B. M. S. COLLEGE OF ENGINEERING, BENGALURU

Autonomous College under VTU

VISION

Promoting prosperity of mankind by augmenting human resource capital through quality technical education & training

MISSION

Accomplish excellence in the field of technical education through education, research and service needs of society

DEPARTMENT OF MECHANICAL ENGINEERING

I to VIII Semester Scheme and Syllabus

With effect from Academic Year 2019 – 20

CONTENTS

DEPARTMENT OF MECHANICAL ENGINEERING

Scheme & Syllabus for UG Programme - I & VIII Semesters

DEPARTMENT VISION

To become a center of excellence in educating students to become successful Mechanical Engineers

DEPARTMENT MISSION

- To empower the students with the fundamentals for a successful career in the field of Mechanical engineering.
- To continue their education through post-graduation, Research & Development.
- To provide service to the society.

PROGRAMME EDUCATIONAL OBJECTIVES

1. PEO1 -Graduates shall have successful careers as Mechanical Engineers, lead & manage teams.
2. PEO2 - Graduates shall be professional in engineering practice and socially responsible
3. PEO3 - Graduates shall be pursuing advanced education, research and engage in the process of life-long learning.

PROGRAMME OUTCOMES

PO 1	Ability to apply knowledge of mathematics, science, and Mechanical engineering fundamentals to solve complex problems in engineering
PO 2	Ability to analyze mechanical engineering problems, interpret data and arrive at meaningful conclusions involving mathematical inferences
PO 3	Ability to design a mechanical system, component, or process to meet desired needs considering public health and safety, and the cultural, societal, and environmental considerations.
PO 4	Ability to understand and solve complex mechanical engineering problems by conducting experimental investigations.
PO 5	Ability to apply appropriate tools and techniques and understand utilization of resources appropriately to complex mechanical engineering activities.
PO 6	Ability to understand the effect of mechanical engineering solutions on legal, cultural, social and public health and safety aspects.
PO 7	Ability to develop sustainable solutions and understand their effect on society and environment.
PO 8	Ability to apply ethical principles to engineering practices and professional responsibilities.
PO 9	Ability to work as a member of a team, to plan and to integrate knowledge of various engineering disciplines and to lead teams in multidisciplinary settings.
PO 10	Ability to make effective oral presentations and communicate technical ideas to a broad audience using written and oral means
PO 11	Ability to lead and manage multidisciplinary teams by applying engineering and management principles.
PO 12	Ability to adapt to the changes and advancements in technology and engage in independent and life-long learning

SCHEME OF INSTRUCTION FOR FIRST YEAR

1st SEMESTER

	Code	Course Title	Credits				Contact Hours	Marks			SEE Hrs
			L	T	P	Tot		CIE	SEE	Tot	
1	18MA1BSEM1	Engineering Mathematics-1	3	1	0	4	5	50	50	100	3
2	18PY1BSPHY	Applied Physics	4	0	1	5	6	50	50	100	3
3	18EC1ESEEE	Elements of Electronics Engineering	3	0	0	3	3	50	50	100	3
4	18ME1ESEME	Elements of Mechanical Engineering	3	0	1	4	5	50	50	100	3
5	18CS1ESCCP	C Programming	3	0	1	4	5	50	50	100	3
6	18HS1NCKAN	Kannada Language	Non-Credit Mandatory Course								
	TOTAL		**16**	**1**	**3**	**20**	**24**	**Total**		**500**	

2nd SEMESTER

	Code	Course Title	Credits				Contact Hours	Marks			SEE Hrs
			L	T	P	Tot		CIE	SEE	Tot	
1	18MA2BSEM2	Engineering Mathematics-2	3	1	0	4	3	50	50	100	3
2	18CY2BSCHY	Engineering Chemistry	4	0	1	5	4	50	50	100	3
3	18EE2ESELE	Basic Electrical Engineering	3	0	1	4	3	50	50	100	3
4	18ME2ESEED	Elements of Engineering Drawing	1	0	2	3	1	50	50	100	3
5	18CV2ESENM	Engineering Mechanics	3	1	0	4	3	50	50	100	3
6	18HS2NCENG	Functional English	Non-Credit Mandatory Course								
	TOTAL		**14**	**2**	**4**	**20**	**14**	**Total**		**500**	

SCHEME OF INSTRUCTION FOR SECOND YEAR

3rd SEMESTER

	Code	Course Title	Credits				Contact Hours	Marks			SEE Hrs
			L	T	P	Tot		CIE	SEE	Tot	
1	19MA3BSEM3	Engineering Mathematics – 3	3	1	0	4	5	50	50	100	3
2	19ME3DCMSM	Material Science and Metallurgy	3	0	1	4	5	50	50	100	3
3	19ME3DCFME	Fluid Mechanics	3	0	0	3	3	50	50	100	3
4	19ME3DCMAP	Manufacturing Processes	3	0	1	4	5	50	50	100	3
5	19ME3DCSOM	Strength of Materials	2	1	0	3	4	50	50	100	3
6	19ME3DCCMD	Computer Aided Machine Drawing	1	1	1	3	5	50	50	100	3
7	19ME3ESBTD	Basic Thermodynamics	3	0	0	3	3	50	50	100	3
8	19IC3HSCPH	Constitution of India, Professional Ethics and Human Rights	1	0	0	1	1	50	50	100	2
	TOTAL		**19**	**3**	**3**	**25**	**31**	**Total**		**800**	

4th SEMESTER

	Code	Course Title	Credits				Contact Hours	Marks			SEE Hrs
			L	T	P	Tot		CIE	SEE	Tot	
1	19MA4BSHEM	Higher Engineering Mathematics	3	0	0	3	3	50	50	100	3
2	19ME4DCMFT	Manufacturing Technology	3	0	1	4	5	50	50	100	3
3	19ME4DCDM1	Design of Machine Elements-1	3	1	0	4	5	50	50	100	3
4	19ME4DCKOM	Kinematics of Machines	2	1	0	3	4	50	50	100	3
5	19ME4DCMMM	Mechanical Measurements & Metrology	3	0	1	4	5	50	50	100	3
6	19ME4DCATD	Applied Thermodynamics	3	0	1	4	5	50	50	100	3
7	20HS4ICEVS	Environmental Studies	1	0	0	1	1	50	50	100	3
8	20HS4MCKAN	Kannada Language	1	0	0	1	1	50	50	100	3
9	19ME4DLNAM	Numerical Applications for Mechanical Engineering Lab	0	0	1	1	2	50	50	100	3
	19ME4NCPDC	**Non-credit mandatory Course** (Personality Development and Communication Skills)									
	TOTAL		**19**	**2**	**4**	**25**	**31**	**Total**		**800**	

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SCHEME OF INSTRUCTION FOR THIRD YEAR
5th SEMESTER

	Code	Course Title	Credits				Contact Hours	Marks			SEE Hrs
			L	T	P	Tot		CIE	SEE	Tot	
1	20ME5DCMAE	Management and Entrepreneurship	2	0	0	2	2	50	50	100	3
2	20ME5DCDOM	Dynamics of Machines	3	0	0	3	3	50	50	100	3
3	20ME5DCDM2	Design of Machine Elements – 2	3	0	0	3	3	50	50	100	3
4	20ME5DCTUM	Turbo Machines	2	0	1	3	4	50	50	100	3
5	20ME5DCCCR	CAD / CAM and ROBOTICS	3	0	1	4	5	50	50	100	3
6	20ME5DCORE	Operations Research	3	0	0	3	3	50	50	100	3
7	20ME5DE ***	Elective – I	3	0	0	3	3	50	50	100	3
8	20ME5DE ***	Elective – II	3	0	0	3	3	50	50	100	3
9	20ME5DCMW1	Mini-Project Work – Phase 1	0	0	1	1	0	50	50	100	3
	20ME5NCYSM	**Non-credit mandatory Course** (Yoga & Stress Management)									
	TOTAL		**22**	**0**	**3**	**25**	**26**	**Total**		**900**	

20ME5DE ***	**ELECTIVE – 1**

	Code	Course Title
1.	20ME5DENTM	Non-Traditional Machining
2.	20ME5DETOE	Theory of Elasticity
3.	20ME5DEIFD	Incompressible Fluid Dynamics
4.	20ME5DERES	Renewable Energy Sources
5.	20ME5DEAMM	Applied Electronics, Microprocessor and Microcontroller
6.	20ME5DESQC	Statistical Quality Control
7.	20ME5DEPYP	Python Programming

20ME5DE ***	**ELECTIVE – 2**

	Code	Course Title
1.	20ME5DESFE	Surface Engineering
2.	20ME5DECMT	Composite Material Technology
3.	20ME5DEICE	Internal Combustion Engines
4.	20ME5DEBHM	Biomechanics of Human Movement
5.	20ME5DEEV1	Electric and Hybrid Vehicles – 1
6.	20ME5DEETF	Experimental Techniques for Incompressible Flow
7.	20ME5DEFMS	Flexible Manufacturing Systems

SCHEME OF INSTRUCTION FOR THIRD YEAR
6th SEMESTER

	Code	Course Title	Credits				Contact Hours	Marks			SEE Hrs
			L	T	P	Tot		CIE	SEE	Tot	
1	20ME6DCMEV	Mechanical Vibrations	3	0	0	3	3	50	50	100	3
2	20ME6DCFHT	Fundamentals of Heat Transfer	2	1	1	4	6	50	50	100	3
3	20ME6DCMFE	Modelling and Finite Element Analysis	3	0	1	4	5	50	50	100	3
4	20ME6DCCOE	Control Engineering	2	1	0	3	4	50	50	100	3
5	20ME6DE ***	Elective – III	3	0	0	3	3	50	50	100	3
6	20ME6DE ***	Elective – IV	3	0	0	3	3	50	50	100	3
7		Open Elective – 1	3	0	0	3	3	50	50	100	3
8	20ME6DLDES	Design Lab	0	0	1	1	1	50	50	100	3
9	20ME6DCMW2	Mini-Project Work – Phase 2	0	0	1	1	0	50	50	100	3
	20ME6NCSNE	**Non-credit mandatory Course** (Social Networking)									
	TOTAL		**19**	**2**	**4**	**25**	**28**	**Total**		**900**	

20ME6DE ***	**ELECTIVE – 3**

	Code	Course Title
1.	20ME6DETOP	Theory of Plasticity
2.	20ME6DEROB	Fundamentals of Robotics
3.	20ME6DECFD	Computational Fluid Dynamics
4.	20ME6DEPOM	Production and Operation Management
5.	20ME6DESTT	Solar Thermal Technologies
6.	20ME6DEPDM	Product Design and Manufacturing
7.	20ME6DEDIM	Digital Manufacturing
8.	20ME6DERPR	R Programming

20ME6DE ***	**ELECTIVE – 4**

	Code	Course Title
1.	20ME6DECIM	Computer Integrated Manufacturing
2.	20ME6DEHRM	Human Resource Management
3.	20ME6DEOPT	Optimization Techniques
4.	20ME6DEEV2	Electric and Hybrid Vehicles – 2
5.	20ME6DEGAD	Gas Dynamics
6.	20ME6DEIOT	Internet of Things
7.	20ME6DEMCL	Machine Learning

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SCHEME OF INSTRUCTION FOR FOURTH YEAR
7th SEMESTER

	Code	Course Title	Credits				Contact Hours	Marks			SEE Hrs
			L	T	P	Tot		CIE	SEE	Tot	
1	20ME7DCMCT	Mechatronics	2	0	1	3	4	50	50	100	3
2	20ME7DCPRM	Project Management	2	0	0	2	2	50	50	100	3
3	20ME7DE ***	Elective – V	3	0	0	3	3	50	50	100	3
4	20ME7DE ***	Elective – VI	3	0	0	3	3	50	50	100	3
5		Open Elective – 2	3	0	0	3	3	50	50	100	3
6	20BI7BSBFE	Biology for Engineers	2	0	0	2	2	50	50	100	3
7	20ME7DCPW1	Project Work – Phase 1	0	0	3	3	0	50	50	100	3
	TOTAL		**15**	**0**	**4**	**19**	**17**	**Total**		**700**	

20ME7DE ***	**ELECTIVE – 5**

	Code	Course Title
1.	20ME7DEHAP	Hydraulics & Pneumatics
2.	20ME7DETED	Tool Engineering Design
3.	20ME7DETRI	Tribology
4.	20ME7DENDT	Non-Destructive Testing
5.	20ME7DEAHT	Advanced Heat Transfer
6.	20ME7DEARB	Advanced Robotics
7.	20ME7DERAC	Refrigeration and Air-conditioning

20ME7DE ***	**ELECTIVE – 6**

	Code	Course Title
1.	20ME7DEADM	Additive Manufacturing
2.	20ME7DEPPE	Power Plant Engineering
3.	20ME7DEHSE	High Speed Flow and Experimental Techniques
4.	20ME7DEFRM	Fracture Mechanics
5.	20ME7DEARI	Artificial Intelligence
6.	20ME7DEAUE	Automotive Engineering
7.	20ME7DECOG	Computer Graphics

SCHEME OF INSTRUCTION FOR FOURTH YEAR
8th SEMESTER

	Code	Course Title	Credits				Contact Hours	Marks			SEE Hrs
			L	T	P	Tot		CIE	SEE	Tot	
1	20ME8HSIPR	Intellectual Property Rights	2	0	0	2	2	50	50	100	3
2		Open Elective – 3	3	0	0	3	3	50	50	100	3
3	20ME8DCSEM	Seminar	0	0	1	1	0	50	50	100	3
4	20ME8DCPW2	Project Work - Phase 2	0	0	10	10	0	50	50	100	3
	TOTAL		**5**	**0**	**11**	**16**	**5**	**Total**		**400**	

III Semester Syllabus

Course		Credits : 04			Marks	
Name	**Engineering Mathematics – 3**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**19MA3BS EM3**	**3**	**1**	**0**	**50**	**50**

PRE-REQUISITES: Basic concepts of trigonometry, trigonometric formulas, methods of differentiation, methods of integration, partial derivatives, solution to ordinary differential equations.

SYLLABUS:

UNIT – 1

Matrices

Introduction: Elementary row transformations, Echelon form of a matrix, rank of a matrix by elementary row transformations. Consistency of a system of linear equations and solution. Solution of a system of non-homogenous equations: Gauss elimination method, Gauss-Seidel method, LU decomposition method. Eigenvalues and eigenvectors of matrices, reduction of a matrix to diagonal form, Rayleigh's Power method. **08 hours**

UNIT – 2

Fourier Series

Introduction: Dirichlet's conditions, Fourier series of a periodic functions of period 2l, Fourier series of functions having points of discontinuity. Applications: Fourier series of typical waveforms-saw toothed waveform, triangular waveform, square waveform, half-wave rectifier, full wave rectifier and modified saw tooth waveform. Practical harmonic analysis. **07 hours**

UNIT – 3

Fourier Transforms

Infinite Fourier transform, Fourier Sine and Cosine transforms, properties, convolution theorem, Inverse transforms. **07 hours**

UNIT – 4

Numerical Solution of Partial Differential Equations

Finite-Difference formulas to partial derivatives. Applications: Solution of one-dimensional heat equation using 2-level formula and Schmidt explicit formula and Crank-Nicolson two-level implicit formula. Solution of one-dimensional wave equation using explicit three level formula and implicit scheme. **07 hours**

UNIT – 5

Calculus of Variations

Variation of a functional, Euler's equation, variational problems.
Applications: Hanging cable problem, Brachistochrone problem, right circular cylinder, Isoperimetric problems. **07 hours**

REFERENCES:

Text Books

1. Higher Engineering Mathematics, B.S. Grewal, 43rd edition, 2014, Khanna Publishers.
2. Advanced Engineering Mathematics, Dennis G. Zill and Cullen, 4th edition, 2011, Jones and Bartlett India Pvt. Ltd.

Reference Books

1. Higher Engineering Mathematics, B.V. Ramana, 7th reprint, 2009, Tata McGraw Hill.
2. Advanced Engineering Mathematics, Erwin Kreyszig, 10th edition Vol.1 and Vol.2, 2014, Wiley-India.

E-Books / Web References

1. Engineering Mathematics, K. A. Stroud, Dexter J. Booth, Industrial Press, 2001 http://books.google.co.in/books/about/Engineering_Mathematics.html?id=FZncL-xB8dEC&redir_esc=y.
2. Advanced Engineering Mathematics, P. V. O'Neil, 5th Indian reprint, 2009, Cengage learning India Pvt. Ltd.
3. http://ocw.mit.edu/courses/mathematics/ (online course material)

MOOCs

1. http://nptel.ac.in/courses.php?disciplineId=111
2. https://www.khanacademy.org/
3. https://www.class-central.com/subject/math (MOOCS)
4. E-learning: www.vtu.ac.in

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Compute solution of a system of algebraic equations.
CO 2	Demonstrate an understanding to Fourier series and Fourier transforms.
CO 3	Demonstrate an understanding to Fourier transforms.
CO 4	Employ analytical techniques to solve partial differential equations with appropriate boundary conditions.
CO 5	Obtain the extremal of a functional.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

To set one question each from units 1, 4, 5 and two questions each from units 2 & 3.

Course		Credits : 04			Marks	
Name	**Material Science and Metallurgy**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**19ME3DC MSM**	**3**	**0**	**1**	**50**	**50**

PRE-REQUISITES:
Concepts of unit cell, space lattice, Unit cells for cubic crystals (Simple cubic, BCC & FCC) and HCP structure and calculations of radius, Coordination Number and Atomic Packing Factor. Miller indices, Point, line, surface defects and volume defects.

SYLLABUS:

UNIT – 1

Mechanical behaviour: Stress strain diagram for ductile and brittle materials, linear and non-linear elastic properties, properties in plastic range, engineering stress-strain and true stress & strain.
Plastic deformation: Slip & twinning, critically resolved shear stress, strain hardening, Bauschinger's effect, strain ageing, recovery, recrystallization and grain growth.
Properties of materials: Magnetic and optical
Diffusion in solids: Diffusion Mechanism, Fick's laws of diffusion, factors affecting diffusion **07 Hours**
Fracture: Brittle and ductile fracture, Griffith's criterion.
Creep: Creep curve, creep mechanism, factors affecting creep and creep test.
Fatigue: Fatigue cycles, fatigue test, SN curve, fatigue mechanism, factors affecting fatigue life**.** **04 Hours**

UNIT – 2

Solidification - Nucleation and grain growth in pure metals and alloys.
Solid solutions: Types of solids solutions, Hume-Rothery rules for governing the formation of solid solutions and intermediate phases
Cooling curves and phase diagrams: Construction of phase diagrams, Gibbs phase rule and Lever rule, phase diagrams of Isomorphous, Eutectic, Eutectoid, Peritectic and Peritectoid systems. Problems on Isomorphous and Eutectic systems. **06 Hours**

UNIT – 3

Iron – Iron carbide equilibrium diagram: Equilibrium phases, invariant reactions, critical temperatures, slow cooling of steels (hypo, hyper and eutectoid steels).
TTT diagram: Construction of TTT diagram, TTT diagram for eutectoid, hypo and hyper eutectoid steels, continuous cooling curves. Effect of alloying elements on steels.
06 Hours

UNIT – 4

Heat treatment processes: Annealing and its types, normalizing, hardening, tempering, martempering, austempering, surface heat treatment methods and heat treatment of non-ferrous materials (dispersion hardening and precipitation hardening) **05 Hours**

Ferrous materials and Non-ferrous materials:
Composition, properties, and its applications of low and high carbon steels, alloy steels & cast irons (grey, malleable, nodular and white)
Smart materials: Heusler alloys: Composition, properties and its applications,

Polymers: Properties, types and applications, **Ceramics:** Properties, types and applications **06 Hours**

UNIT – 5

Composite Materials: Definition, classification. Properties and applications of FRPs, MMCs and Ceramic composites.

Production methods of FRPs (Pultrusion, filament winding, hand lay-up, autoclave/ vacuum bag processes and spray forming processes) and MMCs (powder metallurgy, stir casting, squeeze casting and in-situ methods). **05 Hours**

REFERENCES:

Text Books

1. Materials Science & Engineering- An Introduction William D. Callister Jr. Wiley India Pvt. Ltd.
2. Foundation of Material Science and Engineering, Smith, McGraw Hill

Reference Books

1. Introduction to Material Science for Engineering, James F. Shackel ford. Pearson, Prentice Hall.
2. Materials Science & Engineering, V. Raghavan, Prentice Hall.
3. Mechanical Metallurgy, George E Dieter, McGraw Hill.
4. Material Science and Metallurgy, O P Khanna, Dhanpat Rai publications.
5. Physical Metallurgy Principles, Robert. E. Reed-Hill.
6. Theory of Heusler and Full-Heusler Compounds, Iosif Galanaki, Springer Series in Materials Science book series (SSMATERIALS, volume 222)

E-Books / Web References

1. Material Science, R.D. Rawlings, CRC Press, 2004 (http://link.springer.com/book/10.1007%2F978-1-4899-6826-5)
2. Material Science and Engineering, V. Raghavan, PHI, 2004. (http://phindia.com/bookdetails/materials-science-and-engineering-raghavan-v--isbn-978-81-203-5092-2)
3. http://nptel.ac.in/courses/Webcourse-contents/IIScBANG/Material%20Science/New_index1.html
4. http://www.intechopen.com/books/materials-science-advanced-topics
5. Material Science, S. L Kakani, Amit Kakani, New Age International Publishers (https://iimtstudies.files.wordpress.com/2014/03/material-sciencekakani-2004.pdf)

MOOCs

1. https://legacy.saylor.org/me203/Intro/
2. https://courses.edx.org/courses/MITx/3.032x/3T2014/courseware/fa156567e80a483ab833f2b1a581923c/8a344b60a6c04f8da5ebda9a0a7c402e/

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

To set one question each from units 2, 3 and 5 and two questions each from units 1 and 4.

Material-Testing LAB

List of Experiments

1. Tensile, Shear and Compression tests of metallic specimen using Universal Testing Machine
2. Torsion test, Bending test on metallic specimen

3. Izod and Charpy test on various specimens
4. Brinell and Vicker's hardness test on various specimens
5. Examination of different engineering materials. Identification of microstructures of Plain Carbon Steel, Tool Steel, Gray Cast Iron, SG Iron, Brass, Bronze, Aluminium alloys and composites.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Select appropriate materials based on applications through the knowledge of micro-structure and properties of metals & composites.
CO 2	Compute phase change parameters in isomorphous & eutectic systems.
CO 3	Identify appropriate transformation process to obtain required material properties.
CO 4	Choose appropriate heat-treatment process fulfilling given criteria.
CO 5	Determine the Mechanical properties of materials and Micro structure by conducting experimental investigations.

Course		Credits : 03			Marks	
Name	**Fluid Mechanics**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**19ME3DC FME**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
1. Vector Calculus
2. Engineering Mechanics

SYLLABUS:

UNIT – 1

Fluid Pressure and its Measurements: Concept of continuum, Newton's law of viscosity, Pascal's law, hydrostatic Law, manometry (simple, differential, inverted and inclined manometers), numericals. **05 Hours**

UNIT – 2

Hydrostatic Forces on surfaces: Concepts of center of pressure along a horizontal plane, vertical plane and inclined plane surface submerged in static fluid, numericals.
Buoyancy and Stability: Buoyancy, center of buoyancy, meta center and meta centric height (analytical method), Stability of immersed and floating bodies, numericals.
05 Hours

UNIT – 3

Fluid Kinematics and Dynamics: Types of flows, Eulerian and Lagrangian representation, Continuity equation in 3D (Cartesian coordinate only), velocity and acceleration fields, stream lines, streak lines, time line and path lines, material derivative, linear motion and deformation, angular deformation, vorticity, numericals.
Newton's second law along a streamline and normal to streamline, Euler equation of motion and reduction to Bernoulli equation, Venturi meter, Orifice meter and Pitot tube, Navier Stokes equation, numericals. **12 Hours**

UNIT – 4

Impact of jets: Force exerted on stationary and moving plates- vertical, inclined and curved (symmetrical) , numericals.
Viscous flow through pipes: Major losses, minor (no derivation) losses, Hagen Poiseuille equation, numericals.
Introduction to External flows: Drag and Lift, Friction and pressure drag, numericals
12 Hours

UNIT – 5

Dimensional Analysis: Rayleigh's method, Buckingham Π theorem, dimensionless numbers (Reynolds Number, Mach number, Froude Number, Weber's Number, Knudsen Number), numericals. **05 Hours**

REFERENCES:

Text Books

1. Fundamentals of Fluid Mechanics by Munson, Young, Okiishi, Huebsch, 6th Edition, Wiley publications.
2. Fluid Mechanics-Fundamentals & Applications by Yunus A Cengel and John A Cimbala, 3nd Edition, Tata McGraw Hill.

Reference Books

1. A text book of Fluid Mechanics and Hydraulic Machines by Dr. R K Bansal, Laxmi Publications (P) Ltd,

2. Fluid Mechanics, Hydraulics and Fluid Machines by Ramamrutham, Dhanpat Rai Publications.
3. Introduction to Fluid Mechanics by Fox and MacDonald, 8th Edition, Wiley India.

E-Books / Web References

1. http://nptel.ac.in/courses/112104118/
2. http://nptel.ac.in/courses/112105171/

MOOCS

1. http://www.mooc-list.com/course/fluid-mechanics-saylororg
2. https://legacy.saylor.org/me201/Unit01/

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Apply the concepts of fluid mechanics, pressure distribution and buoyancy to determine the static forces of the fluids.
CO 2	Analyse external & internal flows for evaluating various flow-parameters.
CO 3	Perform dimensional analysis to formulate mathematic model.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

To set one question each from units 1, 2 and 5 and two questions each from units 3 and 4.

