balancing Techniques, and Flexible Manufacturing Systems.
3. To expose students to computer aided process planning, material requirement planning, capacity planning etc.
4. To introduce the students to concepts of Additive Manufacturing, Internet of Things, and Industry 4.0 leading to Smart Factory.

UNIT	CONTENT	Hrs.
UNIT 1	**Introduction to CIM and Automation:** (BLENDED TEACHING) Automation in Production Systems, automated manufacturing systems- types of automation, reasons for automating, Computer Integrated Manufacturing, computerized elements of a CIM system, CAD/CAM and CIM. Mathematical models and matrices: production rate, production capacity, utilization and availability, manufacturing lead time, work-in process, Numerical problems and automation strategies.	**08**
UNIT 2	**Automated Production Lines and Assembly Systems:** (BLENDED TEACHING) Fundamentals, system configurations, applications, automated flow lines, buffer storage, control of production line, analysis of transfer lines, analysis of flow lines without storage, partial automation, analysis of automated flow lines with Storage buffer, fundamentals of automated assembly systems, numerical problems.	**08**
UNIT 3	**Flexible Manufacturing Systems:** (BLENDED TEACHING) Fundamentals of Group Technology and Flexible Manufacturing Systems, types of FMS, FMS components, Material handling and storage system, applications, benefits, computer control systems, FMS planning and design issues, Automated Storage and Retrieval Systems, AS/RS and Automatic parts identification systems and data capture. **Line Balancing:** Line balancing algorithms, methods of line balancing, numerical problems on largest candidate rule, Kilbridge and Wester method, and Ranked Positional Weights method.	**08**
UNIT 4	**Computerized Manufacture Planning and Control System:** (ONLINE TEACHING) Computer Aided Process Planning, Retrieval and Generative Systems, benefits of CAPP, Production Planning and Control Systems, typical activities of PPC System, computer integrated production management system, Material Requirement Planning, inputs to MRP system, working of MRP, outputs and	**08**

	benefits, Capacity Planning, Computer Aided Quality Control, Shop floor control. **Automated Assembly Systems:** Design for automated assembly systems, types of automated assembly system, Parts feeding devices-elements of parts delivery system-hopper, part feeder, Selectors, feedback, escapement and placement. **Automated Guided Vehicle System**: Introduction, types, Vehicle guidance and routing, System management.	
UNIT 5	**Additive Manufacturing Systems:** (ONLINE TEACHING) Basic principles of additive manufacturing, slicing CAD models for AM, advantages and limitations of AM technologies, Additive manufacturing processes: Photo polymerization, material jetting, binder jetting, material extrusion, Powder bed sintering techniques, sheet lamination, direct energy deposition techniques, applications of AM. Recent trends in manufacturing, Hybrid manufacturing. **Future of Automated Factory:** Industry 4.0, functions, applications and benefits. Components of Industry 4.0, Internet of Things (IOT), IOT applications in manufacturing, Big-Data and Cloud Computing for IOT, IOT for smart manufacturing, influence of IOT on predictive maintenance, industrial automation, supply chain optimization, supply-chain & logistics, cyber-physical manufacturing systems.	**07**

TEXT BOOKS:

1. Automation, Production system & Computer Integrated manufacturing, M. P. Groover" 4th Edition, 2015, Pearson Learning.
2. Principles of Computer Integrated Manufacturing, S. Kant Vajpayee, Prentice Hall India.
3. CAD/CAM/CIM, Dr P Radhakrishnan, 3rd edition, New Age International Publishers, New Delhi.

REFERENCE BOOKS

1. "CAD/CAM" by Ibrahim Zeid, Tata McGraw Hill.
2. "Principles of Computer Integrated Manufacturing", S.Kant Vajpayee, 1999, Prentice Hall of India, New Delhi.
3. "Work Systems and the Methods, Measurement and Management of Work", Groover M. P, Pearson/Prentice Hall, Upper Saddle River, NJ, 2007.
4. "Computer Automation in Manufacturing", Boucher, T. O., Chapman & Hall, London, UK, 1996.
5. "Introduction to Robotics: Mechanics and Control", Craig, J. J., 2nd Ed., Addison-Wesley Publishing Company, Readong, MA, 1989.
6. Internet of Things (IoT): Digitize or Die: Transform your organization. Embrace the digital evolution. Rise above the competition, by Nicolas Windpassinger, Amazon.
7. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press)
8. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, 2nd Ed. (2015), Ian Gibson, David W. Rosen, Brent Stucker
9. "Understanding Additive Manufacturing", Andreas Gebhardt, Hanser Publishers, 2011
10. Industry 4.0: The Industrial Internet of Things, A press, 2017, by Alasdair Gilchrist.

COURSE OUTCOMES (COS): On completion of this course you should be able to:

CO1: Able to define Automation, CIM, CAD, CAM and explain the differences between these concepts.

CO2: Explain the basics of automated manufacturing industries through mathematical models and analyse different types of automated flow lines.

CO3: Analyse the FMS, GT, AS/RS and automated flow lines to reduce down time and enhance productivity.

CO4: Design and development of various types of Computerized Manufacture Planning and Control System, materials handling systems, CAPP, MRP, capacity planning, shop floor control and CAQC.