Course		Credits : 04			Marks	
Name	**Manufacturing Processes**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**19ME3DC MAP**	**3**	**0**	**1**	**50**	**50**

PRE-REQUISITES:
1. Elements of Mechanical Engineering
2. Engineering Physics

SYLLABUS:

UNIT – 1

Manufacturing process: Introduction to basic manufacturing, Classification of manufacturing process, Applications.
Metal Casting: Introduction about metal casting, steps involved in making casting, Advantages and limitations, Applications.
Pattern making: Functions of pattern, Classification of pattern, Different pattern materials, various pattern allowances in design of pattern, Simple problems in design of pattern.
Mould making: Moulding sand ingredients, Types of moulds, Mould making, Desirable properties of Sand mould, functions of cores, important factors in core design and making.
09 Hours

UNIT – 2

Gating system: Concept of gating system, different types of gating systems, gating system design, risering design, numericals on gating and risering design.
Solidification: Introduction to solidification, Progressive and directional solidification, solidification variables, methods of achieving directional solidification.
Special casting processes: Shell moulding, investment casting, Gravity die casting, Pressure die casting, Centrifugal casting, Slush casting, Continuous casting, Injection moulding.
Defects in casting: Introduction, types of defects, causes and remedies. **11 Hours**

UNIT – 3

Welding: Weldability, Different types of weld joints, TIG Welding & MIG Welding, Laser Beam Welding, Friction stir welding, Explosive welding, Resistance welding, Thermit welding.
Metallurgical aspect of Welding: Metallurgical effects of welding, weld metal solidification, formation of different weld zones, Weld cracking, Corrosion of weld, defects in welding & remedies. **07 Hours**

UNIT – 4

Powder Metallurgy: Introduction to powder metallurgy, Preparation of powders (Atomization, Electrolysis, and Granulation Process, Mechanical Alloying), Powder Blending, Powder Compaction, Sintering. Finishing operations, application of powder metallurgy products, advantages and limitations.
Special Techniques in Powder Metallurgy: Powder forging, Powder Extrusion, Powder deposition techniques and its applications. **05 Hours**

UNIT – 5

Rapid Prototyping: Introduction to RP and advantages and limitations, Applications, Stereo lithography Apparatus (SLA), Fused Deposition Modeling, Laminated Object Manufacturing, Selective Laser Sintering, Laser Engineered Net Shaping (LENS).
06 Hours

REFERENCES:

Text books

1. Foundry Technology, O.P. Khanna, Dhanpat rai publications (P)-2003 reprint.
2. Manufacturing Technology: Foundry, Forming and Welding, P N Rao, 2nd Edition Tata Mc Graw-Hill publishing company Limited.

References

1. Manufacturing technology, Swaroop Kalpak Jain, Steuen R. Schmid, Pearson Education Asia, 5th Ed.2006.
2. Principles of metal casting, Richard W Heine, Carl R Loper, Philip C Rosenthal, Tata McGraw-Hill, 2002.
3. Workshop Technology, Vol-1, H.K Hajara Choudhary, 12th Edition, MPP Publisher, 2001.
4. Welding Technology, O.P Khanna, Dhanpat Rai, 2001.
5. Manufacturing Process-1, K Radhakrishana, Sapna.
6. Powder Metallurgy Technology, G. S. Upadhyaya, Cambridge International science publishing
7. Rafiq I. Noorani, Rapid Prototyping, "Principles and Applications", Wiley & Sons, 2006.

E-Books / Web References

1. Principles of foundry technology, 4th edition, P L Jain, Tata McGraw Hill, 2006. (https://books.google.co.in/books?id=NOotk64Grx0C&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false)
2. Advanced Welding Processes technology and process control, John Norrish, Wood Head Publishing, 2006. (http://www.elcoweld.com/files/editor/downloads/elmi/AWP1.pdf)
3. http://www.astm.org/DIGITAL_LIBRARY/STP/SOURCE_PAGES/STP494.htm
4. http://efoundry.iitb.ac.in/Academy/index.jsp
5. http://nptel.ac.in/courses/112107145/
6. https://link.springer.com/book/10.1007/978-1-4419-1120-9

Scheme of Examination (SEE):

SEE: Answer five full questions selecting one from each unit.

Two questions each to be set from unit 1 & 2 and One question each from unit 3, 4 & 5.

Foundry and Sand Testing Lab

List of Experiments

Part A:

Testing of molding sand and core sand

1. Compression, shear and permeability tests on green sand specimen
2. Tension and bending tests on core sand specimen
3. Sieve analysis to find grain fineness number of base sand
4. Clay content test

Part B:

1. Use of foundry tools and other equipments
2. Preparation of moulds using two moulding boxes with and without Patterns (Split pattern, Core boxes)
3. Production of metal component using sand casting

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Classify primary manufacturing processes, such as casting, welding, powder metallurgy and Rapid Prototyping
CO 2	Analyze and select suitable sand ingredients, gating system, mould and calculate the dimensions on sand mold.
CO 3	Assess the defects in casting and welding by analyzing the microstructure
CO 4	Identify real time applications of special casting process, Powder Metallurgy, welding and Rapid Prototyping in industries.
CO 5	Select different processes of Rapid prototyping for given applications used in various industries.
CO 6	Design the sand mould as per given drawing.
CO 7	Demonstrate the process of mould making.

Course		Credits : 03			Marks	
Name	**Strength of Materials**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**19ME3DC SOM**	**2**	**1**	**0**	**50**	**50**

PRE-REQUISITES:
1. Engineering Mechanics - Statics
2. Engineering Mathematics - Calculus

SYLLABUS:

UNIT – 1

Simple stress and strain: Introduction, stress, strain, mechanical properties of materials, Linear elasticity, Hooke's Law and Poisson's ratio, stress-strain behaviour in tension for mild steel and non-ferrous metals. extension / shortening of a bar, bars with cross sections varying in steps, bars with continuously varying cross sections (circular and rectangular), principle of super position. elongation due to self-weight for constant cross section, simple shear stress, shears strain, elastic constants and their relations. Stress in composite section subjected to external loads and temperature change, volumetric strain. **(5L + 3T)**

Compound stresses: Introduction, plane stress, stresses on inclined sections, principal stresses and maximum shear stresses, graphical method - Mohr's circle for plane stress. **(2L + 2T)**

UNIT – 2

Bending moment and Shear forces in beams: Introduction, types of beams, loads and reactions, shear forces and bending moments, rate of loading, sign conventions, relationship between shear force and bending moments, shear force and bending moment diagrams for different types of beams subjected to concentrated loads, uniformly distributed load, uniformly varying load & external moment. **(4L + 3T)**

UNIT – 3

Bending and shear stresses in beams: Introduction, theory of simple bending, assumptions in simple bending, relationship between bending stresses, radius of curvature and bending moment, moment carrying capacity of a section, shearing stresses in beams, shear stress across rectangular, circular. **(4L + 1T)**

Deflection of beams: Introduction, differential equation for deflection, equations for deflections, slope and moments, double integration method for cantilever and simply supported beams for point loads, UDL and couple, Macaulay's method. **(3L + 1T)**

UNIT – 4

Torsion of circular shafts: Introduction, pure torsion, assumptions, derivation of torsional equations, polar modulus, torsional rigidity / stiffness of shafts, power transmitted by solid and hollow circular shafts**.** **(3L + 1T)**

UNIT – 5

Thick and Thin cylinders: Stresses in thin cylinders, Lame's equation for thick cylinders subjected to internal and external pressures, Changes in dimensions of cylinder (diameter, length and volume), simple numericals. **(3L + 1T)**

Columns and Struts: Introduction, Euler's formula for critical load of columns for different end conditions, limitations of Euler's theory, Rankine's formula. simple numericals. **(2L + 1T)**

REFERENCES:

Text Books

1. Mechanics of Materials, S.I. Units, Ferdinand Beer & Russell Johnstan, 7th Ed, TATA McGrawHill-2014

2. Mechanics of Materials, K.V.Rao, G.C.Raju, Subhash Stores, First Edition, 2007

Reference Books

1. Strength of Materials, S. S. Bhavikatti, Vikas Publishing House-Pvt. Ltd., 4th Ed. 2013
2. A Text book of Strength of Materials, R. K. Bansal, Laxmi Publications, 2010.
3. Strength of Materials, W. A. Nash, Schaum's Outline Series, Fourth Edition-2007
4. Mechanics of Materials, R. C. Hibbeler, Prentice Hall, Pearson Edu., 2005

E-Books / Web References

1. Statics and Strength of Materials, Shehata, 2nd edition, 1994. (http://www.astm.org/DIGITAL_LIBRARY/JOURNALS/TESTEVAL/PAGES/JTE12637J.htm)
2. http://www.astm.org/DIGITAL_LIBRARY/JOURNALS/TESTEVAL/PAGES/JTE12637J.htm
3. http://www.freeengineeringbooks.com/Civil/Strength-of-MaterialBooks.php

MOOCs

1. https://www.edx.org/course/mechanical-behavior-materials-mitx-3-032x
2. https://mitopencourseware.wordpress.com/2013/02/27/new-mitx-mooc-2-01x-elements-of-structures/

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Compare and choose appropriate materials for given applications.
CO 2	Investigate various structural members subjected to different loading conditions for determination of stresses & strains.
CO 3	Evaluate mechanical properties of cylindrical shafts subjected to torsional loads.
CO 4	Analyse cylindrical pressure vessels under various loadings.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

Two questions each to be set from Units 1 and 3 and one question from units 2, 4, and 5.

Course		Credits : 03			Marks	
Name	**Computer Aided Machine Drawing**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**19ME3DC CMD**	**1**	**1**	**1**	**50**	**50**

SYLLABUS:

UNIT – 1

Sections of Solids: Sectioning, Sectional views, Representation of section plane, Hatching, Sectioning of engineering objects when the axis is inclined to one plane of projection and parallel to the other. Solids involving Square, Pentagonal, Hexagonal prisms, Square, Pentagonal, Hexagonal pyramids, Cylinder, Cone and Tetrahedron. **(2 L + 4 T) Hours**

UNIT – 2

Assembly Drawing:
CONVENTIONS: Conventional representation of details in machine drawing- drilled and tapped holes, countersunk and counter bored holes, internal and external threads, undercuts, grooves, chamfers, fillet radii and keyways. Conventions to represent standard components-bolts, nuts, washers, screws, cotters, pins, circlips, bearings, gears, springs and flanges.
FITS AND TOLERANCES: Limits, fits and tolerances-need, types, representation of tolerances on drawing, Geometric tolerance-uses, types of form and position tolerances, symbols, method of indicating geometric tolerances on part drawings. Surface finish symbols- methods of indicating the surface roughness. **(2 L) Hours**

Assembly of – Plummer block, Machine vice, Tail stock, Gear pump, Ram's bottom safety valve, Petrol engine connecting rod. **(9 L + 22 T) Hours**

LAB: Using Computer Aided Software (2 Hours Per week**)**
Part modeling using a CAD software-extracting views and sections, calculation of mass and section properties.
Assembly of parts, creation of bill of materials and extraction of views of the following assemblies in 3D using software.
(a) Socket and Spigot cotter joint
(b) Protected type flanged coupling
(c) Screw Jack
(d) Machine vice
(e) Plummer block

REFERENCES:
Text Books
1. **Machine Drawing** by K.R. Gopalkrishna, 20th Edition, Subhas stores, 2007.
2. **Machine Drawing** by N. D. Bhat & V. M. Panchal, 42nd Edition, Charotar Publishing House, 2007.

Reference Books
1. **SOLIDWORKS 2018: Basic Tools** by Paul Tran CSWE, CSWI, SDC Publications.
2. **SOLIDWORKS 2018: Intermediate Skills** by Paul Tran CSWE, CSWI, SDC Publications.

E-Books / Web References
1. https://grabcad.com/library
2. **50 SolidWorks Exercises: Learn by Practicing**, by Mason Ilic,
3. **Solidworks 2018 Learn by doing - Part 1**, by Tutorial Books

MOOCS

1. **SOLIDWORKS Training and Tutorials**, Lynda.com

CIE:

Test 1: Unit 1 + Machine drawing Conventions (Manual Drafting)...10 Marks
Test 2: Unit 2 (Assemblies - Manual Drafting).....20 Marks
Test 3: Lab (CAD Modeling).....20 Marks
Split – up of Marks

Theory			**Lab**			**Grand Total**
Test	Sheet Submission	Total	Test	Assignment	Total	
Average of T1 & T2 15	10	25	20	05	25	50

Scheme of Examination (SEE): 03 Hours (Manual Drafting)

Unit 1 → 20 Marks
Unit 2 → Assembly Drawing (2 Principal views) → 80 Marks.
Examiner to set one question each from Units 1 & 2 (reference: Text-book 1 only).

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Choose appropriate views to give information about machine parts.
CO 2	Apply drawing conventions to communicate design intent unambiguously.
CO 3	Sketch sectional views to reveal interior features of machine parts to enhance clarity.
CO 4	Identify relationships of each part to the others in assemblies
CO 5	Construct assembly drawings showing all parts in their operational positions
CO 6	Create geometric models of mechanical parts and assemblies employing CAD tool.

Course		Credits : 03			Marks	
Name	**Basic Thermodynamics**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**19ME3ES BTD**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
1. Engineering Mathematics
2. Engineering Physics
3. Engineering Chemistry

SYLLABUS:

UNIT – 1

Fundamentals: Macroscopic and Microscopic approaches, Thermodynamic system, control volume, properties, state and process, cycles, Thermodynamic Equilibrium, Quasi-static process. **02 Hours**

Temperature: Thermal Equilibrium, Zeroth Law, Measurement of Temperature, Reference points, Ideal gas Temperature scale, Celsius Temperature scale and International Practical Temperature scale. **03 Hours**

Work & Heat: Exact and inexact differentials, Thermodynamic definition of Work: examples, displacement work, work as a path function, different forms of work transfer, Heat: definition of heat, heat as a path function, Specific heats, and examples of work and heat interactions. **05 hours**

UNIT – 2

First Law of Thermodynamics: First law for cyclic and non-cyclic processes, concept of total energy and energy as the property of a system, various modes of energy, internal energy and enthalpy, Steady Flow Energy Equation (SFEE), Examples of steady flow processes, PMM-1, Limitations of the First Law. **06 hours**

UNIT – 3

Second Law of Thermodynamics: Definition of direct and reversed heat engine (Refrigerator and heat pump), definition of thermal efficiency and COP, Kelvin-Planck and Clausius statements, Equivalence of Kelvin-Planck and Clausius statements, Reversibility and Irreversibility, Causes for Irreversibility, Carnot cycle, Absolute Thermodynamic Temperature scale. **06 hours**

Entropy: Clausius inequality, Definition of entropy, entropy as a property, Two reversible adiabatic paths cannot intersect each other, Entropy change in reversible and Irreversible process, Principle of increase of entropy, Illustration of process on T-s diagram, Entropy generation in a closed system and open system, First and Second Laws combined relations. **05 hours**

UNIT – 4

Availability and Exergy: Available and unavailable energy, concept of availability, availability of heat source at constant and variable Temperatures, Dead state, Exergy balance equation and Exergy analysis for non-flow and steady flow systems, Helmholtz and Gibbs function, second law efficiency. **07 hours**

UNIT – 5

Ideal and Real gases: Definition of Ideal gas, equation of state, internal energy and enthalpy as functions of Temperature, universal and particular gas constants, perfect and

semi-perfect gases. For various quasi-static processes: Evaluate heat, work, and change in internal energy, enthalpy and entropy. Definition of Real gas, Vander Waal's Equation and its constants in terms of critical properties, law of corresponding states, compressibility factor and chart. **05 hours**

REFERENCES:

Text Books

1. Basic and Applied Thermodynamics, P. K. Nag, 2nd Edition, Tata McGraw Hill, 2009
2. Thermodynamics: An Engineering Approach, Yunus A. Cengel and Michael A. Boles, 8th Edition, Tata-McGraw Hill Pub, 2016.
3. Fundamentals of Thermodynamics, Gordon J. Van Wylan & Richard E. Sonntagg, 7th Edition, Wiley Eastern Ltd, 2009.
4. Engineering Thermodynamics, Rajput, 4th Edition, Laxmi Publications, 2010
5. Engineering Thermodynamics, Achuthan, 2nd Edition, Phi Learning publications, 2009.

E-Books / Web References

1. Engineering Thermodynamics, Achuthan, 2nd Edition, Phi Learning, 2009
2. Fundamentals of Engineering Thermodynamics, Rathakrishnan, 2nd Edition, Phi Learning, 2005
3. http://nptel.ac.in/courses/112104113/
4. http://nptel.ac.in/courses/112108148/
5. http://nptel.ac.in/courses/112105123/

MOOCs

1. https://www.coursera.org/course/introthermodynamics
2. https://www.iitbombayx.in/courses/IITBombayX/ME209xA15/2015_T1/about
3. https://legacy.saylor.org/me103/Intro/

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Apply the energy balance to thermodynamic systems involving heat and work interactions to determine thermodynamic properties.
CO 2	Evaluate the performance of energy conversion devices undergoing a thermodynamic process or cycle and entropy of system.
CO 3	Analyze a thermodynamic system for Availability & Irreversibility
CO 4	Estimate the properties of systems employing ideal and real gases as working fluids

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

Two questions each to be set from units 1 & 3 and one question each from units 2, 4 & 5.

IV Semester Syllabus

Course		Credits : 03			Marks	
Name	**Higher Engineering Mathematics**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**19MA4BS HEM**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES: Trigonometric formulas, methods of differentiation, methods of integration, partial derivatives. Basic concepts in Probability, discrete random variable, Binomial distribution.

SYLLABUS:

UNIT – 1

Numerical Methods

Solution of algebraic and transcendental equations: Newton-Raphson method. Finite Differences and interpolation: Forward differences, backward differences. Newton- Gregory forward interpolation formula, Newton-Gregory backward interpolation formula, Lagrange's interpolation formula, Lagrange's inverse interpolation. Numerical integration: Simpson's 1/3rd, Weddle's rule. Numerical solution of ordinary differential equations: Runge-Kutta method of fourth order.

Applications: Application of numerical methods to engineering problems. **7 hours**

UNIT – 2

Complex Analysis 1

Function of a complex variable, limits, continuity and differentiability of a complex valued function, Analytic functions, properties of analytic functions, Cauchy-Riemann equations in cartesian and polar form, construction of analytic functions by Milne-Thomson method, Conformal mapping - Transformations - $w = z^2$ and $w = z + \frac{a^2}{z}\ (z \neq 0)$, Bilinear transformations. **7 hours**

UNIT – 3

Complex Analysis 2

Complex integration: Line integral, Problems on line integral, Cauchy's theorem, Cauchy's integral formula.

Complex series: Taylor's, Maclaurin's and Laurent's series (without proof).

Zeros, Poles and Residues: Residue theorem (without proof) **7 hours**

UNIT – 4

Statistics and Probability

Curve fitting – Principle of least squares, fitting a straight line, fitting of a parabola, fitting of exponential curves of the form $y = a\ b^x$, $y = ae^{bx}$. Correlation and regression.

Probability distributions: Discrete distribution - Poisson distribution. Continuous distribution-normal distribution. **7 hours**

UNIT – 5

Joint Probability Distributions

Discrete random variable, Mathematical expectation, Covariance and Correlation.

Markov Chain

Markov Chain, Probability vectors, stochastic matrices, fixed point vector, regular stochastic matrices. Higher transition probabilities, stationary distribution of regular Markov chains. **7 hours**

REFERENCES:

Text Books

1. Advanced Engineering Mathematics, R.K. Jain, S. R. K. Iyengar, 4th edition, 2014, Narosa Publishers.
2. Higher Engineering Mathematics, B.S. Grewal, 43rd Edition, 2014, Khanna Publishers.

Reference Books

1. Advanced Modern Engineering Mathematics, Glyn James, 3rd edition, 2004, Pearson Education.
2. Advanced Engineering Mathematics, Erwin Kreyszig, 10th edition, vol.1, vol. II, 2014, Wiley-India
3. Higher Engineering Mathematics, B.V. Ramana, 2007, Tata McGraw Hill.
4. Numerical methods for Scientific and Engineering Computation, M. K. Jain, S.R. K Iyengar, R. K. Jain, 5th edition, 2008, New Age International (P) Limited Publishers.

E-Books / Web References

1. Engineering Mathematics, K. A. Stroud, Dexter J. Booth, Industrial Press, 2001 http://books.google.co.in/books/about/Engineering_Mathematics.html?id=FZncL-xB8dEC&redir_esc=y.
2. Advanced Engineering Mathematics, P. V. O'Neil, 5th Indian reprint, 2009, Cengage learning India Pvt. Ltd.
3. http://ocw.mit.edu/courses/mathematics/ (online course material)

MOOCs

1. http://nptel.ac.in/courses.php?disciplineId=111
2. https://www.khanacademy.org/
3. https://www.class-central.com/subject/math (MOOCS)

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Calculate numerical solutions of algebraic equations, transcendental equations and ordinary differential equations.
CO 2	Construct analytic functions and evaluate real and complex integrals.
CO 3	Apply the principles of least squares to fit a straight line, parabolic and exponential curve for a given data.
CO 4	Estimate the relation between two variables and perform regression analysis.
CO 5	Apply the basic principles of probability and probability distributions.
CO 6	Obtain the probability of an event using discrete and continuous distributions, including then-step transition probability. Analyse and classify simples states (Recurrent/transient)

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

To set one question each from units 2, 4, 5 and two questions each from units 1 & 3.

Course		Credits : 04			Marks	
Name	**Manufacturing Technology**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**19ME4DC MFT**	**3**	**0**	**1**	**50**	**50**

PRE-REQUISITES:
1. Elements of Mechanical Engineering
2. Engineering Physics
3. Strength of Materials

SYLLABUS:

UNIT – 1

Introduction to metal forming: Introduction to forging types & operations, forging die design parameters, Forging hammers & presses, Applications of forging, Defects in forged components.
Introduction to rolling: Roll mill configurations, geometrical relationships, process variables, Applications of rolling, defects in rolled components.
Introduction to Extrusion: Types of extrusion, process variables, deformation pattern, production of seamless tubes & pipes using Mannesmann mill and reeling mill, Defects in extruded products. **11 Hours**

UNIT – 2

Introduction to Sheet metal forming: Shearing (blanking, piercing, punching, nibbling, lancing, notching) and non - shearing (bending, stretching, spinning, embossing, coining, drawing), operation & applications of stretch forming & deep drawing, defects in sheet metal formed components, simple numericals to estimate the force requirement in punching.
Introduction to High Energy Rate Forming: operation & applications of explosive forming, Electro hydraulic forming & Electromagnetic forming. **05 Hours**

UNIT – 3

Theory of Metal Cutting: Single point cutting tool nomenclature, Merchants circle diagram and simple problems. Tool wear, tool life, Taylor's tool life equation, effects of cutting parameters on tool life, cutting tool materials, Properties of cutting fluids.
Production Lathe: Specification, Capstan & Turret lathe - constructional features, tool & work holding devices. Simple numerical on machining time.
Shaping, Slotting and Planing Machines Tools: Driving mechanisms of Shaper, Slotter and Planer. Operations done on Shaper, Planer & Slotter. Difference between shaping and planning operations. **08 Hours**

UNIT – 4

Drilling Machines: Constructional features (Radial & Bench drilling Machines), operations, types of drill & drill bit nomenclature. Calculation of machining time.
Milling Machines: constructional features (Column and knee and vertical Milling Machine), milling cutters nomenclature, milling operations, calculation of machining time.
Indexing: Simple, compound, differential and angular indexing calculations. Simple numerical on indexing.
Grinding: Abrasives and bonding, mounting, truing and dressing of grinding wheels. Introduction to lapping and honing. **10 Hours**

UNIT – 5

Non-traditional machining processes: Principle, equipment, operation & applications of Ultrasonic Machining, Abrasive Water Jet Machining, Electro Discharge Machining, Electro Chemical Machining, Laser Beam Machining. **05 Hours**

REFERENCES:
Text books
1. Workshop technology, Hazara Choudhry, Vol-II, Media Promoters & Publishers Pvt ltd

2004
2. Production Technology, R.K Jain, Khanna Publications, 2003
3. Mechanical Metallurgy, George E. Dieter, McGraw Hill, Third edition.
4. Workshop technology, B S Raghuwanshi, Vol-II, Dhanpat Rai & Publishers Co.

Reference Books

1. Production Technology, HMT, Tata McGraw Hill, 2001.
2. Fundamentals of Metal machining and machine tools by G. Boothroyd, McGraw Hill, 2000
3. Manufacturing Science by Amitabha Ghosh and Malik, affiliated East west press, 2003.

E-Books / Web references

1. Fundamentals of machining and machine tools,3rd edition, Geoffrey Boothroyed and Winston A. Knight, Taylor & Francis Group, 2006 (Link:https://books.google.co.in/books?id=Y0cRCFalmekC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false)
2. Nontraditional Machining Processes, J. Paulo Davim, Aveiro, Portugal, February 2013 (Link:http://www.springer.com/us/book/9781447151784http://nptel.ac.in/courses/112105127/)
3. http://www.astm.org/DIGITAL_LIBRARY/MNL/SOURCE_PAGES/MNL11.htm
4. http://www.astm.org/DIGITAL_LIBRARY/JOURNALS/COMPTECH/PAGES/CTR10654J.htm

MOOCs

1. http://nptel.ac.in/courses/112105126/

Scheme of Examination (SEE):

Answer FIVE full questions, each of 20 marks.
To set two questions each from Units 1 and 4 and one question each from units 2, 3 and 5.

Machine Tools and Machining - Lab

List of Experiments

One Model each involving

a) Lathe operations
b) Milling operations
c) Shaping operation

Part A

a) Preparation of one model on lathe involving plane Turing, taper turning, Step turning, facing, convex shape turning, external thread cutting, V-thread and square thread.

Part B

b) Cutting of V-groove using a shaper, cutting of spur gear teeth, Helical gear using milling machine.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Identify the various bulk metal, sheet metal, non-traditional forming, non-conventional machining processes based on application
CO 2	Analyze various process parameters to infer their effect on process capability in metal-cutting & metal-forming operations.
CO 3	Perform indexing calculations for division of parts on Milling machine
CO 4	Produce simple components using various machine tools.
CO 5	Select appropriate tool required to produce the required configuration.

Course		Credits : 04			Marks	
Name	**Design of Machine Elements – 1**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**19ME4DC DM1**	**3**	**1**	**0**	**50**	**50**

PRE-REQUISITES:

1. Engineering Mechanics
2. Strength of Materials
3. Engineering Materials

SYLLABUS:

UNIT – 1

Introduction: Definitions: normal, shear, biaxial and triaxial stresses, Stress tensor, Principal stresses. Engineering materials and their mechanical properties. Stress-strain diagrams, Stress Analysis, Design considerations: Codes and Standards.

Design for Static & Impact strength: Static loads and factor of safety. Theories of failure: Maximum normal stress theory, Maximum shear stress theory, Distortion energy theory; Failure of brittle materials, Failure of ductile materials. Stress concentration, Determination of stress concentration factor.