CO5: Visualize and appreciate the modern trends in Manufacturing like additive manufacturing, Industry 4.0 and applications of Internet of Things leading to Smart Manufacturing.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	1	2	1	1	1	1	2	1	1
CO2	3	3	2	3	1	1	1	2	1	3	1	2
CO3	3	3	3	2	2	1	1	1	2	3	1	1
CO4	3	3	3	1	2	1	1	1	1	2	1	2
CO5	3	3	3	1	2	1	1	1	1	2	1	2
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2017-18 ACADEMIC YEAR: 2020-21
SEMESTER : EIGHTH

COURSE TITLE : COMPUTATIONAL FLUID DYNAMICS (PROFESSIONAL ELECTIVE - 6)		
Sub Code: ME812	**No of Credits : L-T-P-SS 03:00:00:00 =03**	**No. of lecture hours/week : 03 Total Number of Lecture hours : 39**
Exam Duration : 3 hours	**CIE Marks: 50**	**SEE Marks : 100**
Pre-requisites	**Fluid dynamics, Mathematics**	

COURSE OBJECTIVES:

1. To understand the fundamentals of CFD and fluid flow equations in conservation forms.
2. To understand the various methods of solving linear algebraic equations.
3. To know the discretization methods and understand how it can be used in heat conduction problems.
4. To know the equations related to convection and diffusion and understand the methods to solve these equations.
5. To understand the Navier Stokes equations and turbulent modeling.

	CONTENTS	**Hrs**
UNIT-1	**INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS** (BLENDED MODE)	**07**
	Computational Fluid Dynamics: What, When, and Why?, CFD Applications, Experimental investigations, theoretical calculations, advantages and disadvantages of theoretical calculations, Fundamental principles of conservation, Reynolds transport theorem, Conservation of mass, Conservation of momentum, Conservation of Energy equations, Navier-Stokes equation, Time-average equations for turbulent flow, the turbulent kinetic energy equation, the general differential equations, Nature of coordinates : Independent variables, choice of coordinates, one way and two way coordinates.	
UNIT-2	**SOLUTION OF SYSTEMS OF LINEAR ALGEBRAIC EQUATIONS** (CLASSROOM MODE)	**08**
	Criteria for unique solution, infinite number of solutions and no solution, Solution techniques for systems of linear algebraic equations: Elimination, Iteration and Gradient Search method, Elimination method: Forward elimination and backward substitution, Assessment of number of computations, L-U decomposition technique, Tridiagonal matrix algorithm (TDMA): Thomas algorithm Iteration methods: Jacobi's method and Gauss Siedel method, Generalized analysis of the iterative methods, Sufficient condition for convergence, Rate of convergence, Scarborough criteria of sufficient condition for convergence in Gauss Siedel Method, Illustrative examples of Jacobi's method and Gauss Siedel method.	
UNIT-3	**DISCRETISATION METHODS AND HEAT CONDUCTION** (CLASSROOM MODE)	**08**
	The Discretization concept, The structure of Discretization equation, Methods of deriving the Discretization equation: Taylor series formulation, variation formulation, method of Weighted residuals, Control Volume formulations. Illustrative examples, Four basic rules, Numerical problems. Heat conduction: Steady one dimensional Conduction: The basic Equation, The grid Spacing, The interface conductivity, Non linearity, Source term Linearization, Boundary conditions, Unsteady one dimensional Conduction: the general Discretization equation,	

	Explicit, Crank Nicolson and fully implicit schemes, Two dimensional and three dimensional situation, Over relaxation and Under relaxation Methods. Problems.	
UNIT-4	**CONVECTION AND DIFFUSION** (CLASSROOM MODE)	**08**
	Steady one dimensional Convection and diffusion, the primary derivation, the upwind scheme, the exact solution, The Exponential scheme, The Hybrid scheme, The power law scheme, consequences of various scheme, Discretization equation for Two dimension, details of derivation, final Discretization equation, Discretization equation for Three dimension, one way space coordinates, outflow boundary conditions, False diffusion: common and proper view of False diffusion.	
UNIT-5	**NAVIER STOKES EQUATIONS AND TURBULENT MODELLING** (ONLINE MODE)	**08**
	Discretization of the Momentum Equation: Stream Function-Vorticity approach and Primitive variable approach, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorithm, Important features of turbulent flow, Vorticity transport equation, Statistical representation of turbulent flows: Homogeneous turbulence and isotropic turbulence, General Properties of turbulent quantities, Reynolds average Navier stokes (RANS) equation, Closure problem in turbulence: Necessity of turbulence modeling, Different types of turbulence model: Eddy viscosity 2 models, Mixing length model, Turbulent kinetic energy and dissipation, The κ-ε model, Advantages and disadvantages of κ -ε model.	

TEXT BOOKS:

1. **Computational Fluid Dynamics: The Basics with Applications,** John D. Anderson, Jr., McGraw-Hill International Editions, 1995.
2. **Computational Fluid Flow and Heat Transfer,** K. Muralidhar and T.Sundararajan (Editors), 2nd Edition, Narosa Publishing House, 2003.
3. **Introduction to Computational Fluid Dynamics:** H.K. Versteeg and W. Malalasekera, Pearson Education Limited, 2nd Edition, 2007.

REFERENCE BOOKS:

1. **Computational Fluid Methods for Fluid Dynamics**, J.H. Ferziger and M. Peric, Springer (India) Pvt. Ltd., 3rd Edition, 2002.
2. **Introduction to Computational Fluid Dynamics**, Pradip Niyogi, S.K. Chakrabartty, M.K. Laha, Pearson Education, 2011.
3. **Numerical Heat Transfer and Fluid Flow**, Suhas V. Patankar, Hemisphere Publishing Corporation, 1980.

e-LEARNING RESOURCES

Videos, Lecture notes: http://www.nptel.ac.in

COURSE OUTCOME (CO)

After completion of the course, students will be able to:

CO1: Understand the fundamental concepts of computational fluid dynamics and explain Reynolds transport theorem.