Impact strength: Introduction, Impact stresses due to axial & bending load.
Consideration of creep and thermal stresses in design. **(9L + 4T)**

UNIT – 2

Design for Fatigue Strength: Introduction- S-N Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit, Endurance limit modifying factors: size effect, surface effect, Stress concentration effects; Fluctuating stresses, Goodman's and Soderberg's relationship; Stresses due to combined loading. **(5L + 3T)**

UNIT – 3

Design of Shafts: Torsion of shafts, design for strength and rigidity with steady loading, ASME & BIS codes for power transmission shafting, shafts under fluctuating loads and combined loads. **(6L + 1T)**

Design of Keys & Cotter Joints: Keys: Types of keys, Design of keys and cotter joints, Design of splines.

Couplings: Design of Flange Couplings, Bush and Pin type flexible coupling.

(6L + 1T)

UNIT – 4

Riveted and Welded Joints: Types, rivet materials, failures of riveted joints, Joint efficiency, Boiler joints, Tank and Structural joints, Riveted Brackets. Welded Joints: Types, strength of butt and fillet welds. **(7L + 2T)**

UNIT – 5

Threaded Fasteners: Stresses in threaded fasteners, Effect of initial tension, Design of threaded fasteners under static, dynamic loads.

Power Screws: Mechanics of power screw, Stresses in power screws, efficiency and self-locking, Design of power screw. **(6L + 2T)**

REFERENCES:

Data Handbooks (allowed for reference during examinations also):

1. Machine Design Databook, K. Lingaigh, 2nd Edition, McGraw Hill Education, 2010
2. Design Data Hand Book by K. Mahadevan and K. Balaveera Reddy, CBS Publication, 4th Ed. 2013

Textbooks

1. Mechanical Engineering Design: Joseph E Shigley and Charles R. Mischke. McGraw Hill International edition, 6th Edition 2003.
2. Design of Machine elements: V.B. Bhandari, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2010.

Reference Books

1. Machine Design: Robert L. Norton, Pearson Education Asia, 2001.
2. Design of Machine Elements: M. F. Spotts, T. E. Shoup, L. E. Hornberger, S. R. Jayaram and C. V. Venatesh, Pearson Education, 2006.
3. Machine Design: Hall, Holowenko, Laughlin (Schaum's Outlines Series) Adapted by S. K. Somani, Tata McGraw Hill Publishing Company Ltd., New Delhi, Special Indian Edition, 2008.
4. Fundamentals of Machine Component Design: Robert C. Juvinall and Kurt M Marshek, Wiley India Pvt. Ltd., New Delhi, 3rd Edition, 2007.
5. Design of Machine Elements-1: J.B.K. Das & P.L. Srinivasa Murthy, Sapna Book House, VII Edition, June, 2012.
6. Design data: Data Book of Engineers by PSG college-Kalaikathir Achchagam – Coimbatore, 2012.

E-Books / Web References

1. Machine Design, Robert L. Norton, 5/e, e-Textbook, ISBN-10: 0133369048, ISBN-13: 9780133356717, 2014.
2. Shigley's Mechanical Engineering Design (Smartbook), Richard Budynas and Keith Nisbett, 10/e, e-Textbook, ISBN-13: 978-1259241222 ISBN-10: 0073398209, 2014
3. http://nptel.ac.in/courses/112105124/
4. http://www.astm.org/

MOOCs

http://freevideolectures.com/free-college-courses-online/#MechanicalEngg

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Apply concepts of mechanics of materials to estimate the stresses in a machine element and predict failure of components based on theories of failure
CO 2	Analyse the effect of fatigue load on machine elements and factors affecting it to predict failure.
CO 3	Design machine elements such as Shafts, Keys, Cotter joints, Structural joints, Fasteners and Power screws.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Units 2, 4 & 5 and two questions each from Units 1 & 3.

Course		Credits : 03			Marks	
Name	**Kinematics of Machines**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**19ME4DC KOM**	**2**	**1**	**0**	**50**	**50**

PRE-REQUISITES:
1. Engineering Physics
2. Engineering Mechanics

SYLLABUS:

UNIT – 1

Introduction: Definitions: link or element, kinematic pairs, degrees of freedom, Grubler's criterion (without derivation), kinematic chain, mechanism, structure, mobility of mechanism, Grashoff's criterion, inversion, machine.
Kinematic Chains and Inversions: Inversions of four bar chain; single slider crank chain and double slider crank chain.
Mechanisms: Quick return motion mechanisms - Whitworth mechanism, crank-&-slotted lever mechanism, straight line mechanisms – Peaucellier's mechanism, Tchebicheff mechanism, intermittent motion mechanisms – Geneva mechanism, ratchet-&-pawl mechanism; toggle mechanism; Davis & Ackerman steering gear mechanism **(9L)**

UNIT – 2

Velocity & Acceleration Analysis of Mechanisms (Graphical Methods) Velocity and acceleration analysis of four bar mechanism and slider crank mechanism by vector polygons: relative velocity and acceleration of particles in a common link, relative velocity and accelerations of coincident particles on separate links – Coriolis component of acceleration. Angular velocity and angular acceleration of links, velocity of rubbing. **(5L + 5T)**

UNIT – 3

Velocity Analysis by Instantaneous Center Method: Definition, Kennedy's theorem, determination of linear and angular velocities using instantaneous center method.
Klein's Construction: Analysis of velocity and acceleration of single slider crank mechanism.
Spur Gears: Gear terminology, law of gearing, characteristics of involute action, path of contact, arc of contact, contact ratio, interference in involute gears, methods of avoiding: interference, backlash, comparison of involute and cycloidal teeth. **(4L + 3T)**

UNIT – 4

Gear Trains: Simple gear trains, compound gear trains for large speed reduction, epicyclic gear trains, algebraic and tabular methods of finding velocity ratio of epicyclic gear trains. Tooth load and torque calculations in epicyclic gear trains. **(4L + 1T)**

UNIT – 5

Cams: Types of cams, types of followers, displacement, velocity and acceleration time curves for cam profiles. disc cam with reciprocating follower having knife-edge, roller and flat-faced follower, disc cam with oscillating roller follower, follower motions including SHM, uniform velocity, uniform acceleration and retardation and cycloidal motion. **(4L + 4T)**

REFERENCES:

Text Books

1. Theory of Machines, Rattan S.S, Tata McGraw-Hill Publishing Company Ltd., 4th Edition, 2014
2. Theory of Machines and Mechanisms, P. L. Ballaney, Khanna Publications, - 2003

Reference Books

1. Theory of Machines & Mechanisms, Uickers, J.J., Pennock G.R. & Shigley J.E, SI Edition, 3rd Edition, 2009 OXFORD University Press
2. Theory of Machines, Thomas Bevan, 3rd Edition, 2010, Pearson Education Ltd.

E-Books / Web References

1. Robt. F. McKay, The Theory of Machines (https://archive.org/details/theoryofmachines00mckarich)
2. Theory of Machines, Sadhu Singh, 3rd Edition. 2011, Pearson, Kindle Edition (http://www.cs.cmu.edu/~rapidproto/mechanisms/tablecontents.html)

MOOCs

NPTEL Course: "Kinematics of Machines"
(http://nptel.ac.in/courses/112104121/1)

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Apply knowledge of fundamentals of kinematics to common mechanisms and determine kinematic-parameters of mechanisms.
CO 2	Estimate various profile-parameters in gears.
CO 3	Analyze the performance of gear trains for power transmission.
CO 4	Synthesize cam profiles for different applications.
CO 5	Use modern-tools to simulate simple mechanisms.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

To set one question each from units 3, 4 and 5 and two questions each from units 1 and 2.

Course		Credits : 04			Marks	
Name	**Mechanical Measurements and Metrology**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**19ME4DC MMM**	**3**	**0**	**1**	**50**	**50**

PRE-REQUISITES:

1. Engineering Physics
2. Engineering Mathematics

SYLLABUS:

UNIT – 1

Introduction

Introduction to metrology & measurements, definition, objectives and classification of metrology, standards of length- wave length standard, sub division of standards, numerical problems on length calibration **02 Hours**

Systems of Limits, Fits & Tolerancing

Definition of tolerance, tolerance specification in assembly, principle of interchangeability and selective assembly, limits of size, Indian standards, concepts of limits of size and tolerances, cost v/s tolerances, compound tolerances, accumulation of tolerances, definition of fits, types of fits and their designation (IS 919-1963), Geometrical Dimensioning and Tolerancing (GD&T), hole basis system, shaft basis system, simple problems. **07 Hours**

Gauges

Classification of gauges, Taylor's principle, design of GO, NO GO gauges, wear allowance on gauges, types of gauges- plain plug gauges, ring gauges, snap gauge, limit gauge, simple problems. **02 Hours**

UNIT – 2

Comparators

Introduction to comparators, classification, characteristics, systems of displacement amplification in mechanical comparators, Reed type, Sigma comparator, Zeiss ultra-optimeter, Solex air gauge, ultrasonic gauges, LVDT. **03 Hours**

Line & End Standards

Line and end standard, slip gauges, wringing phenomena, numerical problems on slip gauges. **04 Hours**

Angular Measurements

Bevel protractor, sine bar, angular gauges, numerical on building of angles. **03 Hours**

UNIT – 3

Measurements & Measurement Systems

Definition, generalized measurement system, accuracy, precision, calibration, threshold, sensitivity, hysteresis, repeatability, linearity, loading effect, system-response-time delay, errors in measurement. **02 Hours**

Transducers Intermediate & Terminating Devices

Primary & secondary transducers, classification, advantages, introduction to mechanical and electrical amplification, terminating devices, mechanical oscillographs. **02 Hours**

UNIT – 4

Force, Torque & Pressure Measurements

Working principle of analytical balance, proving ring, prony brake, hydraulic dynamometers,

Pirani gauge, Mcleod gauge, Bridgeman gauge. **03 Hours**

Temperature & Strain Measurements

Resistance thermometer, thermocouple laws of thermocouple, materials used for construction, optical pyrometer, electrical strain gauge, Wheatstone bridge for strain measurement.

03 Hours

UNIT – 5

Measuring Machines

Universal measuring machine, profile projector, tool maker's microscope, co-ordinate measuring machine and types, machine vision, autocollimator, laser interferometer.

04 Hours

Metrology for Nano Measurements

Clean room technology, scanning electron microscopy, transmission electron microscopy, atomic force microscopy, confocal microscopy, focused ion beam, photoelectron spectroscopy, x-ray diffraction (working principles with block diagrams for all the concepts in this unit with advantages and limitations). **05 Hours**

REFERENCES:

Text Books

1. Mechanical Measurements, Beckwith Marangoni and Leinhard, Pearson Education, 6th Ed., 2006.
2. Engineering Metrology, R. K Jain, Khanna Publishers, Twentieth Edition 2008.
3. Nano: The Essentials, Understanding Nano Science and Technology, by T Pradeep, Tata McGraw Hill Publishing 2009.
4. Measurement Systems, Applications & Design, by Ernest O. Doebelin, Fourth Edition1990.

Reference Books

1. Engineering Metrology, I C Gupta, Dhanpat Rai Publications, Delhi
2. Mechanical Measurements and Instrumentation, Er. R K Rajput, S K Kataria & Sons Publications, 2012

E-Books / Web References

1. Cleanroom Technology, FESTO world wide (http://www.festo.com/net/SupportPortal/Files/8842/HB_CleanRoom_en.pdf)
2. Nanometrology, European Nanotechnology Gateway, Eighth Nanoforum Report (http://nanoparticles.org/pdf/nanometrology.pdf)
3. NPTEL course on Metrology & Measurements Link: http://nptel.ac.in/courses/112106138/
4. MIT Open courseware Lecture: Metrology, shot noise and Heisenberg limit Link: http://ocw.mit.edu/courses/physics/8-422-atomic-and-optical-physics-ii-spring-2013/video-lectures/lecture-7-metrology-shot-noise-and-heisenberg-limit-part-1/

Scheme of Examination (SEE):

Answer FIVE full questions, each of 20 marks

Two questions each to be set from units 1 and 2 and one question each from units 3, 4, and 5.

MECHANICAL MEASUREMENTS & METROLOGY LAB

Part A: Metrology

1. Calibration of line and end standards equipment using slip gauges.
2. Calibration of pressure gauge
3. Calibration of load cell
4. Calibration of LVDT
5. Calibration of thermocouple

Part B

1. Measurement of angles using sine-bar, sine-center and bevel protractor
2. Measurement of screw thread using two wire and three wire method
3. Measurement of surface roughness using Talysurf and mechanical comparator
4. Measurement of gear tooth profile using gear tooth vernier
5. Measurement using optical profile projector and toolmaker's microscope
6. Measurements of alignment using autocollimator (Demo)
7. Use of strain gauge for determining elasticity in specimen
8. Principal stresses and strains in a shaft subjected to combined bending and torsion using strain rosettes
9. Contact and non-contact measurements using CMM and 3D Scanner

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Estimate errors during calibration of measuring instruments
CO 2	Select the system of limits, fits, tolerances and gauging, various measuring instruments for measuring mechanical quantities
CO 3	Design various types of fits and tolerances of shafts and holes
CO 4	Build Measurement circuits for various measurement scenarios.
CO 5	Compare the measurement processes and devices in engineering applications
CO 6	Demonstrate calibration of various physical parameters and phenomena.

Course		Credits : 04			Marks	
Name	**Applied Thermodynamics**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**19ME4DC ATD**	**3**	**0**	**1**	**50**	**50**

PRE-REQUISITES:
Basic Thermodynamics

SYLLABUS:

UNIT – 1

Gas Power cycles: Air standard cycles: Otto cycle, Diesel cycle and Dual cycle, Brayton cycle. **06 hours**

UNIT – 2

I.C. Engines: 4-stroke I.C. engines, Combustion of SI engine and CI engine, Knocking and Detonation, Performance analysis of I.C Engines, heat balance, Morse test, Willian's line method. **06 hours**

UNIT – 3

Reciprocating compressors: Operation of a single stage reciprocating compressor, Work input through p-v diagram and steady state steady flow analysis. Effect of clearance and volumetric efficiency. Adiabatic, isothermal and mechanical efficiencies. Multi-stage compressor, saving in work, optimum intermediate pressure, inter-cooling: perfect and imperfect, minimum work for compression. **05 hours**

UNIT – 4

Pure substances: Definition of pure substance, Formation of steam: Sub-cooled liquid, saturated liquid, mixture of saturated liquid and vapor, saturated vapor and superheated vapour states of a pure substance with water as example. Latent heat & dryness fraction. Representation on P-T, P-v, T-s and H-s diagrams. Use of steam tables and Mollier diagram. **05 hours**

Vapour Power cycles: Rankine Cycle, Actual Vapour Cycle processes, Reheat and Regenerative cycles. **06 hours**

UNIT – 5

Refrigeration: Air refrigeration (only Reversed Brayton cycle), properties of refrigerant, Vapour Compression refrigeration, Vapor Absorption refrigeration. **06 hours**

Psychrometry: Properties of dry and wet air, Dry bulb Temperature, wet bulb Temperature, dew point Temperature, partial pressures, specific and relative humidity and their relation, Enthalpy and adiabatic saturation Temperature. Construction and Use of psychrometric chart, Analysis of various processes: heating, cooling, dehumidifying and humidifying and adiabatic mixing of streams of air. **06 hours**

REFERENCES:

Text Books

1. Basic and Applied Thermodynamics, P. K. Nag, 2nd Edition, Tata McGraw Hill, 2009
2. Thermodynamics: An Engineering Approach, Yunus A. Cengel and Michael A. Boles, 7th Edition, Tata-McGraw hill Pub, 2011.

Reference Books

1. Fundamentals of Thermodynamics, Gordon J. Van Wylan & Richard E Sonntagg, 7th Edition, Wiley Eastern Ltd, 2009.
2. Engineering Thermodynamics, Rajput, 4th Edition, Laxmi Publications Pvt. Ltd., 2010

3. Engineering Thermodynamics, J.B. Jones and G. A. Hawkins, John Wiley and Sons.
4. Thermo Dynamics, S. C. Gupta, 1st Edition, Pearson Edu. Pvt. Ltd., 2005.
5. Elements of heat Engines (Vol I, II, III), R.C. Patel and C.J. Karamchandani, Acharya Publications, 2010

E- Books / Web References

1. Engineering Thermodynamics, Achuthan, 2nd Edition, Phi Learning, 2009
2. Fundamentals of Engineering Thermodynamics, Rathakrishnan, 2nd Ed., Phi Learning, 2005
3. http://www.nptel.ac.in/syllabus/112106133/

MOOCs

1. https://www.coursera.org/course/introthermodynamics
2. https://www.edx.org/course/thermodynamics-iitbombayx-me209-1x
3. https://legacy.saylor.org/me103/Intro

Lab – Syllabus

PART – A

1. Determination of Flash point and Fire point of lubricating oil using Abel Pensky, Martin (closed) and Cleavland (Open Cup) Apparatus.
2. Determination of Calorific value of solid, liquid and gaseous fuels.
3. Determination of Viscosity of a lubricating oil using Redwood, Saybolt and Torsion Viscometers.
4. Valve Timing/port opening diagram of an I.C. engine (2 stroke/4 stroke).
5. Determination of area of P-V diagram using planimeter.

PART – B

1. Performance Tests on Internal Combustion Engines:
Calculations of Indicated Power, Brake Power, Thermal efficiencies, Specific Fuel Consumption, Frictional Power and heat balance sheet for
   (a) Four stroke Diesel Engine
   (b) Four stroke Petrol Engine
   (d) Two stroke Petrol Engine
   (e) Variable Compression Ratio Engine.
2. Morse test for multi Cylinder Diesel/Petrol Engine.
3. Performance Test on Reciprocating compressor.
4. Performance Test on Vapour Compression Refrigeration system.
5. Performance Test on Vapour Absorption Refrigeration system.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Apply the first and second laws of thermodynamics in the analysis of energy components to determine the properties pertaining to thermodynamic-cycles.
CO 2	Analyze the thermodynamic-cycles of internal combustion engines in order to evaluate its performance.
CO 3	Assess benefits of improvements to thermodynamic systems
CO 4	Investigate the performance of thermodynamic systems for their performance
CO 5	Synthesise & interpret the experimental data of thermal systems

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

To set one question each from units 1, 2 and 3 and two questions each from units 4 and 5.

Course		Credits : 01			Marks	
Name	**Numerical Applications for Mechanical Engineering Lab**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**19ME4DL NAM**	**0**	**0**	**1**	**50**	**50**

PART – A

Introduction to MATLAB – As Programming Language

1. Introduction to Simple Calculations with MATLAB
   a) Data Types (Numeric, String) and their conversion
   b) Scalar Quantities and Variables
   c) Mathematical Functions
      - Arithmetic Functions +,-,/,*
      - Bitwise Operators, Relational Operators, Logical Operators
      - Trigonometric and inverse trigonometric Functions
   d) Vectors and Matrices
      - Matrix Multiplication (scalar and Matrix Multiplications, division)
      - Sum, Transpose, Diagonal and Inverse of a Matrix.
      - LU decomposition, QR Factorization
2. Introduction to User Defined Functions, and Scripts
3. 2D and 3D plots (including contour plots)
4. Flow Control
   a) Loops (For Loop, While Loop, Do while loop)
   b) Conditional Statements if else
   c) Switch statement
   d) Vectorization
5. Polynomials
   a) Inbuilt functions - root, polyfit, polyval, etc.
   b) Root Finding by Bisection, Newton-Raphson Method, Secant Methods
6. Numerical Integration Methods
   a) Trapezoidal Rule
   b) Simpsons rules (1/ 3^{rd} and 3/ 8^{th} Rule)
7. Solving ODE using - Runge-Kutta Methods

PART – B

Application of MATLAB to Mechanical Engineering

1. Engineering Mechanics
   - Statics: Forces in Structures (Trusses, Friction etc)
   - Dynamics
     - Path of Projectile
     - Moving Rigid bodies
2. Strength of Materials
   - Plot Shear Force, Bending moment and Deflection diagrams for different beams
     - Cantilever
     - Simply supported beam
3. Fluid Mechanics
   - Statics: Pascal Law
   - Dynamics
     - Applications of Bernoulli principle
     - Stream function and Potential functions
4. Kinematics and Kinetics of Four Bar Mechanism
5. Design of Machine Elements: Shaft subjected to combined torsion, bending and axial loads
6. Manufacturing: Generating a Merchant-circle diagram.

References:

1. An Engineer's Guide to MATLAB, Edward B. Magrab, MD Shapour Azarm, MD Balakumar Balachandran, MD James H. Duncan, MD Keith E. Herold Fischell, MD Gregory C. Walsh Leica
2. Essential MATLAB for Engineers and Scientists by Brian D. Hahn and Daniel T. Valentine
3. MATLAB an introduction with applications – Amos Gilat
4. Danilo. *6.094 Introduction to MATLAB, January IAP 2010***.** (Massachusetts Institute of Technology: MIT Open Courseware), http://ocw.mit.edu (Accessed 31 May, 2012). License: Creative Commons BY-NC-SA
5. Numerical Methods in MATLAB, Center for Interdisciplinary Research and Consulting, Department of Mathematics and Statistics University of Maryland, Baltimore County
6. MATLAB PROGRAMS for Textbook Kinematics, Dynamics, and Design of Machinery by K. J. Waldron and G. L. Kinzel
7. An Introduction to Programming and Numerical Methods in MATLAB by S.R. Otto and J.P. Denier
8. MATLAB Tutorial - Qian Wang Mechanical Engineering Penn State University

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Apply algorithmic problem-solving skills
CO 2	Create functions, scripts, programs which solve medium complex engineering tasks.
CO 3	Develop solutions to mathematical models applied to practical Mechanical engineering problems.
CO 4	Utilize MATLAB software to simulate practical problems

Assessment

Scheme for Examination:

Part A	15 Marks (05 Write-up + 10 Calculations)
Part B	25 Marks (05 Write-up + 20 Calculations)
Viva-voce	10 Marks
Total	50 Marks

V Semester Syllabus

Course		Credits : 02			Marks	
Name	**Management and Entrepreneurship**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DCMAE**	**2**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT – 1

Management: Introduction, Meaning, Nature and functions of management, Roles of Manager, Managerial Skills, Management as a science, art or profession- Management & Administration, Development of Management thought-early management (Taylor & Henri Fayol) approaches and Modern Management (Qualitative, Contingency & Systems) approaches. **3 Hours**

Planning: Nature & importance of planning, Forms of planning, Types of plans (listing), Importance of Planning, Steps in planning process, Planning premises, Limitations of planning

Decision making: Types of decisions, Steps in decision making, Difficulties in decision making. **3 Hours**

UNIT – 2

Organising: Meaning, Characteristics and Process of organizing, Span of Management, Principles of Organizing, Organization structure.

Staffing: Introduction, Functions of staffing, Importance, Short term, long term manpower planning, Recruitment, Selection, Placement

3 Hours

UNIT – 3

Directing & Controlling: Introduction, Requirements of effective direction, Motivation (Maslow, McGregor theory) Leadership styles (Autocratic, Democratic & Free rein)

Communication: Importance of Communication, Purposes of communication, Formal & Informal communication, Barriers to communication.

Co-ordination and Control: Techniques of co-ordination, Meaning and steps in control process, Essentials of effective control system. **6 Hours**

UNIT – 4

Entrepreneurship: Introduction, Characteristics of a successful entrepreneur, Classification of entrepreneurs, Role of entrepreneur in economic development, Problems faced by entrepreneurs. Case studies **3 Hours**

UNIT – 5

Small Scale Industry: Definitions of SSI, Importance of SSI, Definitions of SSI, Problems faced by SSI, Sickness in SSI, Institutions supporting SSIs central and state wise, Industry Associations. Introduction to Government Policies on Entrepreneurship: Start-up India Schemes. **4 Hours**

Setting up a small business enterprise: Formalities for setting up of a small business enterprise, Preparation of Business Plan. Types of Registration of companies. **4 Hours**

TEXT BOOKS:

1**. Principles of Management** – P.C. Tripathi, P.N. Reddy, Tata McGraw Hill

2. **Essentials of Management** – Harold Koontz, Heinz Weihrich, 5th Edition, Tata McGraw Hill

3. **Entrepreneurship Development – Small Business Enterprises** – Poornima M. Charantimath – Pearson Education – 2006

REFERENCE BOOKS:

1. **Management Fundamentals – Concepts, Application, Skill Development** – Robert Lusier – Thomson
2. **Essentials of Entrepreneurship and Small Business Management**-Thomas W Zimmerer and Norman M Scarborough, Doug Wilson, Fifth Edition, PHI, New Delhi.
3. **Management** – Stephen Robbins – Pearson Education / PHI – 17th Edition, 2003.
4. **Startup India -** www.startupindia.gov.in

E-learning:

https://india.gov.in/topics/industries/micro-small-medium-enterprises
http://www.archive.india.gov.in/business/starting_business/index.php

MOOCS:

https://www.class-central.com/subject/management-and-leadership
https://www.class-central.com/subject/entrepreneurship

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Compare various management approaches, planning and decision strategies
CO 2	Organize the staffing and structure for an organization
CO 3	Make use of communication methods, leadership styles for building effective control in an organization
CO 4	Develop entrepreneurial ideas
CO 5	Identify the institutions supporting the small-scale industries
CO 6	Plan various steps involved in setting up a business enterprise

Scheme of Examination: (SEE)

Answer five full questions selecting one from each unit.
To set one question each from Unit 2, 3 & 4 and two questions each from units 1 & 5.

Course		Credits : 03			Marks	
Name	**Dynamics of Machines**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DCDOM**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
Intended for students who are familiar with:
- Engineering Mechanics
- Kinematics of machines

SYLLABUS:

UNIT – 1

Static Force Analysis: Introduction, Static equilibrium, Equilibrium of two and three force members. Member with two forces and torque, Free-body diagrams, Static force analysis of simple mechanisms. Principle of virtual work. **6 Hours**

Turning Moment Diagram: Turning moment diagram and flywheels, Fluctuation of Energy. Determination of size of a flywheel. **5 Hours**

UNIT – 2

Friction and Belt Drives: Definitions; Types of friction, laws of friction, Friction in pivot and collar bearings. Flat belt drive, ratio of belt tensions, centrifugal tension, power transmitted. Belt thickness and width calculations. **5 Hours**

Analysis of Cams: Analysis of Tangent cam with reciprocating roller follower, Analysis of Circular arc cam operating flat faced, Undercutting in Cams **5 Hours**

UNIT – 3

Balancing of Rotating Masses: Static and dynamic balancing, Balancing of single rotating and many rotating masses by another mass in one plane. Effect of transferring rotating mass from one plane to another. Balancing of several rotating masses by balancing masses in different plane. **6 Hours**

UNIT – 4

Balancing of Reciprocating Masses: Inertia effect of crank and connecting rod, single cylinder engine, balancing in multi cylinder-inline engine (primary & Secondary forces), V-type engine; Radial engine – Direct and reverse crank method. **6 Hours**

UNIT – 5

Gyroscope: Vectorial representation of angular motion, gyroscopic couple. Effect of gyroscopic couple on the movement of a Naval ship, plane disc, aeroplane, stability of a two-wheeler and four-wheeler taking a turn **6 Hours**

TEXT BOOKS:
1. **Theory of Machines and mechanisms**: Dr. Jagdish Lal, Metropolitan Book Co. Pvt. Ltd., New Delhi, 2nd Edition, 1999.
2. **Theory of Machines**: Rattan S.S. Tata McGraw Hill Publishing Company Ltd., New Delhi, 3rd Edition, 2009.

REFERENCE BOOKS:
1. **Theory of Machines,** Thomas Bevan, CBS Publication 1984.
2. **Kinematics & Dynamics of Machinery,** Robert L. Norton, McGraw Hill, 2009.
3. **Theory of Machines,** P. L. Ballaney, Khanna Publishers, New Delhi, 16th Edition, 1988.

MOOCs:

1. Dynamics* (https://www.edx.org/course/dynamics-mitx-2-03x)
2. NPTEL Course: "Dynamics of Machines"(http://nptel.ac.in/courses/112104114)

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Determine the forces in mechanisms for static equilibrium.
CO 2	Design a flywheel based on energy fluctuation.
CO 3	Estimate the power in bearings and belt drives and the power of engine using turning moment diagram
CO 4	Analyse the tangent and circular arc cam and effect of gyroscopic couple on rotors, ships, aero planes and automobiles.
CO 5	Solve problems concerning static and dynamic balancing of systems involving rotating masses and partial balancing of reciprocating engines

Scheme of Examination (SEE):

Answer Five full questions selecting one from each unit.

To set One question each from Unit 3, 4 & 5 and two questions each from Units 1 & 2.

Course		Credits : 03			Marks	
Name	**Design of Machine Elements – 2**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DCDM2**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
Engineering Mechanics,
Strength of Materials,
Design of Machine Elements-I

SYLLABUS:

UNIT – 1

Curved Beams: Expressions for stresses in open curved beams, numerical problems in open section curved beams. **4 Hours**

Springs: Types of springs, Terminology for compression springs, Stresses and Energy stored in Helical coil springs of circular cross section, Stress and deflection in helical coil springs of circular cross sections.

Leaf springs: Stress and deflection in leaf springs. Equalized stresses (Nipping) in leaf spring leaves Numerical problems in leaf springs. **6 Hours**

UNIT – 2

Clutches & Brakes: Design of Clutches: Single plate clutch and multi plate clutches.

Design of Brakes: Block/Shoe brakes (Single Block Brakes only), Band brakes - Simple and Differential Band brakes, Self-locking of brakes, Heat generation in Brakes. **5 Hours**

UNIT 3

Spur & Helical Gears: Design of Spur Gears: Definitions, stresses in gear tooth: Lewis equation and form factor, Design for strength, Dynamic load and wear load.

Design of Helical Gears: Definitions, formative number of teeth; Design based on strength, dynamic and wear loads. **7 Hours**

Bevel and Worm Gears: Design of Bevel Gears: Definitions, formative number of teeth, Design based on strength, dynamic and wear loads.

Design of Worm Gears: Definitions, Design based on strength, dynamic, wear loads and efficiency of worm gear drives. **5 Hours**

UNIT 4

Lubrication and Bearings: Lubrication: purpose and requirement, Lubricant types, properties and selection, Classification of Bearings, bearing characteristic number and bearing modulus, coefficient of friction, minimum oil film thickness, Heat generated, Heat dissipated, Numerical problems on journal bearing design. **7 Hours**

UNIT 5

Design of Flexible Elements: Selection and design of V-belts, Ropes and Chains for different applications. **5 Hours**

Design Data Hand Books (Allowed for reference during CIE & SEE Examination also):

1. Machine Design Databook, Lingaiah K, 2nd Edition, Tata McGraw Hill Publishing, 2014
2. Design Data Hand Book, K. Mahadevan and K. Balaveera Reddy, CBS Publication, 4th Ed./4th Reprint, 2018

Text Books:

1. **Shiegly's Mechanical Engineering Design**: Richard G Budynas and J Keith Nisbett, McGraw Hill Education, Special Indian Edition, 10th Edition 2014.
2. **Design of Machine Elements**: V. B. Bhandari, Tata McGraw Hill Publishing Company Ltd., New Delhi, 3rd Edition 2017.

Reference Books:

1. **Machine Design, An Integrated Approach**: Robert L. Norton, Pearson Education 4th Edition, 2010
2. **Design of Machine Elements**: M. F. Spotts, T. E. Shoup, L. E. Hornberger, S. R. SI Contributions by A P Harsha, Pearson Education, 8th Edition, 2019.
3. **Schaum's Outlines Machine Design**: Allen S Hall, Alfred R Holowenko, Herman G Laughlin, Adapted by S. K. Somani, Tata McGraw Hill Education India, New Delhi, Special Indian Edition, 2008.
4. **Design of Machine Elements -2** : J. B. K. Das and P. L. Srinivasa Murthy, Sapna Book House, 2017.

E-Books:
Shigley's Mechanical Engineering Design [Kindle Edition], Richard Budynas, McGraw-Hill Higher Education; 10 edition, January 2014.

MOOCs:

1. http://nptel.iitg.ernet.in/
2. http://www.nptelvideos.in/2012/12/design-of-machine-elements.html

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

CO 1	Solve for stresses in curved beams, springs, clutches and brakes
CO 2	Deduce equations for stresses in curved beams, springs and gears
CO 3	Estimate the load carrying capacities of curved beams, helical and leaf springs and bearings.
CO 4	Compare different types of clutches, brakes, springs, gears and power transmission elements
CO 5	Design of gears, springs, clutches, brakes and bearings
CO 6	Choose power transmission elements like belt drives, chain drives, rope drives and the bearings for different applications

Scheme of Examination (SEE):
Students to answer five full questions selecting one from each unit.
To set one question each from Units 2, 4 & 5 and two questions each from Units 1 & 3.

Course		Credits : 03			Marks	
Name	**Turbo Machines**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DCTUM**	**2**	**0**	**1**	**50**	**50**

SYLLABUS:

UNIT – 1

Introduction: Definition, Parts of a Turbomachine; Classification; Application of First and Second Law; Efficiencies, Dimensionless parameters and their significance (No Derivation only Discussion); Specific speed, Stagnation and static properties and their relations.
General Analysis of Turbomachines: Euler equation and its alternate forms- components of energy transfer; Meridonial plane, Velocity triangles; Degree of Reaction; Utilization factor, Vane efficiency, Speed ratio. **04 Hours**

UNIT - 2

Centrifugal Compressors: Schematic diagram, Expression for overall pressure ratio; Velocity triangles; Slip factor, power input factor; Compressibility effect – need for pre-whirl vanes; Effect of Blade discharge angle on energy transfer and head coefficient, Surging and choking in centrifugal compressors.
Axial Flow Compressors: Drum and Disk type, work done factor, radial equilibrium theory. **07 Hours**

UNIT - 3

Centrifugal Pumps: Schematic diagram, suction head, delivery head, manometric head, pressure rise, manometric efficiency, hydraulic efficiency, volumetric efficiency, overall efficiency, minimum starting speed, slip, priming, cavitation, MSL, NPSH, multistage centrifugal pumps. **04 Hours**

UNIT – 4

Steam Turbines: Classification; Compounding in steam turbines, Combined velocity diagrams, Work done expressions for Single stage impulse turbine and single stage reaction turbines, Multistage-impulse steam turbine (only discussion) **04 Hours**

UNIT – 5

Hydraulic Turbines: Classification; Efficiencies; Pelton wheel-velocity triangles, Design parameters; Francis turbine–velocity triangles and design parameters; Analysis of Draft tube, Kaplan turbine– Velocity triangles and design parameters. **07 Hours**

TEXT BOOKS:

1. An Introduction to energy conversion, Volume III – Turbo machinery, V. Kadambi and Manohar Prasad, New Age International Publishers (P) Ltd.
2. Turbines, Compressors & Fans, S. M. Yahya, Tata-McGraw Hill Co., 4th Edition.

REFERENCE BOOKS:

1. Principles of Turbo Machinery, D. G. Shepherd, The Macmillan Company (1964)
2. Fundamentals of Turbo machinery, William W Peng, John Wiley & Sons, Inc. 2008.
3. Principles of Turbomachinery, R K Turton, Chapman & Hall, 2nd Edition (1995)
4. Fluid Mechanics and Thermodynamics of Turbomachinery, S L Dixon and C A Hall, Butterworth-Heinemann, 6th Edition.

TURBOMACHINERY LABORATORY

Fluid Mechanics Lab:

1. Determination of Coefficient of Friction of flow through a pipe.
2. Determination of Minor losses in the pipe.
3. Discharge measurement using Orifice, Nozzle, Venturi meter and V-notch.

Performance testing of Turbomachines

1. Impact of Jets-Flat, Inclined and Curve vanes
2. Pelton wheel

3. Francis Turbine
4. Kaplan Turbine
5. Multi stage centrifugal pumps
6. Multi stage centrifugal air compressor
7. Multi stage Axial flow air compressor
8. Centrifugal Air Blower

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Classify typical designs of turbo machines
CO 2	Apply Euler's equation for turbomachinery to analyse energy transfer in turbines and compressors.
CO 3	Evaluate the performance parameters of pumps, compressors, turbines on a 1-D basis with the use of velocity triangles
CO 4	Estimate the data in design and development of Turbomachines.
CO 5	Perform experiments on Turbo machines
CO 6	Analyze and interpret the experimental data

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 3 & 4 and two questions each from Units 2 & 5.

Course		Credits : 04			Marks	
Name	**CAD / CAM and Robotics**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DCCCR**	**3**	**0**	**1**	**50**	**50**

PRE-REQUISITES:
Manufacturing Process, Engineering Mathematics

SYLLABUS:

UNIT – 1

Introduction to CAD/CAM: Introduction to CAD/CAM, CAD/CAM Software. Transformations of geometry: Translation, Scaling, Reflection, Rotation, Homogeneous representation of transformation, Concatenation of transformations. **5 Hours**

UNIT – 2

Geometric Modelling: 3-D Wire frame modelling, Bezier and B-spline curves. Geometric Modelling of Surfaces: Basic surfaces entities, Surface of revolution, blends, intersections. Geometric Modelling of Solids: Solid entities, Boolean operations, B-rep of Solid Modelling, CSG approach of solid modelling. Data Exchange Formats and Applications: Data exchange formats. **10 Hours**

UNIT – 3

Computer Aided Manufacturing (CAM): Introduction to Computer Numerical Control (CNC) and architecture, Designation of axes, Drives & actuation systems, Feedback devices, CNC tooling **5 Hours**

UNIT – 4

CNC Programming: Part programming fundamentals, Manual Part Programming, APT Programming, Geometric & motion commands, Post processor commands. Case studies **7 Hours**

UNIT – 5

Robotics: Anatomy & Configuration of Robot, Characteristics of Robots, Components of Robots and General Architecture, End Effectors, Application of Robots in Manufacturing, Robot Position Sensors - Proximity and Range Sensors – Tactile Sensors – Velocity and Acceleration Sensors - Force and Torque Sensing Devices- Sensing Joint Forces and Slip. Robot Programming. **12 Hours**

TEXT BOOKS:

1. CAD/CAM-Theory and Practice, Ibraham Zeid & R. Shivasubramanian, 2nd Edition, Tata McGraw Hill, 2009.
2. CAD / CAM Principles and Applications, Rao, P.N., McGraw Hill Publishers, New Delhi, 2010
3. Computer Control of Manufacturing, Yoram Koren, McGraw Hill Publications, 2005.

REFERENCE BOOKS:

1. Robotics for Engineering- Koren. Y - Mc-Graw Hill - 1985.
2. CAD/CAM/CIM- P. Radhakrishna, New Age International-2nd edition.
3. Principles of CAD/CAM/CAE systems- Kunwoo Lee, Pearson Publications-

MOOCS:
http://www.nptel.ac.in/courses/Webcourse-contents/IIT-Delhi/Computer%20Aided%20Design%20&%20ManufacturingI/index.htm

CAD CAM Robotics LABORATORY

Part – A

CAD Lab:

Using a modelling software (like SolidWorks):

a) Design & drafting of a turning model comprising of various turning operations & features
b) Design & drafting of a milling model comprising of various milling operations & features

Part – B

CAM Lab:

1) Simulations on SINUMERIK software for:
   a) CNC Turning
   b) CNC Milling
2) Wok-offset & Tool-offset settings on CNC machines, loading workpiece & programs to make a part for both turning & milling
3) Dimensional inspection using CMM of parts produced in the above experiments

Robotics Lab:

Exercises in Programming of Industrial Robot for Pick and place

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Perform feature-based design
CO 2	Select and apply appropriate tools for CAD-CAM & Robotics systems to realize components and processes through manipulators.
CO 3	Implement process plan and associate it with CAD-CAM integration.
CO 4	Demonstrate production of mechanical components using CNC machine tool.
CO 5	Write part program for CNC machines.

Scheme of Examination (SEE):

Students to answer five full questions selecting one from each unit.
To set one question each from Units 1, 3 & 4 and two questions each from Units 2 & 5.

Course		Credits : 03			Marks	
Name	Operations Research	L	T	P	CIE	SEE
Code	20ME5DCORE	3	0	0	50	50

PRE-REQUISITES:

SYLLABUS:

UNIT - 1

Introduction: Evolution of OR, definition of OR, scope of OR, application areas of OR, steps (phases) in OR study, characteristics and limitations of OR, models used in OR.
Solution of Linear Programming Problems: Introduction, linear programming (LP) problem formulation and solution by graphical method. The simplex method-canonical and standard form of an LP problem, slack, surplus and artificial variables- Big M method.
09 Hours

UNIT - 2

sensitivity analysis: Concept of duality, dual simplex method, Degeneracy in simplex method, Numerical on dual simplex method. Revised Simplex method, sensitivity analysis.
07 Hours

UNIT - 3

Transportation Problem: Formulation of transportation problem, types, initial basic feasible solution using different methods, optimal solution by MODI method, degeneracy in transportation problems, application of transportation problem concept for maximization cases, Assignment Problem-formulation, types, application to maximization cases and travelling salesman problems, numerical on travelling salesman problems. **10 Hours**

UNIT – 4

Game Theory: Introduction, formulation of games, types, solution of games with saddle point, graphical method of solving mixed strategy games, dominance rule for solving mixed strategy games.
Sequencing: Introduction, basic assumptions, sequencing "n" jobs on single machine using priority rules, sequencing using Johnson's rule-"n" jobs on 2 machines, "n" jobs on 3 machines, "n" jobs on "m" machines. Sequencing 2 jobs on "m" machines using graphical method. **06 Hours**

UNIT – 5

Replacement Theory: Introduction, replacements of items that deteriorate with time, case 1: value of money does not change with time, case 2: value of money changes with time, to find the optimal replacement policy, replacement of equipment that fails suddenly, individual and group replacement of items that fails completely. **07 Hours**

TEXT BOOKS

1. Operations Research, P K Gupta and D S Hira, Chand Publications, New Delhi - 2007
2. Operations Research, Taha H A, Pearson Education.
3. Operations Research: Principles and Practice, 2nd Edition, T.Philips, A.Ravindran and James J Solberg, John Wiley & Sons.

REFERENCE BOOKS

1. Operations Research, A P Verma, S K Kataria &Sons, 2008
2. Operations Research, Paneerselvan, PHI
3. Operations Research, A M Natarajan, P Balasubramani, Pearson Education, 2005
4. Introduction to Operations Research, Hiller and Liberman, McGraw Hill

E-Books

1. Operations Research: A Model-Based Approach, H. A. Eiselt, Carl-Louis Sandblom

ISBN: 978-3-642-10325-4 (Print) 978-3-642-10326-1 (Online)
2. Introduction to Operation Research, Frederick S. Hillier, Gerald J. Lieberman, McGraw Hill, Seventh Edition.

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

CO 1	Formulate real world problems as a Linear programming model and demonstrate solution by graphical & simplex method, specific LPP like transportation and assignment and demonstrate the solution.
CO 2	Perform sensitivity analysis to identify the direction and magnitude of change of a Linear programming model.
CO 3	Apply the knowledge of game theory concepts to articulate real-word decision situations for identifying, analysing and practicing strategy decision to counter the consequences.
CO 4	Analyse n-jobs and 2 machines, 3 machines problems using Johnson and 2 jobs,-m machine problem graphically.
CO 5	Review replacement policy for item that deteriorate with time and compare individual and group replacement policies.

Scheme of Examination (SEE):
Students to answer five full questions selecting one from each unit.
To set one question each from Unit 2, 4 & 5 and two questions each from Units 1 & 3.

Course		Credits : 01			Marks	
Name	**Mini Project Work – Phase 1**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DCMW1**	**0**	**0**	**1**	**50**	**50**

1. Each project group of maximum 4 students shall take up a project work in consultation with the respective guide in the beginning of fifth semester and it must be completed during sixth semester.
2. A project proposal must be submitted to the department at the start of 5th semester. Project work shall be completed by the end of the academic year. (Each student shall work for 104 hrs in total).
3. The project work shall be executed according to CDIO principles. *ie.,* Conceive, Develop, Implement and Operate principles.
4. Selection and approval of the topic:
   a. Topic should be related to an on-field engineering application, OR
   b. Investigation of the latest technologies in Mechanical Engineering, OR
   c. Coding development and implementation related to Engineering.
5. The group should maintain a workbook containing the schedule of activities including the outcome of the work/results, duly attested by the respective guide.
6. The plan shall include the detailed literature review, patent survey, innovation or conception of idea, problem formulation, material selection and design of products with approximate cost estimation.
7. The guides will regularly monitor the progress of the project work, at least once in a week.
8. Assessment of the project for the award of CIE marks shall be done by the guide and a departmental committee as per the assessment format.
9. The guide shall be an internal examiner for evaluation. The final SEE shall be conducted jointly by internal and external examiners, chosen from related area of the concerned project.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Develop skills in literature and/or patent survey.
CO 2	Understand the material/process standards & implications.
CO 3	Develop ability to conceptualize and realize products.
CO 4	Construct coherent written forms of communication and present effective oral forms of communication.

Assessment of 20ME5DCMW1 : Mini Project Work – Phase 1

Title of the Project: _____

Name of the Guide: _____

Sl. No	**USN**	**Name of the student**	**Assessment by Guide (70%)**					**Assessment by Departmental Committee (30%)**			**Grand Total (50)**
			Literature survey (10)	Topic Selection (05)	Documentation (15)	Attendance (05)	Total (35)	Evaluation (10%) (05)	Presentation (20%) (10)	Total (15)	

Electives – Group 1

Course		Credits : 03			Marks	
Name	**Non-Traditional Machining**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DENTM**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT-1

Introduction- History, need, classification, comparison between conventional and non-conventional machining process and selection.

Ultrasonic Machining (USM) - Introduction, equipment details, cutting tool system design, mechanism of metal removal in USM and its modelling, Problems on MRR, effect of parameters, USM process characteristics, applications, advantages & disadvantages of USM. **5 Hours**

UNIT-2

Abrasive Jet Machining (AJM) - Introduction, equipment details, variables in AJM, nozzle design, shape of cut, mechanism of metal removal, process characteristics, applications, advantages & disadvantages of AJM.

Abrasive Water Jet Machining (AWJM) -Principal, equipment, operation, mechanism of metal removal, application, advantages and limitations. **5 Hours**

UNIT-3

Electrochemical Machining (ECM) - Introduction, study of ECM machine, elements of ECM process, mechanism of metal removal, process characteristics,
Applications such as Electrochemical Grinding, Electrochemical Honing, Electrochemical deburring, advantages, limitations and applications. **6 Hours**

Chemical Machining (CHM)-Introduction, elements of process, mechanism of metal removal, chemical blanking process : Preparation of work piece, preparation of masters, masking with photo resists, etching for blanking, accuracy of chemical blanking, applications of chemical blanking, chemical milling (contour machining), Process steps – masking, Etching, process characteristics of CHM, , advantages, limitations & application of CHM. **6 Hours**

UNIT-4

Electrical Discharge Machining (EDM) -Introduction, mechanism of metal removal, dielectric fluid, spark generator, process parameter advantages, limitations & application of EDM. **6 Hours**

Plasma Arc Machining and Laser Beam Machining: Introduction, equipment, mechanism of metal removal, process parameters, process characteristics, advantages, limitations & applications**.** Laser cutting (LC) – Laser drilling (LD) - Laser marking and engraving (LM) - Laser micromachining (LMM) - Laser engineered net shaping (LENS) - Applications - Limitations Demonstration of Laser engraving machine. **5 Hours**

UNIT-5

Electron Beam Machining and Ion Beam Machining: Introduction, equipment, mechanism of metal removal, process parameters, process characteristics, advantages, limitations & applications.

Special Processing Technology - Rapid Prototyping - Methods - Fused Deposition

Modelling (FDM) - Laminated Object Manufacturing (LOM) - Selective laser sintering (SLA) - Solid Ground curing (SGC) - 3D printing (3DP) - Processing of integrated circuits - Micro and nano fabrication technologies. **6 Hours**

TEXT BOOKS:

1. **Modern machining process,** Pandey and Shan, Tata McGraw Hill 2000
2. **New Technology,** Bhattacharya 2000
3. Abdel, H. and El-Hofy, G. "**Advanced Machining Processes**", McGraw-Hill, USA, 2005.
4. Wellar, E.J. "**Non-Traditional Machining Processes**", Society of Manufacturing Engineers Publications, 2nd Edition, Michigan, 1984.
5. **Non Traditional Manufacturing Processes**, by Gary F Benedict, Taylor & Francis

REFERENCE BOOKS:

1. **Production Technology,** HMT Tata McGraw Hill. 2001
2. **Non-traditional manufacturing Processes, Geoffrey Boothroyd, Marcel Dekker,** 1987
3. **Advanced methods of Machining, J.A McGeough, Chapman and Hall,** 1988

MOOC:

1. http://nptel.ac.in/courses/112105127/

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Classify the various non-traditional machining process to machine new novel materials.
CO 2	Choose an appropriate non-traditional machining technique to machine the given material
CO 3	Compare material removal rate for abrasive jet machining and abrasive water jet machining
CO 4	Identify the Process parameters affecting the functioning of various non-traditional machines.
CO 5	List the advantages, limitations & applications of different non-traditional machines.
CO 6	Inspect 3 D printing, laser engraving and water jet machining to experience a few non-traditional processes.
CO 7	Design and fabricate a component using any NTM process.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

To set one question each from Unit 1, 2 & 5 and two questions each from Units 3 & 4

Course		Credits : 03			Marks	
Name	**Theory of Elasticity**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DETOE**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT - 1

Introduction: Assumptions, Body and surface forces, Stress at a Point, Equilibrium Equations, Stress transformation, Stress invariants, Principal Stresses, Octahedral stresses, Maximum Shear Stresses and Planes, Hydrostatic and deviatoric stresses, 3 D Mohr's circle, Boundary Conditions. **6 Hours**

UNIT - 2

Strain at a point: Strain – displacement relations, Compatibility Equations, Principal Strains, Generalized Hooke's law, fundamental problem classification, displacement formulation, Stress formulation and Mixed Formulation, Plane Stress & Plane Strain Problems. **8 Hours**

Uniqueness theorem**,** Principle of super position, reciprocal theorem, Saint Venant's principle. **1 Hour**

UNIT - 3

Two Dimensional Problems: Cartesian co-ordinates – Airy's stress functions –Polynomial solutions, Investigation of Airy's Stress function for simple 2D problems – Bending of a narrow cantilever beam of rectangular cross section under edge load. **7 Hours**

UNIT - 4

General Equations in Cylindrical Co-Ordinates: 2D Equations of equilibrium, Strain – displacement relations**,** Thick cylinder under uniform internal and / or external pressure, shrink fit. **6 Hours**

Stresses in rotating discs and cylinders. Stresses in an infinite plate with a circular hole subjected to uniaxial and biaxial loads, stress concentration. **6 Hours**

UNIT – 5

Torsion of Prismatic Bars: Saint venant's semi inverse method applied to circular, elliptical and triangular bars**,** membrane analogy, torsion of closed thin tubes. **5 Hours**

TEXT BOOKS:

1. **Advanced Mechanics of solids**, L. S. Srinath, Tata Mc. Graw Hill, 2003
2. **Theory of Elasticity:** S. P. Timoshenko and J. N Gordier, McGraw – Hill Ltd., Tokyo, 1990.

REFERENCES BOOKS:

1. **Theory of Elasticity:** Dr. Sadhu Singh, ISBN 9788174090606, Fourth Edition, Khanna Publications, 2018
2. **Elasticity, Theory, Applications & Numericals:** Martin H Sadd, Elsevier. 2005
3. **Applied Elasticity,** Sitharam, T. G & L. Govindaraju, ISBN-10: 9385909347, I K International Publishing House Pvt. Ltd; 1 edition , 2016
4. **Applied Elasticity,** C.T. WANG Sc. D., ISBN-10: 0070681252 Mc. Graw Hill Book Co.1953

E-Books:

1. Theory of Elasticity by L.D. Landau and E. M. Lifshitz
http://www.me.ust.hk/~meqpsun/Notes/Theory%20Of%20Elasticity(Landau-1959)

2. Elasticity - theory, applications and applications by Martin H. Sadd
http://iate.oac.uncor.edu/~manuel/libros/Mechanics/Elasticity/Elasticity%20%20Theory,%20applications,%20and%20numerics%20-%20M.Sadd.pdf

MOOCs:

1. Theory of Elasticity, by Prof. Amit Shaw, Prof. Biswanath Banerjee IIT https://onlinecourses.nptel.ac.in/noc20_ce42
2. Mechanical Behavior of Materials, Part 1: Linear Elastic Behavior https://www.edx.org/course/mechanical-behavior-materials-part-1-mitx-3-032-1x

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Apply basic concepts of continuum mechanics to elasticity problems
CO 2	Choose suitable solution strategies for boundary value problems
CO 3	Determine stresses and displacements in simple solids such as pressurized cylinders, shrink fitted cylinders, rotating disc and shaft, plate with hole
CO 4	Examine behaviour of non-circular shafts and thin tubes under torsion.
CO 5	Utilize MATLAB or equivalent software to simulate boundary value problems
CO 6	Develop analytical solutions for problems of limited complexity

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Units 1, 3 & 5 and two questions each from Units 2 & 4.