CO2: Demonstrate the different methods of solving a system of linear algebraic equations.

CO3: Understand the concept of Discretization and its methods; Discretize the heat conduction equations and solve numerical problems.

CO4: Derive the one dimensional steady convection and diffusion equation; Discretize these equations using different methods.

CO5: Discretize the momentum equation and understand the various turbulent models.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	1	1	1	1	1	1	1	1	1
CO2	3	3	2	1	1	1	1	1	1	1	1	1
CO3	3	3	3	1	1	1	1	1	1	1	1	1
CO4	3	3	2	1	1	1	1	1	1	1	1	1
CO5	3	3	3	1	1	1	1	1	1	1	1	1
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										
3. Each full question shall have maximum of 3 sub-divisions.										

ADMISSION YEAR : 2017-18 ACADEMIC YEAR: 2020-21
SEMESTER : EIGHTH

COURSE TITLE : SMART MATERIALS (PROFESSIONAL ELECTIVE - 6)		
Sub Code: ME813	**No of Credits =03** **L-T-P-SS::3:0:0:0**	**No. of lecture hours/week : 03** **Total Number of Lecture hours : 39**
Exam Duration : 3 hours	**CIE Marks: 50**	**SEE Marks : 100**
Pre-requisites	**Material science, Composite materials**	

COURSE OBJECTIVES:

1. The aim of this course is to integrate research results with curriculum development for the benefit of the students in physics, materials science and engineering civil and structural engineering, mechanical and aerospace engineering, industrial and systems engineering, as well as electrical and electronic engineering.
2. The fundamentals of smart materials, device and electronics, in particular those related to the development of smart structures and products.
3. The skills, knowledge and motivation in the design, analysis and manufacturing of smart structures and products.

#	CONTENTS	Hrs
UNIT-1	**INTRODUCTION TO SMART MATERIALS (Classroom Teaching)**	**07**
	Characteristics of composites and ceramic materials, Smart materials and their types, dynamics and controls, concepts, Electro-magnetic materials and shape memory alloys-processing and characteristics.	
UNIT-2	**SMART STRUCTURES (Blended Learning)**	**08**
	Types of smart Structures, potential feasibility of smart structures, key elements of smart structures, applications of smart structures. Piezoelectric materials, properties, piezoelectric constitutive relations, poling and coercive field, field strain relation. Hysteresis, creep and strain rate effects, inchworm linear motor.	
UNIT-3	**SENSING AND ACTUATION (Blended Learning)**	**08**
	Principles of electromagnetic, acoustics, chemical and mechanical sensing and actuation, Types of sensors and their applications, signal processing, principals and characterization of sensors.	
UNIT-4	**SHAPE MEMORY ALLOY (Blended Learning)**	**08**
	Experimental Phenomenology, Shape Memory Effect, phase transformation, super elasticity, Tanaka's constitutive model, SME testing of SMA wires, vibration control through SMA, Testing of super elasticity, Applications Of SMA. **ER AND MR FLUIDS** Mechanisms and properties, fluid composition and behavior, The Bingham plastic and related models, pre-yield response. Post-yield flow applications in clutches, dampers and others.	
UNIT-5	**VIBRATION ABSORBERS and MEMS (Blended Learning)**	**08**
	VIBRATION ABSORBERS: Series and parallel damped vibrations (overview), active vibration absorbers, fiber optics, physical phenomena, characteristics, sensors, fiber optics in crack detection, applications, biomimetics. **MEMS:** Mechanical properties of MEMS materials, scaling of mechanical systems, fundamentals of theory, the intrinsic characteristics of MEMS, miniaturization, microelectronics integration.	

TEXT BOOKS:

1. **'Analysis and Design',** A. V. Srinivasan, 'Smart Structures –Cambridge University Press, New York, 2001, (ISBN : 0521650267)
2. **'Smart Materials and Structures',** M V Gandhi and B S Thompson Chapmen & Hall, London, 1992 (ISBN : 0412370107)

REFERENCE BOOKS:

1. **'Smart Materials and Structures',** Banks HT, RC Smith, Y Wang, Massow S A, Paris 1996
2. **G P Gibss'Adaptive Structres',** Clark R L, W R Saunolers, Jhon Wiles and Sons, New York, 1998
3. **An introduction for scientists and Engineers',**EsicUdd, Optic Sensors :Jhon Wiley & Sons, New York, 1991 (ISBN : 0471830070).

COURSE OUTCOMES: On completion of this COURSE, students should be able to:
CO1: Understand the physical principles underlying the behaviour of smart materials;
CO2: Analyze the properties of smart structures, Piezo electric materials with the applications and select suitable procedure for fabrication.
CO3: Understand the engineering principles in smart sensor, actuator and technologies
CO4: Explain the principle concepts of ER & MR Fluids and shape memory alloys with principles of working.
CO5: Describe the methods of controlling vibration using smart systems and fabrication methods of MEMS. Explain the principle concepts of Biomimetic, Fibre optics and actuation with principles of working.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	2	1	1	1	1	1	2	1
CO2	3	3	2	3	2	1	1	1	1	1	2	1
CO3	3	3	2	3	3	1	1	1	1	1	2	1
CO4	3	3	3	3	2	1	1	1	1	1	2	1
CO5	3	3	3	3	2	1	1	1	1	1	2	1
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2018-19 ACADEMIC YEAR: 2020-21
SEMESTER : SIXTH

COURSE TITLE : ADVANCED WELDING TECHNOLOGY (PROFESSIONAL ELECTIVE – 2)		
Sub Code: 18ME642	**No of Credits =03** **L-T-P-SS::3:0:0:0**	**No. of lecture hours/week : 03** **Total Number of Lecture hours : 39**
Exam Duration : 3 hours	**CIE Marks : 50**	**Exam Marks : 100**
Pre-requisites	**Manufacturing process**	

COURSE OBJECTIVES

1. To understand the working principle, advantages, disadvantages of arc, gas and thermit welding.
2. The student gains information on different solid-state welding processes.
3. To understand the working principle, weld characteristics and process parameters of power beam welding.
4. To understand the process of thermal cutting of materials, brazing and soldering.
5. To understand the concept about underwater welding, welding in space and welding metallurgy.

#	CONTENTS	Hrs.
UNIT 1	**ARC, GAS AND THERMIT WELDING PROCESSES** (CLASSROOM TEACHING)	**08**
	Classification of welding processes, energy sources used in welding, working principle, process variables, advantages, limitations and applications of electro slag and electro gas welding, resistance welding, gas welding, plasma arc welding and thermit welding.	
UNIT 2	**SOLID STATE WELDING PROCESSES**(CLASSROOM TEACHING)	**08**
	Working principle, process variables, advantages, limitations and applications of Friction welding friction stir welding, ultrasonic welding, diffusion welding and explosion welding	
UNIT 3	**POWER BEAM WELDING PROCESSES** (CLASSROOM TEACHING)	**07**
	Working principle, process variables, advantages, limitations and applications of Electron beam and Laser beam welding	
UNIT 4	**BRAZING, SOLDERING AND THERMAL CUTTING** (ONLINE TEACHING)	**08**
	Introduction, brazing, soldering, various techniques, their advantages, limitations and applications; brazing & soldering consumables. Oxy- Acetylene cutting-working principle, metal powder cutting, introduction to oxygen/air / plasma / metal arc cutting arc cutting and gouging; advantages, limitations and applications of various techniques	
UNIT 5	**UNDERWATER WELDING, WELDING IN SPACE AND WELDING METALLURGY**(BLENDED TEACHING)	**08**
	Introduction to wet and dry under water welding & cutting Introduction, welding techniques, difficulties and advantages of welding in space. Welding metallurgy: Introduction, thermal cycles, prediction of peak temperature, pre heat and cooling rate, weldability of carbon steel, stainless steel & aluminum. Hot & cold cracking phenomenon, weld defects, causes and their remedies. Welding of Cu, Al, Ti and Ni alloys – processes, difficulties, microstructures, defects and remedial measures	

TEXT BOOKS:

1. S.V.Nadkarni, "Modern Arc Welding Technology", Oxford & IBH.
2. R.Little, "Welding Technology, TMH. WELDING CODES AND STANDARDS ME-9111 L T P.
3. Welding metallurgy by Sindo Kou, Welding metallurgy, 2nd Edition Nov. 2002, Wiley

REFERENCE BOOKS:

1. H.B.Cary, "Modern Arc Welding Technology", Englewood Cliffs, Prentice Hall.
2. Leonard P Connor, Welding Hand book, Volume I-III, AWS.
3. Metals Hand book, Volume 6, American Society of Metals.
4. Dave Smith, "Welding skills and technology", McGraw Hill.
5. Parmer R. S., 'Welding processes and Technology", Khanna Publishers, 1997
6. Robert W Messler, Jr. " Principles of welding, Processes, physics, chemistry and metallurgy", Wiley,2004.
7. Larry Jeffus, " Welding Principles and Applications" Fifth edition, Thomson,2002
8. Christopher Davis, 'Laser Welding - A Practical Guide', Jaico Publishing House, 1994.
9. Mishra. R.S and Mahoney. M.W, Friction Stir Welding and Processing, ASM,2007

COURSE OUTCOMES: On completion of the course, student should be able to;

CO1: Understand the mechanism, working principle and process characteristics of different arc, gas and thermit welding processes.

CO2: Have in depth knowledge on working principle, process characteristics of friction, friction stir, ultrasonic, explosion welding and diffusion bonding.

CO3: Describe the mechanism, working principle and process characteristics of high energy beam welding.

CO4: Differentiate between **s**oldering and brazing, their techniques, advantages and limitations, applications and also decide on best cutting techniques for a specific application and their limitations.

CO5: Describe working principle and process characteristics of underwater welding processes, welding in space. And also Welding and weldability of different metals, hot& cold cracking phenomenon, weld defects and their causes and remedies

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	3	1	2	0	1	1	1	1	1	0
CO2	2	3	2	1	2	0	0	1	1	2	1	1
CO3	3	3	2	1	2	0	1	1	1	2	1	1
CO4	2	3	3	1	2	0	0	1	1	2	0	1
CO5	3	2	3	1	2	0	1	1	0	1	1	0
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2018-19 ACADEMIC YEAR: 2020-21
SEMESTER : SIXTH

COURSE TITLE: INTERNAL COMBUSTION ENGINES (PROFESSIONAL ELECTIVE - 2)		
Sub Code: 18ME643	**No of Credits: L-T-P-SS 03:00:00:00 =03**	**No. of lecture hours/week: 03 Total Number of Lecture hours : 39**
Exam Duration : 3 hours	**CIE Marks: 50**	**SEE Marks : 100**
Pre-requisites	**Basic and Applied Thermodynamics**	

COURSE OBJECTIVES:

1. To understand the basic principle of thermodynamic process
2. To understand the basic components and structure of IC engines (both SI and CI engines), process parameters.
3. Understanding the performance of the engine, combustion and exhaust parameters.