Course		Credits : 03			Marks	
Name	**Incompressible Fluid Dynamics**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DEIFD**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT – 1

Introduction and basic concepts: Compressibility of fluids-Compressible and Incompressible, Laminar and turbulent flows, Steady and unsteady flows, Streamlines, path lines, Stream function, vorticity and circulation, Eulerian and Lagrangian formulations, Material derivative; **04 Hours**

Incompressible Navier-stokes equation: Continuity equation, Eulerian formulation, Momentum equation – Lagrangian formulation, Forces acting on a fluid element and the stress tensor, Straining of a fluid element and the strain rate tensor, Relation between the deviatoric stress tensor and the strain rate tensor, Incompressible Navier-Stokes equations. **05 Hours**

UNIT – 2

Analytical Solutions to the Incompressible Navier-stokes equations: Boundary conditions, Parallel flow solutions, Couette-Poiseuille flow, Hagen-Poiseuille flow in a pipe, Flow between concentric rotating cylinders. **06 Hours**

UNIT - 3

Laminar Boundary layer theory: Derivation of the boundary layer equations, Blausius flow over a flat plate, Wall shear and boundary layer thickness, Differential analysis– Principle of similarity, Momentum Integral analysis, Displacement and momentum thickness, Boundary layer flows with non-zero pressure gradient, Karman-Pohlhausen Approximate Method, Falkner-Skan similarity solutions, Separation of boundary layer, Entry flow in a duct. **10 Hours**

UNIT – 4

Potential Flows: Euler equation for inviscid flows, Bernoulli's equation, Relation between Bernoulli's equation and the first law of thermodynamics, Potential flows, Basic flows, Flow singularities and Superposed flows, Lifting and non-lifting flows, source and sink problems. **07 Hours**

UNIT – 5

Vorticity dynamics:

Vorticity and equation, Typical vorticity distributions, Helmholtz's laws for inviscid flow, Kelvin's circulation theorem, Vortex definitions, Inviscid motion of point vortices, Circular line vortex, Fraenkel–Norbury vortex rings, Hill's spherical vortex, Vortex breakdown **07 Hours**

TEXT BOOKS:

1. Fluid Mechanics, F M White.
2. Introduction to Fluid Mechanics and Fluid Machines, S K Som and Suman Chakraborthy
3. Fluid Mechanics, P K Kundu and Cohen
4. Fundamentals of Incompressible Fluid Flow, Babu Vishwanathan, IIT Madras

REFERENCE BOOKS:

1. Introduction to Fluid Mechanics, Fox and McDonald
2. Fluid Mechanics for Engineers, T Schobeiri
3. Fluid Mechanics with Engineering Applications, John Finnemore and Joseph Franzini

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Analyse the dynamics of fluid flow and their parameters
CO 2	Develop an approximation for the properties of incompressible fluids
CO 3	Solve fluid flow problems for incompressible flow conditions
CO 4	Apply concepts of mass, momentum and energy conservation to fluid flow
CO 5	Understand the concepts of turbulent flow

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

To set one question each from Unit 2, 3 & 4 and two questions each from Units 1 & 5.

Course		Credits : 03			Marks	
Name	**Renewable Energy Sources**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DERES**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:

- FLUID MECHANICS & THERMODYNAMICS

SYLLABUS:

UNIT – 1

Introduction

Energy conservation, aspects and principles of energy conservation, conventional energy, World and India Energy programs and scenario, non-conventional sources of energy, Current scenario and prospects of renewable energy sources, Environmental benefits, limitations, national solar mission, Kyoto Protocol goals, Clean development mechanism (CDM), Steps of CDM. **05 Hours**

UNIT – 2

Solar Energy

Solar Photovoltaics: Solar cells, working principle, I-V and P-V characteristics, variation of insolation & temperatures, cell classifications, type of active materials, cell mismatch in module, effects of shadowing, solar cell connecting arrangements, conversion efficiency, fill factor, Maximum Power Point Tracking (MPPT), Solar PV system classifications, standalone system, grid interactive system, concentrating solar PV Systems, Applications.

Solar collectors (Discussion only): Introduction, Flat plate collector, Parabolic collector.

07 Hours

UNIT – 3

Wind Energy

Introduction, principle, classifications, Horizontal axis: single blade, two blade, multi blade, Dutch type, sail type. Design considerations of horizontal axis wind mill, Vertical axis: Savonius, Darrieus, power in wind, power coefficient and maximum power, forces acting on the blade, site selection considerations, wind energy conversion systems, yaw control, Pitch control, Tip speed ratio, solidity, performance of wind machines, Betz criteria, safety systems, Environmental aspects, Applications **10 Hours**

UNIT – 4

Biomass Energy

Biogas: Photosynthesis, Aerobic and Anaerobic digestion, Classification of bio gas plants, Continuous & batch type, Common circular floating gas holder, Common circular fixed dome, Factors affecting bio digestion, feed stock materials, site selection, methods for maintaining gas production, problems of biogas plants.

Gasifiers: Thermal gasification of biomass, classifications, fixed bed: Updraught, Down-draught, Cross draught, Fluidized bed, Applications, problems of gasifiers. Biofuels: Esterification, Transesterification, Ethanol production, ethanol from wood by acid hydrolysis, ethanol from sugarcane, bagasse, properties, environmental effects. **11 Hours**

UNIT – 5

Fuel Cells

Introduction, classifications, Principle of working, Phosphoric Acid Fuel Cell (PAFC), Alkaline Fuel Cell (AFC), Polymer Electrolyte Membrane Fuel Cell (PEMFC), Solid Oxide Fuel

Cell (SOFC), Efficiency, fuels for fuel cells, V-I Characteristic, Fuel Cell Power plant, Applications, Environmental Effects. **06 Hours**

TEXT BOOKS:

1. Non-Conventional Sources of Energy – G. D. Rai, Khanna Publishers, New Delhi.
2. Non-Conventional Energy Resources, B.H. Khan, McGraw Hill Education (India) Private Limited, New Delhi.

REFERENCE BOOKS:

1. Solar Energy- Principles of thermal collection and storage, S.P Sukhatme & J. K Nayak, McGraw Hill Education (India) Private Limited, New Delhi.
2. Renewable energy, Bent Sorensen, Academic Press- Elsevier Publications.

NPTEL/SWAYAM COURSES:

1. https://nptel.ac.in/courses/121/106/121106014/
2. https://swayam.gov.in/nd1_noc20_ge06

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Discuss the working principle of various systems used to harness renewable energy
CO 2	Understand the effect of renewable energy on environment and society
CO 3	Design renewable energy systems for domestic applications
CO 4	Deduce the parameters related to solar PV, wind energy and fuel cells
CO 5	Compute parameters related to solar PV, Wind energy, biomass energy and fuel cells

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Units 1, 2, 5 and two questions from Unit 3, 4.

Course		Credits : 03			Marks	
Name	**Applied Electronics, Microprocessor and Microcontroller**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DEAMM**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT - 1

Digital logic families, Integrated circuits - classification & comparison , JK flip flops and counters , Multiplexers & Demultiplexers, Encoders & Decoders, Adders & Subtractors, D to A convertors (weighted binary resistor network type), counter type and successive approximation type A to D convertors, Numerical. **11 Hours.**

UNIT - 2

Power control – SCR and Triac. Chopper circuits, block diagrams of DC motor and induction motor control. Numerical **06 Hours.**

UNIT - 3

Introduction, Organization of 8085 processor interrupts and addressing modes available. 8085 programming – Instruction set, assembler directives, assembly language programming examples. **11 Hours.**

UNIT – 4

Overview of the 8051 family. The 8051 Architecture Internal Block Diagram, address, data and control bus, working registers, Special Function Registers, Clock and RESET circuits, Stack and Stack Pointer, Program Counter, I/O ports, Memory Structures **5 Hours**

UNIT - 5

Instruction Set and Assembly Language Programming: Introduction, Instruction syntax, assembler directives, immediate addressing, Register addressing, direct addressing, Indirect addressing, Relative addressing, Indexed addressing, bit inherent and bit direct addressing 8051 Instruction set - Data transfer instructions, Arithmetic instructions, Logical instructions, Branch instructions, Bit manipulation instructions, Simple Assembly language programs **06 Hours**

TEXT BOOKS:

1. Digital Fundamentals, Floyd
2. Thyristors and its applications, K.K. Sugandhi and R.K. Sugandhi
3. Gaonkar, “Microprocessor Architecture programming and application,” Wiley Eastern Ltd., New Delhi.
4. M. A. Mazidi, J. G. Mazidi and R. D. McKinlay, “The 8051 Microcontroller and Embedded Systems: Using Assembly and C”, Pearson Education, 2007.

REFERENCE BOOKS:

1. Introduction to Microprocessors by A.P.Mathur, Tata McGraw Hill Pub. Co., New Delhi.
2. Digital Fundamentals by Maris and Melvino.
3. K. J. Ayala, “8051 Microcontroller”, Delmar Cengage Learning,2004.

COURSE OUTCOMES

Upon completion of this course, student will be able to:

CO 1	With timing diagrams involving selection of devices / performance characteristics including numerical
CO 2	Discuss the regulation of power using SCR, triac and electrical actuators: principles and control along with numerical
CO 3	Analyse 8085/ 8051 micro-processor/ micro-controller architecture, programming and interpretations.
CO 4	Develop alternate approaches for logic circuits and 8085 & 8051 programming

Scheme of Examination (SEE):

Answer Five full questions selecting one from each unit.

To set One question each from Unit 2, 4, and 5 and two questions each from Units 1 & 3.

Course		Credits : 03			Marks	
Name	**Statistical Quality Control**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DESQC**	**3**	**0**	**0**	**50**	**50**

Note: Use of Statistical quality control table is permitted in the examination

PRE-REQUISITES:
Mathematics-Statistics & Probability; Manufacturing Processes;

SYLLABUS:

UNIT – 1

Introduction: Definitions of Quality and Quality Improvement; Brief History of Quality Methodology; Statistical Methods for Quality Control and Improvement; The DMAIC Process, Total Quality Management (quality philosophy, links between quality and productivity, quality costs, legal aspects of quality implementing, quality improvement). **4 Hours**

UNIT – 2

Modelling Process Quality: Mean, Median, Mode, Standard deviation, Calculating area, The Deming funnel experiment, Normal distribution tables, finding the Z score, Central limit theorem. **4 Hours**

Methods of Statistical Process Control: SPC-The Magnificent Seven, Applications of SPC, Chance and assignable causes, Statistical Basis of the Control Charts (basic principles, choices of control limits, significance of control limits, sample size and sampling frequency, rational subgroups, analysis of pattern on control charts, warning limits, Average Run Length-ARL) **4 Hours**

UNIT – 3

Control Charts for Variables: Control Charts for X-Bar and R- Charts, Statistical basis of the charts, Development and use of X bar and R charts, Interpretation of charts. Type I and Type II errors, the probability of Type II error. Numerical Problems. **6 Hours**

UNIT – 4

Process Capability: The foundation of process capability, Natural Tolerance limits, c p – process capability index, c pk , p p – process performance index, summary of process measures. Numerical problems. **4 Hours**

Control Charts for Attributes: Binomial distribution, Poisson distribution (from the point of view of Quality control) Control Chart for Fraction Nonconforming, Control Chart for number Nonconforming, Control Charts for Nonconformities or Defects, Control Chart for Number of non-conformities per unit. Numerical problems. **5 Hours**

UNIT – 5

Lot-by-Lot Acceptance Sampling for Attributes: The acceptance sampling problem, single sampling plan for attributes, Double, Multiple, and Sequential sampling, AOQL, LTPD, OC curves, Military Standard 105E, the Dodge-Romig sampling plans. Numerical problems. **6 Hours**

Cumulative-Sum (CUSUM) & Exponentially Weighted Moving Average (EWMA) Control Charts: CUSUM Control Chart (basic principles of the chart for monitoring the process mean); EWMA control chart (EWMA control chart for monitoring process mean), design of an EWMA control chart. **6 Hours**

TEXT BOOK:

1. Statistical Quality Control, E.L. Grant & R.S. Leavenworth, 7th Ed., McGraw- Hill.
2. Statistical Quality Control, R C Gupta, Khanna Publishers, New Delhi, 2005
3. Introduction to Statistical Quality Control, Douglas C Montgomery, Publisher: Wiley; 8th Ed.

REFERENCE BOOKS:

1. **Statistical Process Control and Quality Improvement**, Gerald M. Smith, Pearson Prentice Hall. ISBN 0 – 13-049036-9.
2. **Statistical Quality Control for Manufacturing Managers**, W S Messina, Wiley & Sons, Inc. New York, 1987
3. **Principles of Quality Control**, Jerry Banks, Wiley & Sons, Inc. New York.

MOOCS:

1.https://nptel.ac.in/courses/110/105/110105088/

COURSE OUTCOMES

Upon completion of this course, student will be able to:

CO 1	Analyse different statistical methods for statistical process control.
CO 2	Assess general advantages and disadvantages for alternative process control methods
CO 3	Compare alternative process control methods
CO 4	Identify the different quality control techniques for varying sampling methods
CO 5	Formulate an adequate statistical control problem for a production or similar process.
CO 6	Estimate the quality measures in general by means of modern and relevant statistical tools.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 2& 3 and two questions each from Units 4& 5.

Course		Credits : 03			Marks	
Name	**Python Programming**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DEPYP**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
Basic Programming Skills, Mathematics

SYLLABUS:

UNIT – 1

Introduction to python: Course Overview, Python Development Environments, Simple and compound expressions, Keywords, identifiers, Statements, comments, Assignments, Variables, Datatypes-Numbers, List, Tuple, String, Set, Dictionary, Type conversion, I/O and import, operators, namespace, Handling Errors in python **8 Hours**

UNIT – 2

Logical and Conditionals: Logical expressions, Comparisons, Conditional execution, loops(For, While, If-Else, Switch case, Pass statements). **3 Hours**
Files: File Operations, Open a file, Creating a File, Reading From a File, File offsets, Renaming and deleting, File object methods, Iterating through files **3 Hours**

UNIT – 3

Python Modules, packages, string and list methods: Using modules, package and its use, Characters and strings, String methods, Strings in action, Regular Expressions (RegEx) Simple programs. **7 Hours**

UNIT – 4

Functions: What is a function? Calling and defining functions, local and global variables, name resolution, return statement, functions as objects, function attributes, examples **5 Hours**
Class and Objects: Can I use OOP with python?, Python Classes, Creation of classes, Class Methods, Inheritance, Encapsulation, Polymorphism. **4 Hours**

UNIT – 5

Python requirements for Machine Learning: Python Scipy libraries: Scipy, pandas, Numpy, Dataframes, Matplotlib, sklearn, Seaborn packages **6 Hours**

TEXT BOOK:
1. Python Crash Course: A Hands-On, Project-Based Introduction to Programming, Eric Matthes, 2nd Edition.
2. Learn Python the Hardway by Zeo A Shaw, 3rd Edition.

REFERENCE BOOKS:
1. **Introducing Python** by Bill Lubanovic, O'Reilly Media, 2014.
2. **Python Essential Reference**, 4th Edition by David M. Beazley, Pearson Education, 2009
3. **Learning with Python: How to Think Like a Computer Scientist**, Allen Downey, Jeffrey Elkner and Chris Meyers, Dreamtech Press, 2015.
4. **Learning to Program using Python** by Cody Jackson, Second Edition, 2014.
5. **Programming Python**, Mark Lutz, O'reilly Media, 2015

E-BOOKS:
http://www.onlineprogrammingbooks.com/learning-program-using-python/
http://www.greenteapress.com/thinkpython/thinkpython.pdf

MOOCS:
1. https://www.coursera.org/learn/python

2. https://www.edx.org/course/introduction-computer-science-mitx-6-00-1x-8
3. https://www.class-central.com/mooc/4174/coursera-python-data-structures

COURSE OUTCOMES

Upon completion of this course, student will be able to:

CO 1	Apply the Python environment, basic operations, objects, files, exceptions, OOPs concepts, databases and System tools.
CO 2	Use operations and constructs of programming to implement solutions for engineering problems
CO 3	Provide an analysis for usage of file operations, exception hierarchy and connectivity to database.
CO 4	Justify the importance of different programming constructs and system tools.
CO 5	Implement control structures using appropriate techniques and resources.
CO 6	Interpret various scenario based problems to provide feasible solutions.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Units 2, 3 & 5 and two questions each from Units 1 & 4.

Electives – Group 2

Course		Credits : 03			Marks	
Name	**Surface Engineering**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DESFE**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:

- Engineering chemistry, Physics, Material science & Strength of materials

SYLLABUS:

UNIT – 1

Fundamentals of surface engineering: Surface engineering: classification, definition, scope and general principles, role and estimate of surface roughness. Surface engineering techniques: Cleaning, pickling, etching, grinding, polishing, buffing / puffing (principles only). **6 Hours**

UNIT – 2

Surface engineering by material addition: Surface engineering by material addition: From liquid bath - hot dipping (principle and its application with examples), Electro deposition/ plating: theory and its scope of application.
Surface modification of ferrous and non-ferrous components: Aluminizing, anodizing, calorizing, diffusional coatings (principle and scope of application).
Surface modification using liquid/molten bath: Cyaniding, liquid carburizing (principle, scope of application & diffusion from liquid state).
Surface modification using gaseous medium: Nitriding, carbo-nitriding (principle, scope of application). **10 Hours**

UNIT - 3

Surface coating techniques:
Thin film coatings: PVD: Evaporation, sputtering (DC, RF, and Magnetron), CVD and PECVD, Plasma and ion beam deposition.
Thick film coatings: Plasma spray coating, HVOF & cold spray (principle, process parameters and scope of application).
Functional and Nano-structured coatings: applications in photovoltaics, bio- and chemical sensors, Silicon wafer deposition (Principle and its applications). **10 Hours**

UNIT – 4

Coating characterization: Measurement of coatings thickness porosity & adhesion of surface coatings, measurement of residual stress & stability, surface microscopy & topography by scanning probe microscopy, spectroscopic analysis of modified surfaces, characterization of surface microstructure and properties (name of the techniques and brief operating principle). **7 Hours**

UNIT – 5

Surface engineering by energy beams: General classification, scope and principles, types and intensity/energy deposition profile.
Surface engineering by energy beams: Laser assisted microstructural modification – surface melting, hardening, shocking, surface cladding and surface alloying of steel, non-ferrous metals and alloys. **6 Hours**

TEXT BOOKS

- Surface Engineering for Corrosion and Wear Resistance. J. R. Davis.
- Deposition technologies for films and coatings: developments and applications by R. F. Bunshah, Noyes Publications; First Edition (June 1982), ISBN: 978-0815509066

- K.G. Budinski, Surface Engineering for Wear Resistances, Prentice Hall, Englewood Cliffs, 1988.
- M. Ohring, The Materials Science of Thin Films, Academic Press Inc., 2005
- Surface Finishing Systems. metal and non-metal finishing handbook-guide, George J. Rudzki - - Metals Park : ASM, 1983

REFERENCE BOOKS

- Surface Preparation and Finishes for Metal, James A. Murphy- McGraw-Hill, New York 1971
- Surface treatment and finishing of Aluminium and its alloy,Volume-2, P. G. Sheasby and R. Pinner - - ASM, Metals Park, 1987 - 5th ed.,
- Steel and its Heat Treatment Bofors Handbook, K. E. Thelning - London: Butterworths, 1975.
- Surface Engineering Hand Book, Keith Austin, - London : Kogan Page, 1998

MOOCs/ WEB REFERENCES:

- http://nptel.ac.in/courses/112105053/

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Identify the various surface engineering techniques based on relevance applications.
CO 2	Categorize various surface addition methods based on mechanical & chemical properties and its applications.
CO 3	Select appropriate coating technique for thin and thick films based on relevant applications.
CO 4	Evaluate material properties using various coating characterization techniques.
CO 5	Analyze different energy beam methods of surface modification

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 4, 5& two questions each from Units 2 & 3.

Course		Credits : 03			Marks	
Name	**Composite Material Technology**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DECMT**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
Strength of Materials.

SYLLABUS

UNIT – 1

Introduction to Composite Materials: Definition, classification and characteristics of composite Materials – fibrous composites, laminated composites, particulate composites, Nano composites. **Applications,** future potential of composites. **5 Hours**

Fiber Reinforced Plastic Processing: Layup and curing, fabricating process, open and closed mould process, hand layup techniques; structural laminate bag molding, production procedures for bag molding; filament winding, pultrusion, pulforming, thermoforming, injection molding, blow molding. **6 Hours**

UNIT – 2

Micro Mechanical Analysis of a Lamina: Introduction, Evaluation of the four elastic moduli by Rule of mixture, Numerical problems.

Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Two – dimensional relationship of compliance and stiffness matrix.
6 Hours

UNIT – 3

Macro Mechanics of a Lamina Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems. **6 Hours**

Biaxial Strength Theories: Maximum stress theory, Maximum strain theory, Tsai-Hill theory, Tsai, Wu tensor theory. **4 Hours**

UNIT – 4

Macro Mechanical Analysis of Laminate: Introduction, code, Kirchhoff hypothesis, CLT, A, B, and D matrices (Detailed derivation), Special cases of laminates. **6 Hours**

UNIT – 5

Metal Matrix Composites: Reinforcement materials, types, characteristics and selection base metals selection. Need for production MMC's and its application.

Fabrication Process for MMCs: Powder metallurgy technique, liquid metallurgy technique, diffusion bonding, squeeze technique and secondary processing. **6 Hours**

TEXT BOOKS:

1. **Mechanics of Composite Materials**, Robert M Jones, 2nd Edition, CRC Press, 1998.
2. **Fiber Reinforced Composites, Materials, Manufacturing, and Design,** P. K. Mallick, 3rd Edition, CRC Press, 2007.

REFERENCE BOOKS:

1. **Mechanics of composite materials**, Autar K. Kaw, 2nd Edition, 2005, CRC Press New

York.
2. **Composite Science and Engineering**, K. K. Chawla, 3rd Edition, Springer Verlag 2012.
3. **Composite materials hand book,** Mel M Schwartz, 2nd Edition, McGraw Hill Book Company, 1991
4. **Principles of composite Material mechanics,** Ronald F. Gibron. 3rd Edition, McGraw Hill international, 2011.
5. **Mechanics of Composite Materials and Structures**, Madhujit Mukhopadhya, University Press 2005.

E-Books:
1. http://www.ae.iitkgp.ernet.in/ebooks/

MOOCs:
1. http://nptel.ac.in/downloads/101104010/

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

CO 1	Classify different composite materials based on the composition and structure of the composite material and identify their applications
CO 2	Choose from different manufacturing techniques for making of composites based on type of application
CO 3	Evaluate composite elastic properties based on micro-mechanical behaviour
CO 4	Analyse the composites for their mechanical properties based on macro-mechanical behaviour
CO 5	Examine the composite for their failure mechanisms
CO 6	Formulate A, B and D matrices of Composite laminates based on Kirchhoff's hypothesis and propose different laminate types

Scheme of Examination (SEE):
Students to answer five full questions selecting one from each unit.
To set one question each from Units 2, 4 & 5 and two questions each from Units 1 & 3.

Course		Credits : 03			Marks	
Name	**Internal Combustion Engines**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DEICE**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT – 1

Thermodynamic Cycle Analysis: Deviation from ideal processes, Factors affecting Fuel – Air cycles: Effect of variable specific heats, Effect of dissociation, Effect of operating variables on performance of Fuel Air cycles, Simple numerical problems. **6 Hours**

UNIT – 2

Carburation: Mixture requirements in S.I engine, Simple Carburettor and its limitations, calculation of air-fuel ratio. Simple Numericals

Injection Systems in CI engines: Introduction to Mechanical Injection System, Functional Requirements and classification, Fuel feed pump and Fuel Injector, Spray Characteristics: spray formation, penetration, Atomisation, Rate of fuel Injection using Bernoulli's equation, Simple Numericals

Electronic injection systems: Types, Merits and Demerits, Multi point fuel injection system (MPFI), Electronic control system, Injection timings, Common –Rail Fuel Injection System, HCCI, RCCI. **6 Hours**

UNIT – 3

Combustion Process in S.I. Engines : Theories of combustion process in S.I. engines, Knock free and knocking combustion, Effect of Knock on engine performance, Effect of operating variables on knocking., Knock rating of fuels-octane number, Knock Modelling (Simple Numericals), HUCR values, Anti knock agents Pre ignition - Post ignition.

Combustion in C.I. Engines: Ricardo's three stages of combustion process in C.I. engines, Delay period, factors affecting delay period, Hardenberg and Hase correlation ignition delay. Simple Numericals, Diesel knock Methods of controlling diesel knock, Knock rating of Diesel fuels. **6 Hours**

UNIT – 4

Combustion Chambers: Requirements of combustion chambers, Features of different types of combustion chambers for S.I. engine, System for S.I. engine. I-head, F-head combustion chambers, Chambers, Air swirl turbulence-M type combustion chamber, C.I. engine combustion, Comparison of various types of combustion chambers.