UNIT NO.	CONTENTS	Hrs.
1	**REVIEW OF I.C. ENGINE CYCLES AND CARBURETION** (BLENDED MODE)	**07**
	Review of thermodynamics cycles used in IC engines; Introduction to carburetion, air-fuel mixture requirement at different loads and speeds, Automotive air-fuel mixture requirement, principle of carburetion, simple carburettor, calculation of air-fuel ratio, essential parts of a carburettor, compensating devices, additional systems in modern carburettors, types of carburettors, automobile carburettors, altitude compensation, Numerical problems air-fuel mixture and carburetion.	
2	**MECHANICAL AND ELECTRONIC INJECTION SYSTEMS** (CLASSROOM MODE)	**09**
	Introduction to mechanical injection system; Functional Requirements of an Injection System; Classification of Injection Systems; Fuel Feed Pump, Injection Pump - Jerk Type Pump, Distributor Type Pump; Injection Pump Governor, Mechanical Governor; Pneumatic Governor; Fuel Injector; Nozzle - Types of Nozzle; Spray Formation, Quantity of Fuel and the Size of Nozzle Orifice; Injection in SI Engine; Introduction to electronic injection system; Gasoline injection - Types of Injection Systems, Components of Injection System; Electronic Fuel Injection System - Merits and Demerits of EFI System; Multi-Point Fuel Injection (MPFI) System; Functional Divisions of MPFI System; Injection Timing; Group Gasoline Injection System; Electronic Diesel Injection System; Electronic Diesel Injection Control; Numerical problems on mechanical injection system.	
3	**COMBUSTION IN SPARK IGNITION AND COMPRESSION IGNITIION ENGINES** (CLASSROOM MODE)	**09**
	Introduction; Homogeneous Mixture; Heterogeneous Mixture; Combustion in Spark–Ignition Engines; Stages of Combustion in SI Engines; Flame Front Propagation; Factors Influencing the Flame Speed; Rate of Pressure Rise; Abnormal Combustion; The Phenomenon of Knock in SI Engines, Effect of Engine Variables on Knock; Combustion Chambers for SI Engines; Combustion in Compression-Ignition Engines; Stages of Combustion in CI Engines; Factors Affecting the Delay Period; The Phenomenon of Knock in CI Engines; Comparison of Knock in SI and CI Engines; Combustion Chambers for CI Engines.	
4	**ENGINE ELECTRONICS AND SUPERCHARGING** (CLASSROOM MODE)	**07**

	Introduction; Typical Engine Management Systems; Different types of Position Displacement and Speed, Pressure, Temperature, Intake air flow and Exhaust oxygen measurement sensors and transducers; Supercharging – Introduction; Types Of Superchargers – Centrifugal, Root's and Vane Type; Methods of Supercharging - Electric Motor Driven, Ram Effect, Under Piston, and Kadenacy System of Supercharging; Effects of Supercharging; Limitations to Supercharging; Thermodynamic Analysis of Supercharged Engine Cycle; Power Input for Mechanical Driven Supercharger; Gear Driven and Exhaust Driven Supercharging Arrangements; Turbocharging - Charge Cooling; Numerical problems on supercharged engines.	
5	**NON CONVENTIONAL ENGINES** (ONLINE MODE)	**07**
	Introduction; Comprehensive study on working principle, thermodynamic analysis, design, types, advantages and disadvantages of the following types of engines - Common Rail Direct Injection Engine; Dual Fuel and Multi-Fuel Engines; Multi-fuel Engines; Gasoline Direct Injection Engine; Homogeneous Charge Compression Ignition (HCCI) Engine; Lean Burn Engine; Stirling Engine; Stratified Charge Engine; Variable Compression Ratio Engine; Wankel Engine; Hybrid electric vehicle (HEV), Introduction to Electric Vehicle Propulsion Systems, Motors and Controls for Electric Vehicles Applications, Storage technologies for EV, Battery pack and battery management system, Solar powered EVs.	

TEXT BOOKS

1. **Internal Combustion Engines**, V. Ganesan, Tata Mc-Graw Hill Publications,4th Edition, 2012.
2. **A Text Book of Internal Combustion Engines**, R.K. Rajput, Laxmi Publishers, 2007.
3. **Internal Combustion Engines**, M. L. Mathur and R. P. Sharma, Dhanpat Rai Publications, 2014.

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REFERENCE BOOKS

1. **Internal Combustion Engine Fundamentals**, John B. Heywood, Mc-Graw Hill Education India Limited, 2011.
2. **Engineering Fundamentals of the Internal Combustion Engines,** WillardW Pulkrabek. Pearson Education, 2nd Edition, 2015.

COURSE OUTCOMES: On completion of the course, student should be able to:

CO1: Describe the carburetion and working principle of different type of carburettor. (RBTL: 1, 2, 3)

CO2: Explain the fuel injection systems in IC engines. (RBTL: 1, 2, 3)

CO3: Describe the combustion process and select suitable combustion chambers for IC engines. (RBTL: 1, 2, 3)

CO4: Understand the engine electronics and supercharging and solve problems on supercharged engines. (RBTL: 1, 2, 3)

CO5: Differentiate and select non-conventional engines in the context of modern developments. (RBTL: 1, 2, 3)

(RBTL: Revised Bloom's Taxonomy Levels; 1 – Remembering, 2 – Understanding, 3 – Applying, 4 - Analyzing, 5 - Evaluating, 6 - Creating)

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	0	2	0	0	0	0	0	0	2
CO2	3	3	2	0	2	0	2	0	0	0	0	2
CO3	3	3	2	0	2	0	0	0	0	0	0	2
CO4	3	3	3	3	3	0	0	0	0	2	0	2
CO5	3	3	2	1	3	3	3	0	0	2	0	2
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2018-19 ACADEMIC YEAR: 2020-21
SEMESTER : SIXTH