Heat Transfer in engine and cooling: Introduction, Engine Cooling Systems, Engine Energy Balance, Cylinder Heat Transfer, Heat Transfer Modelling, Heat Transfer Correlations, Overall Average Heat Transfer Coefficient, Simple Numericals **6 Hours**

Fuels: Requirements of a good fuel for IC Engine, Chemical structure of fuels, Influence of chemical structure on knock, Alternative fuels: Alcohols-Properties, advantages and disadvantages, Vegetable oils, Di-methyl ether (DME), Bio gas, design modification **5 Hours**

UNIT – 5

Emission Regulation and Control Systems: Mechanism of pollutant formation, Total emission control package- thermal reactor package, Catalytic converter package, DOC (Diesel Oxidation Catalyst), DPF (Diesel Particulate Filters), Control of NOX -Exhaust gas recirculation, Water injection, Selective catalytic reduction, Emission norms: Bharat stage 4 and 6. **5 Hours**

Modern Developments in Engines:: Super charging of I. C. engines, Factors, Methods, thermodynamic cycle, Types of superchargers (Simple numerical), Stratified charge engines (Lean burned SI engine), Multi fuel engines, Rotary piston engine, Two injector engines, Pilot ignition engine, all ceramic swirl chamber engines, ECU mapping. **5 Hours**

Text Books:

1. **A course in I.C. Engines**, M. L. Mathur and R. P. Sharma, Dhanpat Rai Pub, 2001.
2. **Internal Combustion Engines**, Colin R. Ferguson C. John Wiley & Sons, 1986

Reference Books

1. I.C. Engines, Edward. F. Obert, Harper International edition, 1973.
2. Internal Combustion Engines, Ganeshan, Tata McGraw Hill, 2nd Edition, 2003.
3. Engineering Fundamentals of the I.C. Engine, Willard W. Pulkrabek. 1998.
4. Combustion Engine Process, Lichty, Judge 2000

COURSE OUTCOMES

Upon completion of this course, student will be able to:

CO 1	Compare ideal and real thermodynamic cycles and different types of fuels with respect to their advantages and limitations
CO 2	Evaluate the engine parameters considering theoretical and actual cycles
CO 3	Analyse the current and future SI and CI engine designs, combustion processes, effect of operating variables on engine performance, effect of dissociation, variable specific heats, and exhaust dilution on thermodynamic cycles, chemical structure of fuels
CO 4	Identify the requirements of combustion process for SI and CI engines
CO 5	Understand the effect of I.C. Engine emissions on environment and public health and control them.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

To set one question each from Unit 1, 2 & 3 and two questions each from Unit 4 & 5.

Course		Credits : 03			Marks	
Name	**Biomechanics of Human Movement**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DEBHM**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
Engineering Mechanics

SYLLABUS:

UNIT – 1

Introduction to Biomechanics: - Basic terminology and concept of human musculoskeletal system, anatomy and overall function, structure and function of joints **8 Hours**

UNIT – 2

Measurement of Human Movement: Direct motion measurement systems, Imaging systems electro goniometers, accelerometers, gyroscopes, force platforms, measuring energy consumption, kinematic systems, combined kinematic/kinetic systems, calculation limb and joint angles, calculation of velocity and acceleration, anthropometry, calculation of moments from kinematic and kinetic data. **8 Hours**

UNIT – 3

Work and Energy: Introduction, efficiency, causes of inefficient movement, Calculation of internal and external work, power balance.
Muscle Mechanics: Introduction, Force length characteristics, force velocity characteristics, muscle modelling, Electromyography **8 Hours**

UNIT – 4

Biomechanics of Walking: kinematics, kinetics and energetics of human walking, muscle activity during walking. **8 Hours**

UNIT – 5

Modelling and Simulation of Human Movement: Need for models, Dynamic modelling of human movement, case studies. **7 Hours**

TEXT BOOKS:

1. D. Gordon, E. Robertson, Graham E. Caldwell, Joseph Hamill, Gary Kamen, Saunders N. Whittlesey, "Research Methods in Biomechanics", 2nd Edition, 2014, Human Kinetics Inc.
2. Winter D. A., Biomechanics and Motor Control of Human Movement, Wiley, 2009 Incorporated.

REFERENCE BOOKS

1. J Rose, J G Gamble, Human Walking, Lippincott Williams & Wilkins, 2006
2. Nordin, M., & Frankel, V. H. Basic biomechanics of the musculoskeletal system, Lippincott Williams & Wilkins
3. Whitle M, Gait Analysis: An Introduction, Butterworth Heienmann, 2006

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Apply principles of classical mechanics to the study of human motion
CO 2	Analyse human movement from experimental data
CO 3	Identify the muscle actions that cause movement
CO 4	Discuss the internal and external forces acting on the body during typical human activities

CO 5	Elaborate the methods and limitations of different experimental and analytical techniques used
CO 6	Model simple human movements

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

To set one question each from Unit 1, 4 & 5 and two questions each from Unit 2 & 3.

Course		Credits : 03			Marks	
Name	**Electric and Hybrid Vehicles – 1**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DEEV1**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT – 1

Introduction to Electric Vehicles: EV System, EV History, Electric Vehicles and the Environment, EV Advantages, EV Market, Usage Patterns for Electric Road Vehicles **04 Hours**

Types of Electric Vehicles – EV Architecture: Battery Electric Vehicles, The IC Engine/Electric Hybrid Vehicle, Fuelled EVs, EVs using Supply Lines, EVs which use Flywheels or Supercapacitors, Solar-Powered Vehicles, Vehicles using Linear Motors, EVs for the Future **03 Hours**

UNIT – 2

Internal Combustion Engines: Spark Ignition Engine - Basic Structure and Operation Principle with Otto Cycle, Operation Parameters, Basic Techniques for Improving Engine Performance, Efficiency, and Emissions, Brief Review of SI Engine Control System, Operation Principle with Atkinson Cycle; Compression Ignition Engine, Alternative Fuels and Alternative Fuel Engines. Fuel economy characteristics of internal combustion engine. **06 Hours**

UNIT – 3

Fundamentals of Vehicle Propulsion and Braking: Roadway Fundamentals, Laws of Motion, General Description of Vehicle Movement, Vehicle Resistance, Dynamic Equation, Tire–Ground Adhesion and Maximum Tractive Effort, Power Train Tractive Effort and Vehicle Speed, Vehicle Performance, Operating Fuel Economy, Brake Performance, Velocity and Acceleration, Propulsion System Design. Vehicle power plant and transmission characteristics and vehicle performance including braking performance. **09 Hours**

UNIT – 4

Vehicle Transmission: Power Plant Characteristics, Transmission Characteristics, Manual Gear Transmission (MT), Automatic Transmission, Continuously Variable Transmission, Infinitely Variable Transmissions, Dedicated Hybrid Transmission (DHT) **05 Hours**

Electric Vehicles: Configurations of Electric Vehicles, Performance of Electric Vehicles, Tractive Effort & Energy Consumption in Normal Driving, Regenerative Braking. Drive Cycles: Simple & Standard. **04 Hours**

UNIT – 5

Energy Source - Battery: Battery Basics, Lead-Acid Battery, Alternative Batteries, Battery Parameters, Technical Characteristics, Targets and Properties of Batteries, Battery Modelling **06 Hours**

REFERENCES:

Text Books

1. "Electric and Hybrid Vehicles - Design Fundamentals", Iqbal Husain, CRC Press, 2005
2. "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", M. Ehsani, Y. Gao, S. Longo and K. Ebrahimi, 3rd Ed., 2018

Reference Books

1. "Electric Vehicle Technology Explained", James Larminie, John Lowry, Wiley Publications, 2nd Ed., 2012
2. "Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles "John G. Hayes & G. Abas Goodarzi, John Wiley & Sons, 2018

MOOCs

1. Electric Cars: Introduction - edX [https://courses.edx.org/courses/course-v1:DelftX+eCARS1x+3T2019/course/]
2. Electric Vehicles - Part 1 - SWAYAM https://onlinecourses.nptel.ac.in/noc20_ee18
3. Fundamentals of Electric vehicles: Technology & Economics, https://onlinecourses.nptel.ac.in/noc20_ee99

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Explain types & architectures of various electric vehicles.
CO 2	Analyse vehicle mechanics, propulsion & braking
CO 3	Evaluate electric vehicle performance as compared to I.C Engines
CO 4	Perform battery modelling for various requirements

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

Two questions each to be set from Units 3 and 4 and one question from units 1, 2, and 5.

Course		Credits : 03			Marks	
Name	**Experimental Techniques for Incompressible Flow**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DEETF**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
Fluid Mechanics, Mathematics.

SYLLABUS:

UNIT - 1

Introduction: Aerodynamics, Properties of Air and Water, Flow Similarity, Incompressible Flow, Time Dependence of the Solutions, Aero acoustics.
Wind tunnels: Important Parameters for Similarity, Types of Wind Tunnels, Discussion on Aeronautical Wind Tunnels, Smoke Tunnels, Automobile Wind Tunnels, Aero acoustic Wind Tunnels, Water Tunnels, General-Purpose Wind Tunnels and Environmental Wind Tunnels.
Wind tunnel design: Power Considerations, Section Loss Coefficients, Energy Ratios of Some Typical Circuits, Fan-Straightener Section, Return (or Second) Diffuser, Cooling, Test-Section Flow Quality, Approach to Flow Improvement, Drive System, Wind Tunnel Construction, Test-Section Inserts, Safety. **12 Hours**

UNIT – 2

Pressure, Flow, and Shear Stress Measurements
Pressure, Temperature, Flow Instrumentation, Boundary Layers and Surface Shear Stress, Flow Field and Surface Analyses.
Flow visualization: Path, Streak, Stream, and timelines, Direct Visualization, Surface Flow Visualization, Flow Field Visualization, Data-Driven Visualization.
Calibration of the Test Section: Test-Section Flow Calibration, Wind Tunnel Boundary Layers, Acoustics, Wind Tunnel Data Systems **12 Hours**

UNIT 3

Forces and Moments from Balance Measurements: Forces, Moments, Reference Frames, Balances, Balance Requirements and Specifications, External Balances, Fundamentals of Model Installations, Internal Balances. **06 Hours**

UNIT-4

Boundary Corrections I: Basics and Two-Dimensional Cases: Descriptions of Wind Tunnel Flow, Mathematical Models, Related Developments, and Bodies Spanning the Tunnel. **05 Hours**

UNIT - 5

Experimentation using the wind tunnel facility: Strain gauge force balances, Pressure measurement, smoke visualisation, hot wire thermometry, Aerodynamic analysis on standard geometries. **05 Hours**

Textbooks:

1. Low speed wind tunnel testing, Jewel B. Barlow, William H. Rae, Alan Pope, 3rd edition, John Wiley and Sons (1999).
2. Goldstein, Fluid Mechanics Measurements, 2nd ed., Washington, D.C.: Hemisphere (1983)
3. Van Dyke, An Album of Fluid Motion, Stanford, Calif.: Parabolic Press (1982)
4. Wind Tunnels and their instrumentation - S. M.GORLIN and I. I. SLEZINGER.

References:

1. Handbook of Experimental Fluid Mechanics, Topera, Yarin, Foss, Springer.

2. Bendat and Piersol, Random Data: Analysis and Measurement Procedures, 2nd ed, New York: Wiley (1986)

COURSE OUTCOMES

Upon completion of this course, student will be able to:

CO 1	Understand and design and develop wind tunnels.
CO 2	Apply the measurement and analysis techniques for fluid flow.
CO 3	Conduct and design experiments independently on fluid flow, wind tunnel facility
CO 4	Perform aerodynamic analysis for the standard geometries.
CO 5	Analyse the data and interpret data using the concepts of flow physics

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
Setting one question each from Unit 3, 4 & 5 and two questions each from Units 1 & 2.

Course		Credits : 03			Marks	
Name	**Flexible Manufacturing Systems**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME5DEFMS**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT – 1

Introduction: Introduction to manufacturing system, different type of manufacturing system, volume variety relationship for understanding manufacturing system. **2 Hours**

Flexible Manufacturing System: Components of an FMS, types of system, where to apply FMS technology, FMS work stations. Material handling and storage system: Functions of the handling system, FMS layout configuration, Material handling equipment, FMS Installation, FMS implementation. **2 Hours**

Computer control system: Computer function, FMS data file, system reports planning the FMS, analysis method for FMS, application and benefits. **2 Hours**

UNIT – 2

Distributed data processing in FMS: DBMS and their applications in CAD/CAM and FMS distributed systems in FMS –Integration of CAD and CAM - Part programming in FMS, tool data base - Clamping devices and fixtures data base. **4 Hours**

Manufacturing Cell: Introduction, Description and Classifications of Cell, Unattended Machining, Cellular versus Flexible Manufacturing. **3 Hours**

UNIT – 3

Group Technology: Part families, part classification and coding. Types of classification and coding system, Machine cell design: The composite part concept, types of cell design. Determining the best machine arrangement, benefits of group technology. **5 Hours**

Just In Time and Lean Production: Lean Production and Waste in Manufacturing, just in time production system, automation, work involvement. **3 Hours**

UNIT – 4

Production Planning and control systems: Aggregate Production Planning and the master production schedule, Material Requirements and Planning, capacity planning, shop floor control, inventory control, and extensions of MRP. **4 Hours**

CMM: Introduction, Types, Construction and General Functions of CMM, Operational Cycle Description, CMM Applications, Importance to Flexible Cells and Systems, contact and non-contact inspection principles - programming and operation-in cycle gauging. **5 Hours**

UNIT – 5

Automated Material Movement and Storage System: Introduction, Types of AGV and Their principle of working, Advantages, Limitation and General AGV Guide path, Robots, Benefits of using Industrial Robots, Basic components and benefits of Automated Storage and Retrieval Systems, Conveyors and Pallet Flotation System, Queuing Carrousels and Automatic Work Changers, Coolant and Chip Disposal and Recovery system. **5 Hours**

Cutting Tools and Tool Management: Introduction, Control of Cutting Tools, Tool Management, Tool Strategies, Tool Preset, Identification and Data Transfer, Tool Monitoring and Fault Detection. **4 Hours**

TEXT BOOKS:

1. Paul Ranky., “The design and operation of FMS”, IFS publication, 1983.
2. Mikell P Groover, “Automation Production systems, Computer Integrated Manufacturing”, Prentice Hall, 1987.
3. David J. Parrish, “Flexible Manufacturing” Butterworth-Heinemann, 1990

REFERENCE BOOKS:

1. Flexible Manufacturing System, H. K. Shivanand, M. M. Benal, V. Koti, Publisher : New Age Pub.

2. CAD/CAM, Groover M.P, Zimmers E.W, Publisher : Prentice Hall of India.
3. Flexible Manufacturing Cells and Systems, Luggen

COURSE OUTCOMES

Upon completion of this course, student will be able to:

CO 1	Analyse FMS, Material handling equipment and its applications.
CO 2	Establish integration of CAD / CAM into FMS.
CO 3	Implementation of GT, JIT & Lean production in industries.
CO 4	Understand the principles of PPC and CMM.
CO 5	Categorize various types of AGVS and interpret the importance of Tool Management System.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 2 & 3 and two questions each from Units 4 & 5.

VI Semester Syllabus

Course		Credits : 03			Marks	
Name	**Mechanical Vibrations**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DCMEV**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
1. Engineering Mechanics
2. Engineering Physics
3. Engineering Mathematics (ODE and PDE)

SYLLABUS:

UNIT – 1

Introduction: Types of vibrations, Definitions, Simple Harmonic Motion (S.H.M.), Work done by harmonic force,

Undamped Free vibration of single-degree-of-freedom systems: Derivations for spring mass systems, Methods of Analysis, Natural frequencies of simple systems, Springs in series and parallel, Torsional and transverse vibrations, Effect of mass of spring and Problems. **8 Hours**

UNIT – 2

Damped free vibrations: Types of damping, Analysis with viscous damping - Derivations for over, critical and under damped systems, Logarithmic decrement and Problems. **6 Hours**

UNIT – 3

Harmonically excited vibration: Introduction, Analysis of forced vibration with constant harmonic excitation - magnification factor, rotating and reciprocating unbalances, excitation of support (relative and absolute amplitudes), force and motion transmissibility, Energy dissipated due to damping and Problems.

Whirling of shafts with and without damping, discussion of speeds above and below critical speeds and Problems. **10 Hours**

UNIT – 4

Vibration of two-degree-of-freedom systems: Principle modes of vibrations, Normal mode and natural frequencies of systems (without damping) – Simple spring mass systems, masses on tightly stretched strings, double pendulum, torsional systems, combined rectilinear and angular systems, Undamped dynamic vibration absorber and Problems. **6 Hours**

UNIT – 5

a) Vibration of multi degree freedom systems: Introduction, Maxwell's reciprocal theorem, Influence coefficients, Orthogonality of principal modes, Matrix method, Stodola method, Holzer's method. **9 Hours**

b) Modal analysis & MATLAB programming (attainment only through Alternate assignment tool): Basics of Modal analysis, Introduction to Signal analysis, dynamic testing of machines and structures, Machine condition monitoring and diagnosis.

MATLAB programming: In each chapter students will use numerical codes based on MATLAB to plot response function for various excitations and initial conditions.

TEXT BOOKS:
1. **Mechanical Vibrations (English)** 8th Edition, G. K. Grover, Nem Chand and Brothers
2. **Mechanical Vibrations:** V.P. Singh, Dhanpat Rai & Company Pvt. Ltd., 3rd edition, 2006.
3. **Mechanical Vibrations and Noise Engineering**, A.G. Ambekar, 2nd Edition, 2006

REFERENCE BOOKS:
1. **Mechanical Vibrations:** S.S. Rao, Pearson Education Inc., 4th Edition, 2003.
2. **Mechanical Vibrations:** S. Graham Kelly, Schaum's Outline Series, Tata McGraw Hill, Special Indian edition, 2007.

3. **Theory & Practice of Mechanical vibrations:** J.S. Rao & K. Gupta, New Age International Publications, New Delhi, 2001.
4. **Theory of Vibration with Applications:** W.T. Thomson and Marie Dillon Dahleh, Pearson Education 5th edition, 2007.
5. **Elements of Vibrations Analysis:** Leonanrd Meirovitch, Tata McGraw Hill, Special Indian edition, 2007.

MOOCs:

1. Mechanical Vibrations - http://nptel.ac.in/courses/112103112/
2. Mechanical Vibration - http://ocw.mit.edu/courses/mechanical-engineering/2-003sc-engineering-dynamics-fall-2011/mechanical-vibration/

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Apply basics of engineering such as Newton's second law and the principle of conservation of energy to model mechanical systems using mass, spring and damper elements and develop mathematical models to obtain their governing equations of motion and hence their response.
CO 2	Ability to analyse the vibrational motion of 1-DOF mechanical systems under harmonic excitation conditions.
CO 3	Model the 2DOF physical system into schematic models and formulate & analyse the equations of motion.
CO 4	Compute the responses of multi degree of freedom systems through modal analysis and interpret the results.
CO 5	Develop basic numerical simulation skills using MATLAB to simulate the response of mechanical system models.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 2, & 4 and two questions each from Units 3 & 5.

Course		Credits : 04			Marks	
Name	**Fundamentals of Heat Transfer**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DCFHT**	**2**	**1**	**1**	**50**	**50**

PRE-REQUISITES:
1. Mathematics
2. Thermodynamics
3. Fluid Mechanics

SYLLABUS:

UNIT – 1

Introduction: Introduction to heat transfer and different modes, physical origins and rate equations, Relationship to thermodynamics, Thermal properties of matter, The heat diffusion equation (in Cartesian coordinate), boundary and initial conditions, special cases, discussion on 3-D conduction in cylindrical and spherical coordinate systems (no derivation) **(2L + 1T)**

Conduction: One dimensional steady state conduction: Plane wall, cylinder and sphere, Thermal contact resistance, Critical thickness of insulation. Conduction with thermal energy generation: plane wall, radial systems **(3L + 1T)**

Heat Transfer in Extended Surfaces: Heat transfer through rectangular fin: Long fin, short fin with insulated tip and convective tip. Fin efficiency and effectiveness. **(2L + 1T)**

Transient Conduction: Lumped parameter analysis, Use of Heisler's charts for transient conduction in slab, long cylinder and sphere. **(2L + 1T)**

UNIT – 2

Convective Heat Transfer: Velocity and Thermal boundary layers, in laminar and turbulent flow conditions, Local and avg. convection coefficients, Boundary layer equations for laminar flow and its normalized form, physical interpretations of relevant non-dimensional numbers. **(2L + 1T)**

Forced convection: External flow: The flat plate in parallel flow: Laminar (Blasius solution) and turbulent flow over isothermal plate, Energy equation, Mixed boundary layer conditions, Flat Plates with Constant Heat flux conditions, Cylinder in Cross Flow, Sphere in a flow. **(2L + 1T)**

Internal flow: Hydrodynamic and thermodynamic Considerations, Mean Velocity, Velocity Profile in the Fully Developed Region, Mean Temperature, Newton's Law of Cooling, Fully Developed Conditions, Laminar Flow in Circular Tubes: Thermal Analysis and Convection Correlations for, fully developed and entry regions. **(3L + 1T)**

UNIT – 3

Free convection: The Governing Equations for Laminar Boundary Layers, Empirical Correlations: External Free Convection Flows, Vertical plate, Inclined and horizontal Plates, Long horizontal cylinder, enclosures and Spheres. **(3L + 2T)**

UNIT – 4

RADIATION HEAT TRANSFER: Basic concepts, Radiation heat fluxes, Radiation Intensity, Black body radiation: Planck's distribution, Wein's law, Stefan-Boltzmann law, Kirchhoff's law and Lambert's cosine law. Absorption, Reflection, transmission, and emission by real surfaces, View factor, Blackbody Radiation Exchange**,** Radiation Exchange between Opaque, Diffuse, Gray Surfaces in an Enclosure, Two-Surface Enclosure, Radiation Shields **(4L + 2T)**

UNIT – 5

Heat Exchangers: Thermal design of heat exchangers, overall heat transfer coefficient, fouling and fouling factor, Temperature profile of heat exchangers, Log Mean Temperature Difference (LMTD): parallel & counter flow, LMTD correction factor, heat transfer effectiveness-NTU methods of analysis of heat exchangers. **(3L + 2T)**

TEXT BOOKS:

1. **Fundamentals of heat and mass transfer,** Frank P. Incropera and David P. Dewitt, John Wiley and Son's.
2. **Heat transfer, a practical approach,** Yunus A- Cengel, 5th Edition, Tata Mc Graw Hill

REFERENCE BOOKS:

1. **Heat transfer-A basic approach,** Ozisik, Tata Mc Graw Hill 2002
2. **Heat transfer,** P.K. Nag, Tata Mc Graw Hill 2007.
3. **Heat Transfer, Holman,** Mc Graw Hill
4. **A Textbook on Heat Transfer**, Sukhatme S P

E-Books/Web references:

1. A Text book of Heat Transfer, John H Lienhard, 4th Edition,
2. NPTEL Heat Transfer course for Mechanical Engineering, http://nptel.ac.in/courses/112101097/
3. Heat Transfer, Chris Long & Naser Sayma, Bookboon.com

MOOCs:

1. Fluid flow, Heat and Mass Transfer- http://ocw.tudelft.nl/courses/applied-earth-sciences/fluid-flow-heat-mass-transfer/course
2. Heat transfer course- https://legacy.saylor.org/me204/Intro/

HEAT TRANSFER LABORATORY

PART - A

1. Determination of Thermal Conductivity of a Metal Rod.
2. Determination of Overall Heat Transfer Coefficient of a Composite wall.
3. Determination of Effectiveness on a Metallic fin.
4. Determination of Heat Transfer Coefficient in a free Convection on a vertical/horizontal tube.
5. Determination of Heat Transfer Coefficient in a Forced Convention Flow through a Pipe.

PART - B

6. Determination of Emissivity of a Surface.
7. Determination of Stefan Boltzmann Constant.
8. Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers
9. Performance Test on a Vapour Compression Refrigeration.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Identify the mode of heat transfer
CO 2	Apply principles of heat transfer to thermal systems
CO 3	Analyse conduction heat transfer phenomenon for transient processes
CO 4	Determine convective heat transfer for free and forced convection.
CO 5	Formulate the heat transfer process in heat exchangers for parallel and counter flow arrangement
CO 6	Evaluate the parameters of radiative heat exchange process between surfaces.

Scheme of Examination (SEE):

Answer Five full questions selecting one from each unit.
To set one question each from Unit 3, 4 & 5 and two questions each from Units 1 & 2

Course		Credits : 04			Marks	
Name	**Modelling and Finite Element Analysis**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DCMFE**	**3**	**0**	**1**	**50**	**50**

PRE-REQUISITES:
1. Strength of Materials
2. Engineering Mathematics 1, 2 and 3

SYLLABUS:

UNIT – 1

Fundamental concepts: Principles of Elasticity: stresses-principal, maximum shear and von-Mises stresses, Equilibrium equations, strain displacement relationships in matrix form – Constitutive relationships for plane stress, plane strain, Axisymmetric and 3D. Boundary conditions. **5 Hours**

Potential energy and equilibrium, Rayleigh-Ritz method and Galerkin method-applied to simple problems on axially loaded members, cantilever, simply supported beams, with point loads and distributed loads Gaussian quadrature-1pt, 2pt and 3pt formula. **5 Hours**

Introduction to FEM, basic concept, historical background, general applicability, engineering applications, general description ,comparison with other methods of analysis, commercial packages-pre-processor, solver and post processor. **1 Hour**

UNIT – 2

One dimensional problems: Introduction; Finite Element Modelling – Element Division; Numbering Scheme; Coordinate and Shape Functions; The Potential Energy Approach; Assembly of Global Stiffness Matrix and Load Vector; Treatment of Boundary Conditions; Temperature Effects; Numericals. Stiffness matrix of bar element by direct method, Properties of stiffness matrix. **7 Hours**

UNIT – 3

Trusses & Beams: Local and Global co-ordinate systems, Trusses – assumptions, formulation of Truss element, Hermite functions, formulation of beam. Numericals on Trusses and beams. **6 Hours**

UNIT – 4

2D & 3D Formulation: Triangular and quadrilateral elements. Introduction to axisymmetric–triangular elements. **7 Hours**

Convergence criteria-requirements of convergence of a displacement model, Displacement models and shape functions for (i) tetrahedral and hexahedral elements (Pascal pyramid) and (ii) Higher order elements in bar, triangular, quadrilateral elements (no formulations). Lagrangian and serendipity elements. Iso parametric, sub parametric and super parametric elements. **2 Hours**

UNIT – 5

Heat Transfer Problems: Steady state heat transfer, 1D heat conduction governing equation, boundary conditions, One dimensional element, Galerkin approach for heat conduction, heat flux boundary condition, 1D heat transfer in thin fins. Numericals. **6 Hours**

TEXT BOOKS:

1. Introduction to Finite Elements in Engineering, T. R. Chandrupatla and A. D. Belegundu, 2nd Edition, Prentice Hall, India, 2003.
2. The Finite Element Method in Engineering, S.S. Rao, 4th Edition, Elsevier, 2006.