COURSE TITLE : PRODUCTION AND OPERATIONS MANAGEMENT (PROFESSIONAL ELECTIVE - 2)		
Sub Code: 18ME644	**No of Credits =03** **L-T-P-SS::3:0:0:0**	**No. of lecture hours/week : 03** **Total Number of Lecture hours : 39**
Exam Duration : 3 hours	**CIE Marks: 50**	**SEE Marks : 100**
Pre-requisites	Elementary knowledge of calculus and probability	

Course Objective:

1. Develop an understanding of and an appreciation for the production and operations management function in any organization.
2. To understand the importance of productivity and competitiveness to both organizations and nations.
3. To understand the importance of an effective production and operations strategy to an organization.
4. To understand the various production and operations design decisions and how they relate to the overall strategies of organizations.
5. To understand the relationship of the various planning practices of capacity planning, aggregate planning, project planning and supply management.

UNITS	CONTENTS	Hrs.
UNIT- 1	**PRODUCTION & OPERATIONS MANAGEMENT CONCEPTS** (ONLINE TEACHING)	**08**
	Introduction, Historical Development, Operations Management Definition, Production and Manufacturing Systems, Products v/s Services, Productivity, Factors affecting Productivity, International Dimensions of Productivity, The environment of operations, Operational excellence and world class manufacturing practices. OPERATIONS DECISION MAKING: Introduction, Characteristics of decisions, framework for Decision Making, Decision methodology, Decision supports systems, Economic models, Statistical models. (Simple numericals)	
UNIT- 2	**SYSTEM DESIGN & CAPACITY PLANNING**(BLENDED TEACHING)	**08**
	Design capacity, System capacity, and Determination of Equipment requirement. Facility Location and Facility Layout, Location Planning for Goods and Services, Foreign locations and facility layout. (Simple numericals)	
UNIT- 3	**FORECASTING**, **AGGREGATE PLANNING AND MASTER SCHEDULING**(ONLINE TEACHING)	**08**
	Forecasting: Forecasting Objectives and Uses, Forecasting Variables, Opinion and Judgmental methods, Time Series methods, Exponential smoothing, Regression and Correlation methods, Application and Control of Forecasts. (Simple numericals) **Aggregate Planning And Master Scheduling:** Introduction, Planning and Scheduling, Objectives of Aggregate Planning, Aggregate Planning Methods, Master Scheduling Objectives, Master Scheduling Methods. (Simple numericals)	
UNIT- 4	**INVENTORY CONTROL AND MATERIALS MANAGEMENT** (ONLINE TEACHING)	**08**
	Definition and Need, Components Inventory, inventory control. Scope of Materials	

	Management, Material handling, storage and retrieval, purpose of inventories, Dependent and Independent demand, Inventory cost and Order quantities, Inventory classification and counting (Simple numericals)	
UNIT- 5	**MATERIAL, CAPACITY REQUIREMENTS PLANNING AND PURCHASING & SUPPLY MANAGEMENT** (CLASS ROOM TEACHING)	**07**
	Material and Capacity Requirements Planning: Overview: MRP and CRP, MRP: Underlying Concepts, System Parameters, MRP Logic, System refinements, Capacity Management, CRP activities. Concept of continuous improvement of process. (Simple numericals) **Purchasing & Supply Management**: Purchase and supply chain management. Approaches to purchase and supply chain management, make or buy decision, eProcurement, Vender development, rating, and certification.	

TEXT BOOKS:

1. Operations Management, I. B. Mahadevan. Theory and practice, Pearson, 2007.
2. Operations Management, Monks, J.G., McGraw-Hili International Editions, 1987.

REFERENCE BOOKS:

1. Modern Production/Operations Management, Buffa, Wiley Eastern Ltd.2001
2. Production and Operations Management, Pannerselvam. R., PHI. 2002
3. Productions & Operations Management, Adam & Ebert. 2002
4. Production and Operations Management, Chary, S. N., Tata-McGraw Hill. 2002

COURSE OUTCOMES: On completion of the course, student should be able to:

CO1: Appreciate the production and operations management function in any organization.

CO2: Explain importance of productivity and competitiveness to both organizations and nations.

CO3: Explain importance of an effective production and operations strategy to an organization.

CO4: Explain various production and operations design decisions and how they relate to the overall strategies of organizations.

CO5: Explain relationship of the various planning practices of capacity planning, aggregate planning, project planning and supply management.

MAPPING OF COs WITH POs												
COs/POs	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	0	2	0	0	0	0	0	0	2
CO2	3	3	2	1	2	0	2	0	0	0	0	2
CO3	3	3	2	1	2	0	0	0	0	0	0	2
CO4	3	3	3	3	2	2	0	0	0	2	0	2
CO5	3	3	2	1	3	3	3	0	0	2	0	2
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2017-18 ACADEMIC YEAR: 2019-20
SEMESTER : SIXTH

COURSE TITLE : FINITE ELEMENT METHODS (PROFESSIONAL ELECTIVE – 2)		
Sub Code: 18ME645	**No of Credits =03** **L-T-P-SS::3:0:0:0**	**No. of lecture hours/week : 03** **Total Number of Lecture hours : 39**
Exam Duration : 3 hours	**CIE Marks: 50**	**Exam Marks : 100**
Pre-requisites	**Engineering mathematics, MOM, DOM**	

COURSE OBJECTIVES:

1. To impart structures analysis for stress, strain & dynamic loading knowledge
2. To enable formulation of the dimensional structure, mechanical and thermal problems into FEA.
3. To comprehend the basic concepts and enhance capabilities for solving 2 D complex problems.
4. To introduce the concepts of elastic and static analysis problems.