REFERENCE BOOKS:

1. Finite Element Procedures. Bathe, K. J., Cambridge, 2007. ISBN: 9780979004902.
2. Concepts and Applications of Finite Element Analysis by Robert D. Cook, David

S. Malkus and Michael E. Plesha. John Wiley & Sons.2003
3. Finite Element Method, J.N.Reddy, McGraw –Hill International Edition.
4. Finite Element Methods, by Daryl. L. Logon, Thomson Learning 3rd edition, 2001.
5. Finite Element Analysis, C.S.Krishnamurthy,–Tata McGraw Hill Publishing Co. Ltd, New Delhi, 1995.
6. Text book of Finite Element analysis, P.Seshu–Prentice Hall of India.

E-Books

1. INTRODUCTION TO THE FINITE ELEMENT METHOD by Evgeny Barkanov http://icas.bf.rtu.lv/doc/Book.pdf
2. Finite Element Procedures for Solids and Structures Linear Analysis by Klaus-JOrgen Bathe http://www.adina.com/MITRES2_002S10_linear.pdf

MOOCs

1. Finite Element Method (FEM) Analysis and Applications - https://www.edx.org/course/finite-element-method-fem-analysis-tsinghuax-70120073x
2. A Hands-on Introduction to Engineering Simulations https://www.edx.org/course/hands-introduction-engineering-cornellx-engr2000x
3. http://nptel.ac.in/courses/112104115/
4. https://www.coursetalk.com/providers/mit/courses/finite-element-analysis-of-solids-and-fluids-i
5. https://online-learning.tudelft.nl/courses/linear-modeling-fem/

MODELLING AND FINITE ELEMENT ANALYSIS Lab

No. of Practical Hrs/ Week: 02

PART A

i. Study of a FEA package

ii. Linear Static analysis of
a) Trusses
b) Bars of constant cross section area, tapered cross section area and stepped bar
c) Beams -Simply supported, cantilever, beams with UDL, and beams with varying load etc.
d) rectangular plate with a circular hole
e) axisymmetric problems

PART B

iii. Thermal Analysis -1D &2D problem with conduction and convection boundary conditions
iv. Dynamic Analysis
1) beam for natural frequency determination
2) Bar subjected to forcing function
3) Fixed -fixed beam subjected to forcing function

REFERENCE BOOKS:

1. ANSYS Workbench Tutorial Release 14, Structural and Thermal Analysis Using Ansys Mechanical APDL Release 14 Environment, Kent Lawrence, Schroff Development Corporation, www.SDCpublications.com
2. Practical Finite Element Analysis, Nitin S. Gokhale, Sanjay S. Despande, Dr. Anand N. Thite, Finite To Infinite, ISBN 978-81-906195-0-9

Scheme for Evaluation:

One Question from Part A -	10Marks
One Question from Part B -	10Marks
Viva-Voce -	05 Marks
Total	25 Marks

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Apply basics of Theory of Elasticity to continuum problems.
CO 2	Formulate finite elements like bar, truss and beam elements for linear static structural analysis.
CO 3	Develop models for 2D and axisymmetric finite elements and 1D heat transfer
CO 4	Solve problems of limited complexity in structural and heat transfer domain
CO 5	Utilize finite element software to simulate practical problems.
CO 6	Identify boundary conditions to be incorporated and select suitable elements.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

To set one question each from Unit 2, 3 & 5 and Two questions each from Units 1 & 4.

Course		Credits : 03			Marks	
Name	**Control Engineering**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DCCOE**	**2**	**1**	**0**	**50**	**50**

PRE-REQUISITES: Ordinary Differential Equations, Linear Algebra

SYLLABUS:

UNIT – 1

Introduction to Control Systems & system Modelling: Introduction, Basic Terminologies, Open loop & Closed loop control systems, Real time applications, Analysis and design objectives

Transfer Functions, models of mechanical systems (translational and rotational), Electrical Systems, Models of DC Motors, Block representation of control system elements, Modelling of mechanical & electrical systems in State Space. **(7L + 3T)**

UNIT – 2

Time Response Analysis of control systems: Types of standard test signals (inputs), poles and zeros. Analysis of first & second order system response to step input, pole-placement. Higher order system response, system response with zeros. Concept of stability: Routh-Hurwitz Criterion. Steady state errors, system type, static error constant. **(7L + 3T)**

UNIT – 3

Design and Analysis Using Root Locus: Definition of root loci, general rules for constructing root loci, Analysis using root locus plots, Design of PI, PD and PID controllers using root locus **(5L + 3T)**

UNIT – 4

Bode Plots: Introduction, Asymptotic Approximations: Bode Magnitude and Phase angle plots. Stability, Gain Margin & Phase Margin via Bode plot, Design of Lead-lag compensators via Bode Plots **(4L + 3T)**

UNIT – 5

Polar & Nyquist Plots: Sketching of Polar Plots, Nyquist criterion, Sketching Nyquist Diagram, Stability via Nyquist plots **(3L + 1T)**

Text Books

1. **Control Systems Engineering**, 5th Edition, Norman S Nise, Wiley India - 2009

Reference Books:

1. **Modern Control Engineering,** Katsuhiko Ogata, Pearson Education, 2004.
2. **Automatic Control Systems,** B C Kuo, F Golnaraghi, John Wiley & Sons, 2003.
3. **Modern Control Systems,** Richard C Dorf & Robert H Bishop, Prentice Hall, 2008

E-Books:

1. **Feedback Systems: An Introduction for Scientists & Engineers**, Karl J Astrom & Richard M Murray, Version v2.10b, Princeton University Press - http://www.cds.caltech.edu/~murray/books/AM05/pdf/am08-complete_22Feb09.pdf

MOOCs:

1. Dynamics and Control – **edX**: https://www.edx.org/course/dynamics-control-upvalenciax-dc201x-0

COURSE OUTCOMES

Upon completion of this course, student will be able to:

CO 1	Identify the components of control systems given real life situation
CO 2	Develop transfer function models and state-space models of single input single output, linear time invariant systems
CO 3	Analyse the time response of first and second order systems
CO 4	Evaluate the stability of systems using various methods
CO 5	Design PID controllers & Lead-lag compensators

Scheme of Examination:

Answer five full questions selecting one from each unit.
To set one question each from Units 3, 4 & 5 and two questions from Units 1 & 2.

Course		Credits : 01			Marks	
Name	**Design Lab**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DLDES**	**0**	**0**	**1**	**50**	**50**

Preamble: Designing and manufacturing structures of all kinds in an economic and a safe way is not possible without doing experimental stress analysis. The modernity of structures, with their higher reliability demands, as well as today's more stringent safety rules and extreme environmental conditions necessitate the improvement of the measuring technique and the introduction of new ones. Although theoretical/mathematical analysis is improving enormously, an example of which is the finite element model, it cannot replace experimental analysis and vice versa. Moreover, the mathematical analysis needs more and more accurate parameter data which in turn need improved experimental investigations.

SYLLABUS:

PART – A

1. Determination of Principal Stresses and strains in a member subjected to combined loading using Strain rosettes.
2. Determination of stresses in Curved beam using strain gauge.
3. Determination of Fringe constant of Photo elastic material using.
   a) Circular disc subjected to diametral compression.
   b) Pure bending specimen (four-point bending)
4. Determination of stress concentration using Photo elasticity for simple components like plate with a hole under tension or bending, circular disk with circular hole under compression, 2D Crane hook.
5. Demonstration of Axial (Direct-Stress) Fatigue Testing: Physical Aspects of Fatigue: Phase in fatigue life, Crack initiation, Crack growth, Final fracture, Fatigue fracture surfaces.
6. Demonstration of DIC techniques, determination of strain fields in the gauge section of a test specimen under loading

PART – B

7. Determination of equilibrium speed, sensitiveness, power and effort of Porter/Proel /Hartnel Governor.
8. Determination of Pressure distribution in Journal bearing.
9. Determination of natural frequency, logarithmic decrement, damping ratio and damping coefficient in a single degree of freedom vibrating systems (longitudinal and torsional)
10. Experimental Modal Analysis: Determination of Frequencies and mode shapes of cantilever beam/Plates
11. Balancing of rotating masses
12. Experiments on Gyroscope: To find the gyroscope couple on a motorized gyroscope experimentally and compare with applied couple.

Scheme of Evaluation for SEE	
One question from Part A	20 Marks (05 Write-up +15)
One question from Part B	20 Marks (05 Write-up +15)
Viva-voce	10 marks
Total	**50 marks**

COURSE OUTCOMES

Upon completion of this course, student will be able to:

CO 1	Estimate the natural frequency for longitudinal, torsional and transverse systems and demonstrate a physical understanding of damping as well as frequencies and mode shapes of engineered systems.
CO 2	Make use of Photo elasticity principles for stress analysis.

CO 3	Determine Principal stresses and strains in members subjected to combined loading using Strain Rosettes and compare it with theoretical values
CO 4	Examine the balancing of rotating masses
CO 5	Experiment with different Governors and calculate equilibrium speed, sensitiveness, power and effort
CO 6	Test for gyroscopic behaviour under free and forced precession

Course		Credits : 01			Marks	
Name	**Mini Project Work – Phase 2**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DCMW2**	**0**	**0**	**1**	**50**	**50**

1. Project group formed in fifth semester will continue to work on the chosen project in consultation with the respective guide in sixth semester.
2. Each student shall work for a cumulative of 104 hrs. in total (for the academic year).
3. The project work shall be executed according to CDIO principles. i.e., Conceive, Develop, Implement and Operate principles.
4. The group should maintain a workbook containing the schedule of activities including the outcome of the work/results, duly attested by the respective guide.
5. The plan of work in sixth semester shall include detailed design of the product, fabrication or simulation of the product, assembly and testing, realization as a product with the detailed cost estimation and report writing with results and discussions.
6. The guides will regularly monitor the progress of the project work, at least once in a week.
7. Assessment of the project for the award of CIE marks shall be done by the guide and a departmental committee as per the assessment format.
8. The guide shall be an internal examiner for evaluation. The final SEE shall be conducted jointly by internal and external examiners, chosen from the relevant field.

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

CO 1	Develop skills in literature survey.
CO 2	Understand the material/process standards & implications.
CO 3	Demonstrate the ability to conceptualize and realize finished products.
CO 4	Construct coherent written forms of communication and present effective oral forms of communication.

Assessment of 20ME6DCMW2 : Mini Project Work – Phase 2

Title of the Project: _____
Name of the Guide: _____

Sl. No	**USN**	**Name of the student**	**Assessment by Guide (70%)**					**Assessment by Departmental Committee (30%)**			**Grand Total (50)**
			Literature survey (10)	Topic Selection (05)	Documentation (15)	Attendance (05)	Total (35)	Evaluation (10%) (05)	Presentation (20%) (10)	Total (15)	

Electives – Group 3

Course		Credits : 03			Marks	
Name	**Theory of Plasticity**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DETOP**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
1. Engineering Mechanics
2. Strength of Materials
3. Theory of Elasticity

SYLLABUS:

UNIT – 1

Fundamental of Elasticity: Concept of stress, spherical and deviator stress tensors, octahedral stresses. Principal stresses, Invariants, representative stress. Strain tensor, spherical and deviator strain, octahedral strain and representative strain, cubical dilation, true stress and strain, Generalized Hooke's law, simple elastic strain energy problems. **8 Hours**

UNIT – 2

Yield Criteria: Introduction, yield or plasticity conditions, Von Mises and Tresca criteria, Geometrical representation, yield surface, yield locus (two-dimensional stress space), experimental evidence for yield criteria, energy required to change the shape with basic principle, problems. **6 Hours**

UNIT – 3

Bending of Beams: Analysis for stresses, Nonlinear stress strain curve, Shear stress distribution, residual stresses in plastic bending, problems. **5 Hours**

Torsion of Bars: Introduction, plastic torsion of a circular bar, elastic perfectly plastic material, elastic work hardening of material, residual stresses and problems. **4 Hours**

UNIT – 4

Stress Strain Relations: Introduction, types of materials, empirical equations, theories of plastic flow, experimental verification of St. Venant's theory of plastic flow, the concept of plastic potential. **6 Hours**

UNIT – 5

Plastic Deformation of Metals: Crystalline structure in metals, mechanism of plastic deformation, factors affecting plastic deformation, strain hardening, recovery, recrystallization and grain growth. **4 Hours**

Computational Plasticity: Introduction to nonlinearities in numerical analysis. 1-D Mathematical Model: Yield Criterion. Flow Rule. Loading/Unloading conditions. Isotropic and Kinematic, Hardening Models. 1-D Elasto- Plastic Boundary Value Problem. Computational Aspects of 1-D Elasto-Plasticity: Integration Algorithms for 1-D Elasto Plasticity. **6 Hours**

Text Books

1. Theory of Plasticity, Sadhu Singh, Khanna Publishers (2003)
2. Engineering Plasticity: Theory and Applications to metal forming, R.A.C. Slater, Macmillam, London, 1977.

Reference Books:

1. Basic Engineering Plasticity, DWA Rees, 1st Edition Elsevier.
2. Computational Methods for Plasticity: Theory and Applications, EA de Souza Neto, D Peric, DRJ Owen, John Wiley & Sons Ltd 2008 ISBN: 9780470694527.

E-Books:

1. http://www.vgu.edu.vn/fileadmin/pictures/studies/master/compeng/study_subjects/modules/tp/plastice.pdf
2. http://micro.stanford.edu/~caiwei/me342/
3. http://plas.yolasite.com/notes.php

MOOCs:

1. Mechanical Behavior of Materials, Part 3: Time Dependent Behavior and Failure https://www.edx.org/course

COURSE OUTCOMES

Upon completion of this course, student will be able to:

CO 1	Analyse stresses and strains that exist within a body subjected to general type of loading
CO 2	Predict the failure of components under multi axial loading based on yielding criteria.
CO 3	Solve analytically the elastic-plastic problems of bending and torsion loads
CO 4	Examine the theories of plastic flow, stress-strain relationships in plastic flow and the mechanism of plastic deformation
CO 5	Formulate 1-D elastic-plastic boundary value problems with basic knowledge of computational aspects.
CO 6	Utilize finite element simulation tools to solve plasticity problems with limited complexities (using Alternate Assessment Tool-AAT).

Scheme of Examination (SEE):

Students to answer five full questions selecting one from each unit.
To set ONE question each from Units 1, 2 & 4 and TWO questions each from Units 3 & 5.

Course		Credits : 03			Marks	
Name	**Fundamentals of Robotics**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DEROB**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
Kinematics of Machines, Matrix Algebra

SYLLABUS:

UNIT - 1

Introduction: History of robotics, Applications, anatomy and classification **2 Hours**
Spatial descriptions and Transformations: Description of position and orientation: position vector, Rotation matrix; Mapping: translation and rotation, homogeneous transform; transformation arithmetic, transform equations, other forms of representation of orientation: Euler angles, 2 –vector representation, angle – axis representation, Euler parameters **6 Hours**
Forward Kinematics: Introduction, Link description, link connection description, Denavit-Hartenberg parameters, Derivation of link transformations, concatenating link transformations, actuator space, joint space and Cartesian space **4 Hours**

UNIT 2

Inverse Kinematics: Introduction, Solvability: existence of solution, multiple solutions and method of solution; algebraic vs. geometric approach, algebraic solution by reduction to polynomial, workspace, Repeatability and accuracy **4 Hours**
Instantaneous Kinematics: Jacobians, changing a Jacobian's frame of reference, resolved rate motion control, singularities **4 Hours**

UNIT 3

Trajectory Generation: Introduction, general considerations in path description and generation, Joint space schemes: cubic polynomial, cubic polynomial for a path with via points, linear function with parabolic blends, linear function with parabolic blends for a path with via points, Cartesian space schemes: Cartesian straight line motion, geometric problems with Cartesian paths, path generation at run time **6 Hours**

UNIT 4

Linear Control: Feedback control, second order linear systems, PD control, control law portioning, trajectory following control, disturbance rejection and steady state error, PID control, continuous vs. discrete time control, modelling and control of a single joint, architecture of PUMA 560 robot controller **7 Hours**

UNIT 5

PCU and Actuators: Power conversion unit, Types of actuators, Characteristics of actuating systems, Overview of hydraulic and pneumatic actuators, Electric actuators: PMDC servo motor, Brushless DC motor, stepper motor, modern actuators. **3 Hours**
Sensors: Introduction, Sensor characteristics, contact and noncontact type sensors **3 Hours**

Text Book:

1. Introduction to robotics: mechanics and control, Craig J J, 3/E, Pearson Education India, 2008

Reference Books:

1. Robotics: Fundamental concepts & analysis, Ghosal A, Oxford University Press, 2006
2. Introduction to robotics: Analysis, systems, applications, Niku S B, Pearson Education, 2008
3. Robot Modeling and Control, M W Spong, S Hutchinson, M Vidyasagar, Wiley, 2005

E-Books/Web References:

Harry Asada, and John Leonard. *2.12 Introduction to Robotics, Fall 2005*. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu (Accessed 8 Feb, 2016). License: Creative Commons BY-NC-SA

MOOCs

1. https://www.edx.org/course/robot-mechanics-control-part-i-snux-snu446-345-1x
2. https://www.edx.org/course/robot-mechanics-control-part-ii-snux-snu446-345-2x

COURSE OUTCOMES

Upon completion of this course, student will be able to:

CO 1	Develop representation of robots in workspace.
CO 2	Solve for kinematics of robot manipulators
CO 3	Plan trajectory for robot motion
CO 4	Select actuators, sensors and controllers for robotic applications

Scheme of Examination (SEE):

Students to answer five full questions selecting one from each unit.
To set one question each from Unit 3, 4 & 5 and two questions each from Units 1 & 2.

Course		Credits : 03			Marks	
Name	**Computational Fluid Dynamics**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DECFD**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT – 1

Fundamentals of CFD: Introduction to CFD, steps involved in CFD, Applications, and Comparison of Numerical, Analytical and Experimental techniques.

Governing equations of Fluid Dynamics: Models of flow, the substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, the momentum equation, the energy equation, Equation of state, Navier-Stokes equation for viscous flow, Euler equations for inviscid flow, Conservative and non-conservative forms of the governing equations, Differential and integral forms of governing equations suited for CFD, Physical boundary conditions. **09 Hours**

UNIT – 2

Partial Differential Equations: Mathematical classification of PDE's, Methods of determining the classification, Cramer's rule, eigenvalue method, Illustrative examples of elliptic, parabolic and hyperbolic equations with physical examples.

Basic aspects of Discretisation: Difference between finite difference, finite volume and finite element discretization techniques, Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Forward, backward and central difference methods, Explicit and implicit approaches, equal and unequal spaced grid points, Time and space marching, Errors and an analysis of stability: Errors, Stability: von Neuman stability method and Courant-Friedriehs-Lewy (CFL) condition **07 Hours**

UNIT – 3

Finite Volume Method: Some Conceptual Basics and Illustrations through 1-D SteadyState Diffusion Problems: Physical consistency, Overall balance, rules and FV Discretization of a 1-D steady state diffusion type problem, Source term linearization, Implementation of boundary conditions.

Discretization of Convection-Diffusion Equations: Finite volume discretization of convection-diffusion problem: Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power law scheme, Generalized convection-diffusion formulation, Finite volume discretization of two-dimensional convection-diffusion problem, QUICK scheme. FVM for 1D and 2D unsteady state diffusion problems, Explicit scheme, Crank-Nicolson scheme and fully implicit scheme. **10 Hours**

UNIT – 4

Solution of Systems of Linear Algebraic Equations: Criteria for unique solution, infinite number of solutions, Solution techniques for system of linear algebraic equations: Iteration and Gradient Search method, Elimination method: Gauss elimination method and L-U decomposition technique, Thomas algorithm, Iteration methods: Jacobi's method and Gauss Siedel method, conditions for convergence, Rate of convergence, Relaxation methods, Multigrid method, TDMA technique. **06 Hours**

UNIT – 5

Discretization of Navier Stokes equation: Discretization of the equation: Primitive variable approach, Staggered grid and collocated grid, SIMPLE Algorithm, SIMPLER Algorithm.

Turbulent Flow Modelling: Introduction, transition from laminar to turbulent, Reynolds's Averaged Navier Stokes Equation (RANS), Characteristics of simple turbulent flows, Turbulence models (Discussion): Mixing length, k-ε, k-ω, LES and DNS **07 Hours**

TEXT BOOKS:

1. An introduction to Computational Fluid dynamic, H K Versteeg & W Malalasekera, Pearson Education.
2. Computational Fluid Dynamics, John D. Anderson Jr., McGraw-Hill Education.
3. Computational Fluid Dynamics, T. J. Chung , Cambridge University Press.
4. Numerical Heat Transfer and Fluid Flow, Suhas V. Patankar, Taylor & Francis.
5. Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics – Vol 1 & Vol 2, Charles Hirsch, Butterworth-Heinemann.

REFERENCE BOOKS:

1. Computational fluid mechanics and heat transfer, Richard H. Pletcher, John C. Tannehill, Dale Anderson, Taylor & Francis.
2. Computational methods for fluid dynamics, Ferziger, Joel H., Peric, Milovan, Springer Publications.
3. Riemann Solvers and Numerical methods for Fluid Dynamics – A Practical Introduction- Eleuterio F Toro, Springer Publications.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Understand the fundamental governing equations of fluid dynamics, turbulence and its modelling.
CO 2	Analyse the mathematical characteristics of partial differential equations and apply concepts like accuracy, stability, consistency of numerical methods for the governing equations.
CO 3	Apply finite volume method to discretize the governing equations of fluid flow and heat transfer.
CO 4	Identify and implement numerical techniques for space and time integration of partial differential equations.
CO 5	Write computer programs to solve the Governing equations.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Unit 2, 4 & 5 and two questions each from Units 1 & 3

Course		Credits : 03			Marks	
Name	**Production and Operation Management**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DEPOM**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT - 1

Operations Management and strategy: Historical evolution, systems view of operations, managing the operations subsystem, framework for managing operations, problems of operation manager, strategic role of operations, contemporary operations management topics, operations/manufacturing strategy, strategic planning: for production and operations, framework, productivity and quality, simple numericals, technology and mechanization.

6 Hours

UNIT - 2

Operations capacity: Introduction, capacity planning environment, strategies for modifying, capacity planning modelling. Computer simulation to evaluate capacity, decision tree analysis, tree diagramming, Numericals on the above topics **4 Hours**

UNIT - 3

Forecasting: Introduction, forecasting in operations, forecasting and operation subsystem, characteristics of demand over time, elements of forecasting, useful forecasting models for operations, qualitative (Delphi, naïve), exponential smoothing, regression, behavioural dimensions of forecasting. Numericals on above topics **6 Hours**

Designing products, processes and operations scheduling: New product design, manufacturing process technology, flexible manufacturing system, characteristics, goal, examples, design of services and service processes. Operations scheduling: intermittent systems, scheduling concepts and processes, operation planning and scheduling system, loading, priority sequencing, detailed scheduling, behavioural elements in intermittent systems, shop loading methods(index), sequencing or prioritization: Gantt chart, minimum critical ratio rule, nelsons study, LOB technique. Numericals on above topics **6 Hours**

UNIT - 4

Purchasing and inventory control: Introduction, Bayesian analysis, value engineering, purchasing research, vendor relations, negotiations, price forecasting, forward buying, make or buy, Inventory control: introduction, demand and control system characteristics, inventory concepts and systems, costs, modelling. Numericals on above topics **6 Hours**

Inventory control applications, deterministic, stochastic and single period model inventory models, inventory control applications, procedures, behavioural pitfalls, optimal order quantity, assumptions of EOQ formula, batch size and quantity, joint cycle for multiple products, inventory model with purchase discounts, approaches to determine buffer stock. Numericals on above topics **6 Hours**

UNIT - 5

Job design, production operation standards & work measurement: Introduction, job design, behavioural dimensions, effective job design, production and operation standards, work measurement, techniques, compensation. Numericals on above topics. **5 Hours**

TEXT BOOKS:

1. Production and Operations Management, Models & Behavior, 5th edition, Everete Adam, Jr.

Ronald J Ebert, Prentice Hall India Publications.
2. Production and Operations Management, Chary, 3rd Edition Mc Graw Hill Publications

REFERENCE BOOKS:

1. Production and Operations Management by K. Aswathappa, K Shridhara Bhat, Himalaya Publishing House
2. Operations Management Along Supply Chain, 6th Edition, Russell and Taylor, John Wiley Publications

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Plan to use Operations Management And Strategies for managing operations
CO 2	Identify suitable evaluation methods for capacity planning
CO 3	Choose appropriate scheduling system for operations
CO 4	Compare various types of inventory control
CO 5	Develop various concepts for designing a product
CO 6	Distinguish between several behavioural dimensions

Scheme of Examination (SEE):

Students to answer five full questions selecting one from each unit.
To set one question each from Units 1, 2 & 5 and two questions each from Units 3 & 4

Course		Credits : 03			Marks	
Name	**Solar Thermal Technologies**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DESTT**	**3**	**0**	**0**	**50**	**50**

Note: Usage of Solar Energy Data Handbook is permitted in SEE

PRE-REQUISITES:

- Thermodynamics & Heat Transfer

SYLLABUS:

UNIT – 1

Solar Radiation: Introduction, Solar radiation & measurement: Solar constant, Solar radiation at earth surface. Solar radiation geometry, Sun earth angles: slope, latitude, declination, hour angle, zenith angle, solar altitude angle, surface azimuth angle, solar azimuth angle, solar radiation measurements: Pyranometer, Pyrheliometer, Sunshine recorder, Apparent motion of sun, Sunrise, sunset and day length, inclined surface facing due south, Local apparent time, Monthly average daily global and diffuse radiation, Monthly average hourly global and diffuse radiation, solar radiation on tilted surfaces. **10 Hours**

UNIT – 2

Flat plate & Evacuated tube collectors: Basic systems, Transmissivity of the cover system based on reflection, refraction and absorption. Transmissivity for diffused radiation, transmissivity-absorptivity product, thermal analysis, overall collector heat loss, Top loss, bottom loss, side loss coefficients, collector efficiency factor and heat removal factor. Parameters influencing the performance of collector, Testing Procedure, selective absorber coatings. **10 Hours**

UNIT – 3

Concentrating Collectors: Types (Discussion only): Fresnel lens collector, Compound parabolic collector, Paraboloidal dish collector, Flat plate collector with plane reflectors, Central receiver collector.