#	CONTENTS	Hrs.
UNIT-1	**INTRODUCTION** (BLENDED TEACHING)	**10**
	General description of Finite Element Method, Geometry, Elements, Node Numbering Schemes, Application and limitations. Equilibrium equations in elasticity. Definitions of FEA and FDM. **Interpolation and One – Dimensional Problems** Euler – Lagrange's equation for bar, beam (cantilever / simply supported fixed) Principle of virtual work, principle of minimum potential energy, Raleigh's Ritz method and Galerkin's method boundary conditions. Interpolation polynomials- Linear, quadratic and cubic, 2D PASCAL's triangle. CST elements-Shape functions. Solutions of bars and stepped bars for displacements, reactions and stresses by using penalty approach and elimination approach. Guass-elimination technique. Applications.	
UNIT-2	**HIGHER ORDER ELEMENTS** (ON-LINE TEACHING)	**08**
	Lagrange's interpolation, Higher order one dimensional elements-Quadratic and cubic element and their shape functions. Shape function of 2-D quadrilateral element-linear, quadric element Iso-parametric, Sub parametric and Super parametric elements.	
UNIT-3	**TRUSSES** (CLASS ROOM TEACHING)	**06**
	2D truss Elements Stiffness matrix of Truss element. Examples illustrating how to obtain various internal force diagrams for different types of structural member like trusses Numerical problems.	
UNIT-4	**BEAMS** (CLASS ROOM TEACHING)	**08**
	Governing Differentia Equation for beam bending Hermite shape functions for beam element, Derivation of stiffness matrix. Numerical problems of beams carrying concentrated, UDL and linearly varying loads.	
UNIT-5	**THERMAL ANALYSIS** (CLASS ROOM TEACHING)	**07**
	Steady state Heat Transfer, One Dimensional Heat Conduction – Governing Equation – Boundary Condition. Temperature Gradient & B matrix functional approach to Heat Conduction – Element Conductivity Matrix. Assembly & Boundary Conditions, Heat Flux Boundary Conditions, Forced and Natural Boundary Conditions – Numerical problems. Simple Problems.	

TEXT BOOKS:

1. **Finite Elements in Engineering**, T.R.Chandrupatla, A.D Belegunde, 3rd Ed PHI.
2. **Finite Element Method in Engineering**, S.S. Rao, 4th Edition, Elsevier, 2006.
3. **Fundamentals of Finite Element Method** by Dr. S. M. Murigendrappa, International Publication – 2nd Edition 2009.
4. **Finite Element Methods by S .B. Halesh , Sapna Book House - Bangalore.**

REFERENCE BOOKS:

1. **"Finite Element Methods for Engineers"** U.S. Dixit, Cengage Learning, 2009.
2. **Concepts and applications of Finite Element Analysis**, R.D. Cook D.S Maltus, M.E Plesha, R.J.Witt, Wiley 4th Ed, 2009
3. **Finite Element Methods**, Daryl. L. Logon, Thomson Learning 3rd edition, 2001.
4. **Finite Element Method**, J.N. Reddy, McGraw -Hill International Edition.

COURSE OUTCOMES: on completion of the course, student should be able to:

CO1: Understand the fundamental concepts of FEM and develop an ability to generate the governing FE equations for systems governed by partial differential Equations.
CO2: Understand the concept of shape and interpolation function for higher order elements.
CO3: Understand and analyze the structural applications of trusses.
CO4: Gain the knowledge and able to do analysis of beam structure subjected to different loading conditions.
CO5: Obtain the ability to understand heat conduction, heat flux and apply the boundary conditions with analysis to solve numerical problems.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	2	1	1	2	2	2	0	3
CO2	3	3	2	3	2	1	1	2	2	2	0	3
CO3	3	3	3	3	2	1	1	2	2	2	0	3
CO4	3	3	2	3	2	1	1	2	2	2	0	3
CO5	3	3	3	3	2	2	1	2	2	2	0	3
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2018-19 ACADEMIC YEAR: 2020-21
SEMESTER : SIXTH

COURSE TITLE : FLUID POWER CONTROL SYSTEMS (PROFESSIONAL ELECTIVE – 1)		
Sub Code: 18ME646	**No of Credits : L-T-P-SS 3:0:0:0 =3**	**No. of lecture hours/week : 03 Total Number of Contact Hours : 39**
Exam Duration : 3 hours	**CIE Marks: 50**	**Exam Marks : 100**
Pre-requisites	**Fluid mechanics**	

COURSE OBJECTIVES:

1. To outline the introductory concepts on fluid power control systems.
2. To explain various types of hydraulic pumps and actuators, and their classification and application.
3. To describe the operation of a complete hydraulic circuit drawn with symbols for all components.
4. To outline the basics of a pneumatic system with its components.
5. To describe the pneumatic control system and various logic devices and pneumatic circuits.

#	CONTENTS	Hrs.
UNIT-1	**INTRODUCTION TO FLUID POWER CONTROL** (BLENDED MODE)	**06**
	Review of fluid mechanics (Pascal's law, continuity equation, Bernoulli's equation, Torricelli theorem, Air-to-hydraulic pressure booster, the siphon); Introduction to fluid power: advantages and applications; Types of fluid power control systems: Environmental issues; Fluids in hydraulic system: fluid properties, general types of fluids; Seals, sealing materials and compatibility with fluids; pipe sizing for flow rate and pressure rating requirement, different pipes, tubing and hoses, quick disconnect couplings; Flow through pipes: Laminar and turbulent, Reynolds number, Darcy equation, frictional losses, equivalent thickness technique; Numerical problems.	
UNIT-2	**HYDRAULIC PUMPS AND ACTUATORS** (CLASSROOM MODE)	**09**
	Introduction, Pumping theory, Classification of pumps, construction and working of Gear pumps, Vane pumps, Piston pumps, fixed and variable displacement pumps, Pump performance characteristics, pump noise, pump selection factors; Accumulators: Types, and applications of accumulators; Types of Intensifiers; Pressure switches /sensor, Temperature switches/sensor, Level sensor; Actuators: Classification, cylinder and hydraulic motors, Hydraulic cylinders, single and double acting cylinder, mounting arrangements, cushioning, special types of cylinders; Construction and working of rotary actuators such as gear, vane, piston motors, and Hydraulic Motor. Theoretical torque, power, flow rate, and hydraulic motor performance; Symbolic representation of hydraulic actuators (cylinders and motors); Numerical problems.	
UNIT-3	**HYDRAULIC CIRCUIT DESIGN AND ANALYSIS** (CLASSROOM MODE)	**09**
	Components and hydraulic circuit design Components: Classification of control valves, Directional Control Valves-symbolic representation, constructional features of poppet, sliding spool, rotary type valves solenoid and pilot operated DCV, shuttle valve, and check valves; Pressure control valves - types, direct operated types and pilot operated types; Flow Control Valves -compensated and non-compensated FCV, needle valve, temperature compensated, pressure compensated, pressure and temperature compensated FCV, symbolic representation; Hydraulic Circuit Design: Control of single and Double -acting hydraulic cylinder, regenerative circuit, pump unloading circuit, counter balance valve application,	

	hydraulic cylinder sequencing circuits, hydraulic circuit for force multiplication; speed control of hydraulic cylinder- metering in, metering out and bleed off circuits. Pilot pressure operated circuits; Hydrostatic transmission; Numerical problems.	
UNIT-4	**INTRODUCTION TO PNEUMATIC CONTROL** (CLASSROOM MODE)	**09**
	Definition of pneumatic system, advantages, limitations, applications, Choice of working medium. Characteristic of compressed air. Structure of Pneumatic control System, fluid conditioners and FRL unit. **PNEUMATIC ACTUATORS:** Linear cylinder - types, conventional type of cylinder r-working, end position cushioning, seals, mounting arrangements- applications. Rod - less cylinders types, working, advantages, rotary cylinders- types construction and application, symbols. **COMPRESSED AIR:** Production of compressed air- preparation of compressed air-driers, filters, regulators, lubricators, distribution of compressed air piping layout.	
UNIT-5	**PNEUMATIC CONTROL VALVES AND CIRCUITS** (ONLINE MODE)	**06**
	DCV such as poppet, spool, suspended seat type slide valve, 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. **SIGNAL PROCESSING ELEMENTS:** Use of Logic gates - OR and AND gates in pneumatic applications. Practical Examples involving the use of logic gates, Pressure dependant controls- types - construction - practical applications, Signal elimination and cascading methods, Time dependent controls principle. Construction, practical applications. **ELECTRO-PNEUMATIC CONTROL:** Principles - signal input and output, pilot assisted solenoid control of directional control valves, relay and contactors. Control circuitry for simple signal cylinder application. Numerical problems on pneumatic circuits.	

TEXT BOOKS

1. **Fluid Power with Applications,** Anthony Esposito, Pearson, 7th Edition, 2013**.**
2. **Hydraulics and Pneumatics,** Andrew Par, Jaico Publishing House, 2005.
3. **Fluid Power: Theory and Applications**, James Sullivan, 3rd Edition, Prentice Hall, 1989.

REFERENCE BOOKS

1. **Oil Hydraulics,** Majumdar, S.R., Tata McGraw-Hill Publications, 2002.
2. **Pneumatic Systems: Principles and Maintenance,** Majumdar, S.R., Tata McGraw-Hill Publications, 2005
3. **Fundamentals of Fluid Power Control,** John Watton, Cambridge University Press, 2012..

COURSE OUTCOMES: On completion of the course, students will be able to:

CO1: *Understand* the fundamental theoretical concepts governing the fluid power. (RBTL: 1, 2, 3)

CO2: *Familiarize* with common hydraulic components (such as pumps, actuators, motors, and valves), their use, symbols and their performance characteristics. (RBTL: 1, 2, 3)

CO3: *Formulate* and *analyse* mathematical models of hydraulic circuits and design them for directional, speed, pressure, force and flow control. (RBTL: 1, 2, 3)

CO4: *Understand* the basics of the structure of a pneumatic system and its components. (RBTL: 1, 2, 3)

CO5: *Familiarize* with the pneumatic control valves and circuits, signal processing elements and electro-pneumatic control circuits. (RBTL: 1, 2, 3)
(RBTL: Revised Bloom's Taxonomy Levels; 1 – Remembering, 2 – Understanding, 3 – Applying, 4 - Analyzing, 5 - Evaluating, 6 - Creating)

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	0	2	0	0	0	0	0	0	2
CO2	3	3	2	0	2	0	2	0	0	0	0	2
CO3	3	3	2	0	2	0	0	0	0	0	0	2
CO4	3	3	3	3	3	0	0	0	0	2	0	2
CO5	3	3	2	1	3	3	3	0	0	2	0	2
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										
3. Each full question shall have maximum of 3 sub-divisions										