Cylindrical parabolic collector*:* Orientation and tracking modes, Thermal & performance analysis, concentration ratio, collector efficiency factor, heat removal factor, instantaneous efficiency, effect of various parameters on the performance. **7 Hours**

UNIT – 4

Applications: Water heating: natural and forced circulation, Industrial process heating systems, Space heating: active and passive methods, Space cooling & refrigeration, Drying: direct and indirect type, Distillation: Types, classification, active and passive methods, Power generation: Low, Medium and high temperature systems, Cooking: Box type, Scheffler **6 Hours**

UNIT – 5

Economic Analysis: Investment, Maintenance and operation costs, Initial, Annual costs, Annual savings, cumulative savings, life cycle savings, net present value, present worth factor, payback period, Instalments and loan repayment, add on system analysis **6 Hours**

TEXT BOOKS:

1. Solar Energy- Principles of thermal collection and storage, S.P Sukhatme & J. K Nayak, McGraw Hill Education (India) Private Limited, New Delhi.
2. Non-Conventional Sources of Energy – G. D. Rai, Khanna Publishers, New Delhi.

REFERENCE BOOKS:

1. Solar Engineering of Thermal Processes, John A. Duffie & William A. Beckman, Fourth Edition, John Wiley & Sons, Inc.
2. Non-Conventional Energy Resources, B.H. Khan, McGraw Hill Education (India) Private Limited, New Delhi.

NPTEL/SWAYAM COURSES:

1. https://swayam.gov.in/nd1_noc20_ph14
2. https://nptel.ac.in/courses/112/105/112105050/

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Define parameters related to solar geometry, discuss the working principle of various collectors, radiation measuring devices, solar systems and their testing
CO 2	Deduce the parameters related to Solar Flat plate collector and concentrators
CO 3	Design Solar thermal energy systems for domestic and industrial applications
CO 4	Compute parameters related to Solar radiation and collectors
CO 5	Estimate the parameters related to economics of solar systems

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Units 3, 4, 5 and two questions from Unit 1, 2.

Course		Credits : 03			Marks	
Name	**Product Design and Manufacturing**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DEPDM**	**3**	**0**	**0**	**50**	**50**

SYLLABUS

UNIT – 1

Introduction: Characteristics of successful product development who Designs and develops products, duration and cost of product development, the challenges of product development. A generic development process, concept development: the front-end process, adapting the generic product development process. **04 Hours**

Product Planning: The product planning process, identify opportunities. Evaluate and prioritize projects, allocate resources and plan timing, complete pre project planning, reflect all the results and the process. Case studies. **03 Hours**

UNIT – 2

Identifying Customer Needs: Gather raw data from customers, interpret raw data in terms of customer needs, organize the needs into a hierarchy, establish the relative importance of the needs and reflect on the results and the process. Case studies. **04 Hours**

Product Specifications: What are specifications, when are specifications established, establishing target specifications setting the final specifications. **03 Hours**

Concept Generation: The activity of concept generation clarifies the problem search externally, search internally, explore systematically, and reflect on the results and the process. **03 Hours**

UNIT – 3

Concept Selection: Overview of methodology, concept screening, concept scoring, caveats. **03 Hours**

Concept Testing: Define the purpose of concept test, choose a survey population, choose a survey format, communicate the concept, measure customer response, interpret the result, reflect on the results and the process. Case studies. **03 Hours**

Product Architecture: What is product architecture, implications of the architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues. Case studies. **03 Hours**

UNIT – 4

Industrial Design: Assessing the need for industrial design, the impact of industrial design, industrial design process, managing the industrial design process, is assessing the quality of industrial design. Case studies. **03 Hours**

Design for Manufacturing: Definition, estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors. Case studies. **03 Hours**

UNIT – 5

Robust Design: Introduction to robust design, design of experiments, seven step robust design process, case studies. **07 Hours**

TEXT BOOK:

1. **Product Design and Development:** Karl.T.Ulrich, Steven D Eppinger,. Irwin McGrawHill-2000.

REFERENCE BOOKS:

1. **New Product Development:** Timjones. Butterworth Heinmann, , Oxford. UCI. 1997
2. **Product Design for Manufacture and Assembly:** Geoffery Boothroyd, Peter Dewhurst and Winston Knight.

MOOCS:
1. https://nptel.ac.in/courses/112/107/112107217/
2. https://www.edx.org/learn/product-design

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

CO 1	Understand the characteristics of successful product development, industrial design and design for manufacture and robust design
CO 2	Identify customer needs, specifications and generate concepts
CO 3	Select, test concepts and establish the product architecture
CO 4	Assess the need for prototyping.
CO 5	Apply PDM concepts in designing a survey
CO 6	Analyze and infer on customer response
CO 7	Work in teams for developing survey questionnaire and perform review of literature.

Scheme of Examination:
Answer Five full questions selecting one from each unit.
To set one question each from Unit 1, 4 & 5 and two questions each from Units 2& 3.

Course		Credits : 03			Marks	
Name	**Digital Manufacturing**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DEDIM**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT – 1

INTRODUCTION TO DIGITAL MANUFACTURING Definition of digital manufacturing, Operation Mode and Architecture of Digital Manufacturing System.

03 Hours

UNIT – 2

CAD MODELING: Design process and role of CAD, Types and applications of design models, Three dimensional modelling schemes, Wire frames and surface representation schemes, Solid modelling - Parametric modelling, Assembly modelling.

09 Hours

UNIT – 3

REVERSE ENGINEERING: Need, Reverse engineering process, Reverse engineering hardware and software, Geometric model development.

05 Hours

COMPUTER AIDED MANUFACTURING: Component modelling, Machine and tool selection, Defining process and parameters, Tool path generation, Simulation, Post processing.

06 Hours

UNIT – 4

CONCEPT MODELERS: Introduction, Principle, Thermo jet printer, Sander's model market, 3-D printer, Genisys Xs printer, JP system 5, object quadra system-Rapid proto typing.

05 Hours

DIGITAL FACTORY AND VIRTUAL MANUFACTURING: Introduction, Scope, Methods and Tools Used in Virtual Manufacturing, Benefits. Virtual factory simulation.

05 Hours

UNIT – 5

PRODUCT LIFE CYCLE MANAGEMENT: Introduction, Types of Product Data, PLM systems, Features of PLM System, System architecture, Product information models, Functionality of the PLM Systems.

06 Hours

Text Books:

1. Ibrahim Zeid and Sivasubramanian R, "CAD/CAM - Theory and Practice", Tata McGraw Hill Education, 2011.
2. Vinesh Raja and Kiran J Fernandes, "Reverse Engineering- An Industrial Perspective", Springer-Verlag, 2008

Reference Books:

1. Pham D T and Dimov S, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping", Springer-Verlag, 2001.
2. Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", Springer, 2005.
3. Antti Saaksvuori and Anselmi Immonen, "Product Lifecycle Management", Springer, 2004. 6.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Develop CAD models for 3D printing.
CO 2	Create technical designs part using reverse engineering / Understand and use techniques for processing of CAD models for rapid prototyping.
CO 3	Demonstrate a basic working knowledge of traditional computer controlled manufacturing methods.
CO 4	Operate, maintain, and use of common digital manufacturing equipment's

CO 5	Study the concept of virtual simulation and its applications
CO 6	Understand the principal issues involved in technical product management throughout all phases of the product life cycle.

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Units 1, 2 & 5 and two questions each from Units 3 & 4.

Course		Credits : 03			Marks	
Name	**R Programming**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DERPR**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
Basic Programming Skills

SYLLABUS:

UNIT – 1

Introduction to R: Introduction, Downloading and Installing R, IDEs and Text Editors, Handling Packages in R **3 Hours**

Getting Started with R: Introduction, Working with Directory, Data Types in R, Few Commands for Data Exploration **3 Hours**

UNIT – 2

Loading and Handling Data in R: Introduction, Challenges of Analytical Data Processing, Expression, Variables and Functions, Missing Values Treatment in R, Using the 'as' Operator to Change the Structure of Data, Vectors, Matrices, Factors, List, Few Common Analytical Tasks, Aggregating and Group Processing of a Variable, Simple Analysis Using R, Methods for Reading Data, Comparison of R GUIs for Data Input, Using R with Databases and Business Intelligence Systems, Case-study **10 Hours**

UNIT – 3

Exploring Data in R: Data Frames, R Functions for Understanding Data in Data Frames, Load Data Frames, Exploring Data, Data Summary, Finding the Missing Values, Invalid Values and Outliers, Descriptive Statistics, Spotting Problems in Data with Visualisation **7 Hours**

UNIT – 4

Linear Regression using R: Model Fitting, Linear Regression, Assumptions of Linear Regression, Validating Linear Assumption, Case-study **4 Hours**

Logistic Regression: Why Logistic Regression?, Introduction to Generalised Linear Models, Logistic Regression, Binary Logistic Regression, Diagnosing Logistic Regression, Multinomial Logistic Regression Models, Case-study **5 Hours**

UNIT – 5

Decision Tree: What is a Decision Tree?, Decision Tree Representation in R, Appropriate Problems for Decision Tree Learning, Basic Decision Tree Learning Algorithm, Measuring Features, Hypothesis Space Search in Decision Tree Learning, Inductive Bias in Decision Tree Learning, Why Prefer Short Hypotheses, Issues in Decision Tree Learning, Case-study **7 Hours**

Alternative Assessment: *Students will have to practically work (individually and / or in a team) on R-Software to analyse various case-studies related to real-world problems. This will lead to evaluation for a maximum of 10 marks in CIE.*

TEXT BOOKS:

1. Data Analytics Using R, 1st Ed, Seema Acharya, 2018, McGraw Hill Education.
2. Introduction to Scientific Programming and Simulation Using R, 2nd Ed, Jones, O, Maillardet, R, and Robinson, A, 2014, Chapman and Hall/CRC.

REFERENCE BOOKS:

1. R for Everyone 2nd Ed, Jareo P Lander, 2014, Addison-Wesley Data & Analytics Series
2. Hands-on Programming with R, Garrett Grolemund, O'reilly, 2014
3. R Programming: A Step-by-Step Guide for Absolute Beginners, Daniel Bell, Guzzler Media.

MOOCS:
1. The R Programming Environment (Coursera), John Hopkins University (https://coursera.org/share/b1a1b720bbb5e893fde8d94c7d036de2)
2. Advanced R Programming (Coursera), John Hopkins University (https://coursera.org/share/785e698c723ef15f629f25b2d767369f)

COURSE OUTCOMES

Upon completion of this course, student will be able to:

CO 1	Download, install & handle R software as well as various packages in it.
CO 2	Load data into R & perform various operations on the same.
CO 3	Explain various data-structures & functions available in R.
CO 4	Produce data visualisations.
CO 5	Work on R platform independently and as well as in a team to analyse different case-studies.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Units 1, 3 & 5 and two questions each from Units 2 & 4.

Electives – Group 4

Course		Credits : 03			Marks	
Name	**Computer Integrated Manufacturing**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DECIM**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT – 1

COMPUTER INTEGRATED MANUFACTURING SYSTEMS:
Introduction, Manufacturing Systems, Automation in Manufacturing Systems, Automation Principles and Strategies, Manufacturing Operations, Production Facilities, Hardware Components for automation and process control

06 Hours

UNIT – 2

HIGH VOLUME PRODUCTION SYSTEM:
Work part transport-continuous, Intermittent, synchronous, Pallet fixtures, Transfer Mechanism-Linear- Walking beam, roller chain drive, Rotary-rack and pinion, Rachet & Pawl, Geneva wheel, Buffer storage, control functions-sequence, safety, Quality, Automation for machining operation.

06 Hours

UNIT – 3

ANALYSIS OF AUTOMATED FLOW LINE & LINE BALANCING:
General terminology and analysis, Analysis of Transfer Line without storage upper bound approach, lower bound approach and problems, Analysis of Transfer lines with storage buffer, Effect of storage, buffer capacity with simple problem, Partial automation-with numerical problems, flow lines with more than two stages, Manual Assembly lines, line balancing problem.

MINIMUM RATIONAL WORK ELEMENT:
Work station process time, Cycle time, precedence constraints. Precedence diagram, Balance delay methods of line balancing-largest Candidate rule, Kilbridge and Westers method, Ranked positional weight method, Numerical problems covering above methods and computerized line balancing.

11 Hours

UNIT – 4

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 analysis of Multi-station Assembly Machine analysis of single station assembly.

AUTOMATED GUIDED VEHICLE SYSTEM:
Introduction, Vehicle guidance and routing, System management, Quantitative analysis of AGV's with numerical problems and application. Problems
CAPP, Flexible Manufacturing Systems, Cellular manufacturing, Aggregate Production planning, Master Production Schedule, MRP, Lean Production, JIT.

10 Hours

UNIT – 5

CNC MACHINING CENTERS:
Introduction to CNC, elements of CNC, CNC machining centers, part programming, and fundamental steps involved in development of part programming for milling and turning.
ROBOTICS: Introduction to Robot configuration, Robot motion, Robot Programming, end effectors, Robot sensors and Robot applications.

06 Hours

Text Books:

1. **Automation, Production system & Computer Integrated manufacturing,** M. P. Groover, Pearson India, 2007 2nd edition.
2. **Principles of Computer Integrated Manufacturing,** S. Kant Vajpayee, Prentice Hall India.

Reference Books:

1. **Computer Integrated Manufacturing,** J. A. Rehg & Henry. W. Kraebber
2. **CAD/CAM by Zeid,** Tata McGraw Hill.

E-Books:

1. http://www.me.nchu.edu.tw/lab/CIM/www/courses/Computer%20Integrated%20Manufacturing/Chapter2%20-CIM-introduction.pdf
2. http://ggnindia.dronacharya.info/MTech_ME/Downloads/QuestionBank/IIISem/ComputerIntegratedManufacturingSystems/NPTEL_LINKS_10052016.pdf

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Design automation lines, AGVs, Layouts in Industrial setup
CO 2	Analyse line balancing issues, manufacturing time, material handling in automation
CO 3	Select various mechanisms, robotic configurations, methods of automation for specific purposes in industries
CO 4	Develop CNC programs, machining methods, process plans during automation
CO 5	Apply assembly line techniques, manufacturing models in automation of manufacturing processes
CO 6	Plan production facilities, processes and material handling equipment's during automation

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 2,& 5 and two questions each from Units 3 & 4

Course		Credits : 03			Marks	
Name	**Human Resource Management**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DEHRM**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT – 1

Introduction to HRM:

Meaning, definition, nature and scope of HRM and HRD, evolution of HRM, Difference between Personnel Management and HRM, features of HRM, HRM functions, objectives of HRM, formulating policies, procedures and Programmes, role of personnel manager and HR manager, qualities of HR, Opportunities and Challenges in Human Resource Management. HRM in India: Changing role of HR in India, Globalization and its impact on HR

Job design: Definition, approaches, job design options; Job analysis: definition, process, benefits of job analysis HR planning: introduction, objectives of HRP, linkage of HRP to other plans, definition and need for HRP, benefits of HRP, factors affecting HRP, process, problems and limitations of HRP.

08 Hours

UNIT – 2

Recruitment:

Definition, Objectives, subsystems, factors affecting recruitment policy, centralized and decentralized recruitment, recruitment sources, techniques, process, cost benefit analysis of recruitment sources.

Selection, placement and Induction: Meaning, definition of selection, selection procedure, various types of tests (aptitude, achievement, situational, interest, personality), different types of interviews and interview process, means to make interview effective, medical examination, reference checks, final decision, employment, placement and induction.

07 Hours

UNIT – 3

Human Resource Development:

Performance management: Introduction, meaning, need, purpose, - objectives, contents of PAS, appraisers and different methods of appraisal (both traditional and modern methods), uses, limitations and problems of performance appraisal, post appraisal feedback. Potential appraisal – meaning, Philips model

Training and development: Meaning of T & D, benefits of training, need and objectives, Training Need Analysis, training methods, on-the job and off-the-job training, and final evaluation.

Employee mobility: Internal mobility: Introduction, meaning, different types. Promotion: Meaning, purpose, bases of merit, seniority, merit cum seniority, benefits, problems, promotion policy. Transfer: Meaning, purpose, types, reasons, benefits. Demotion: Meaning, need for demotion policy. Career planning and Development: Meaning, need, career development actions.

External mobility: Introduction, meaning, types. Absenteeism- Meaning, types, causes, calculation, minimizing absenteeism. Employee attrition- Meaning, reasons, calculation of 48 attrition rate, retention strategies, managing separations and right sizing-voluntary and involuntary separations

09 Hours

UNIT – 4

Compensation & Benefits Administration:

Introduction, definition, need for sound salary administration, objectives, factors affecting wages/ salary levels, job evaluation, wage salary survey, salary structure, salary fixation, incentives, profit sharing, bonus concepts, ESOPs, RSU's, pay for performance, Benefits administration, employee welfare and working conditions-statutory and voluntary measures.

07 Hours

UNIT – 5

Nature of IR, parties to IR - Employees, trade unions, employers' associations, role of government, judiciary and employee relations, factors affecting employee relations and IR decisions. Industrial peace and harmony: Discipline maintenance, Grievance Handling, Workers participation in management, maintaining good human and industrial relations, benefits accrued by the organization due to the development of congenial environment.

08 Hours

Text Books:

1. **Managing Human Resources** – Bohlander et.al, – Cengage Learning13 Ed., 2004.
2. **Human Resource Management, Text & Cases** – VSP Rao, Excel Books, 2005

Reference Books:

1. **Human Resource Management – Text & Cases** – K. Ashwatappa; 5thEdition, TMH.
2. **Human Resource Management** - Cynthia Fisher, Shaw – Wiley /Biztantra, 5/e, 2005
3. **Human Resource Management** – Gary Dessler, Person Publications, 10th Edition
4. **Human Resource Management** – Robert L Mathias, 9th Edition

MOOCs:
https://www.springboard.com/udemy/human-resource-processes-and-management/

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Understand and apply the fundamental concepts in People Management
CO 2	Analyse the business situation and utilize the people management skills
CO 3	Develop critical thinking skills to make decisions involving people
CO 4	Gain knowledge on Industrial Relations to handle people related issues

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Unit and two questions each from Units

Course		Credits : 03			Marks	
Name	**Optimization Techniques**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DEOPT**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
Engineering Mathematics

SYLLABUS:

Unit-1

Mathematical Preliminaries: Vector spaces and matrices, rank, norms, Eigen values and Eigen vectors, orthogonal projections, quadratic forms, gradient, Taylor series.
Basics of constrained and unconstrained optimization: Introduction, conditions for local minimizers
Newton's method: Root finding, unconstrained optimization, nonlinear least squares
08 Hours

Unit-2

Constrained Optimization: Equality constrained optimization, Lagrange condition, and second order conditions Inequality constrained optimization, KKT condition, and second order conditions. **10 Hours**

Unit-3

Algorithms for constrained optimization: Newton's method, quadratic programming, Globalization strategies: merit function, line search and trust region methods, filters. Nonlinear Programming, SQP algorithm, interior point methods. **10 Hours**

Unit-4

Practical Issues: Infeasible constraints, rank deficient constraints, constraint redundancy, discontinuities, scaling, non-unique solution, finite difference derivative approximation, automatic differentiation. **06 Hours**

Unit-5

Global search algorithms: Genetic algorithms, simulated annealing, particle swarm optimization **05 Hours**

Text Books:
Edwin K. P. Chong, Stanislaw H. Zak, An Introduction to Optimization, Wiley, 4th Ed, 2017

Reference Books
1. Nocedal, Jorge and Wright, Stephen. Numerical optimization. Springer, 1999
2. S. S. Rao, "Engineering Optimization: Theory and Practice", John Wiley & Sons, 1996.
3. Kalyanmoy Deb, "Optimization for Engineering Design: Algorithms and Examples", 2nd Ed, Prentice Hall of India, 2004.

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

CO 1	Formulate engineering optimization problem
CO 2	Solve single optimization problems by various relevant methods, solve LPP by simplex method.
CO 3	Develop algorithm for constrained optimization.
CO 4	Examine various optimization techniques and demonstrate their applicability.

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 4 & 5 and two questions each from Unit 2 & 3.

Course		Credits : 03			Marks	
Name	**Electric and Hybrid Vehicles – 2**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DEEV2**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
Electric and Hybrid Vehicles – 1.

SYLLABUS:

UNIT – 1

Alternative Energy Sources: Fuel Cells – Fuel Cell Characteristics, Fuel Cell Types, Hydrogen Storage Systems, Reformers & Fuel Cell EV; Supercapacitors and Ultracapacitors; Flywheels **04 Hours**

DC and AC Electric Machines: Motor and Engine Ratings; EV and HEV Motor Requirements; DC Machines; Three-Phase AC Machines; Induction Machines; Regenerative Braking; dq Modeling **07 Hours**

UNIT – 2

PM and SR Machines: Permanent Magnet Machines – Permanent Magnets, PM Synchronous Motors, PMSM Models, PM Brushless DC Motors; Switched Reluctance Machines – SRM Configuration, Basic Principle of Operation, SRM Design **04 Hours**

Power Electronics and Motor Drives: Electric Drive Components – Power Converters, Drive Controller; Power Electronic Switches – Diode, Power Transistors, Power MOSFETs, IGBT, Bidirectional Switch; DC Drives – Two-Quadrant Chopper, Open-Loop Drive; Operating Point Analysis **07 Hours**

UNIT – 3

AC and SR Motor Drives: AC Drive – Six-Step Operation, Pulse Width Modulation, Current Control Methods; Vector Control of AC Motors – Vector Control of Induction Motors, Rotor Flux-Oriented Vector Control, Direct and Indirect Vector Control; PM Synchronous Motor Drives – Vector Control, Flux Weakening, Current and Voltage Controllers; SR Motor Drives – SRM Converters, SRM Controls **06 Hours**

UNIT – 4

Electric Vehicle Drivetrain: EV Transmission Configurations; Transmission Components – Gears, Automobile Differential, Clutch, Brakes; Ideal Gearbox: Steady State Model – Gear Ratio, Torque-Speed Characteristics; EV Motor Sizing – Initial Acceleration, Rated Vehicle Velocity, Maximum Velocity, Maximum Gradability **05 Hours**

UNIT – 5

Hybrid Electric Vehicles: Types of Hybrids – Series and Parallel HEVs, Series-Parallel Combination; Internal Combustion Engines – Reciprocating Engines, Gas Turbine Engine; Design of an HEV – Hybrid Drivetrains, Sizing of Components **06 Hours**

REFERENCES:

Text Books

1. "Electric and Hybrid Vehicles – Design Fundamentals", Iqbal Husain, CRC Press, 2005

Reference Books

3. "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", M. Ehsani, Y. Gao, S. Longo and K. Ebrahimi, 3rd Ed., 2018
4. "Electric Vehicle Technology Explained", James Larminie, John Lowry, Wiley Publications, 2nd Ed., 2012

MOOCs

1. Electric Cars: Introduction - edX [https://courses.edx.org/courses/course-v1:DelftX+eCARS1x+3T2019/course/]
2. Electric Vehicles - Part 1 - SWAYAM [https://onlinecourses.nptel.ac.in/noc20_ee18/announcements]

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Explain and discuss various aspects of alternative energy sources & hybrid vehicles.
CO 2	Analyse various types of machines & motor-drives.
CO 3	Evaluate electric vehicle drivetrain.
CO 4	Perform modelling of DC & AC Machines.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
Two questions each to be set from Units 1 and 2 and one question from units 3, 4, and 5.

Course		Credits : 03			Marks	
Name	**Gas Dynamics**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DEGAD**	**3**	**0**	**0**	**50**	**50**

UNIT – 1

Fundamental equations of steady flow: Definition of Compressible Flow, Flow Regimes, Conservation equations in integral form; One dimensional Continuity, momentum and energy equation. Differential forms of conservation equations and their non-conservation forms, Entropy equation.

Isentropic flow: Acoustic velocity, Mach number, Mach cone and Mach angle. Flow parameters, stagnation temperature, pressure and density. Wave propagation, Alternative forms of energy equations.

09 Hours

UNIT - 2

Variable area flow: Velocity variation with Isentropic flow, Criteria for acceleration and deceleration. Flow through nozzle, Effect of pressure ratio on Nozzle operation. Convergent nozzle and convergent divergent nozzle. Effect of back pressure on nozzle flow. Isothermal flow functions and Flow Generalized one dimensional flow.

07 Hours

UNIT - 3

Normal shock waves: Development of shock wave, Shock analysis-general fluid, working equations for perfect gases, Hugoniot equation, Tables and charts for normal shock, Shocks in nozzles, Moving normal shocks.

07 Hours

UNIT – 4

Oblique shock waves: Tangential velocity superposition, Oblique shock analysis-perfect gas, Mach reflection, shock intersections, Variation of flow parameters and Gas tables for oblique shocks.

07 Hours

UNIT – 5

Expansion waves: Formation of rarefaction waves, Prandtl-Meyer relation, over expanded and under expanded nozzles, Supersonic air foils

Rayleigh flow: Stagnation temperature change. Rayleigh line, Pressure ratio and temperature ratio, Entropy considerations and maximum heat transfer. **09 Hours**

TEXTBOOKS:

1. Modern compressible flow, Anderson, McGaw Hill, 2008.
2. Fundamentals of Gas Dynamics, R.D. Zucker and O. Biblarz, John Wiley & Sons, Inc. 2nd Ed, 2002.
3. Gas Dynamics, E Radhakrishnan PHI-200.
4. Mechanics of Fluids, Bernard Massey, John Ward-Smith, Taylor & Francis,

REFERENCE BOOKS:

1. Introduction to Gas Dynamics: Rolty, Wiley 1998
2. Elements of Gas Dynamics: Liepmann and Roshko, Wiley 1994.
3. The dynamics and thermodynamics of compressible fluid flow: Shapiro Ronold press. 1994.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Apply continuity, momentum and energy equations to compressible flows
CO 2	Solve problems involving isentropic and non-isentropic flows including flows across normal shock waves.
CO 3	Demonstrate the use of data handbook to solve compressible flow subjected to oblique shocks and shock reflections.

CO 4	Deduce the equations for expansion
CO 5	Apply the Rayleigh flow correlations for the compressible flow with a heat transfer condition.

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
Setting one question each from Units 2, 3 & 4 and two questions each from Units 1 & 5.

Course		Credits : 03			Marks	
Name	**Internet of Things**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DEIOT**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

Unit-1

Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service(XaaS), Role of Cloud in IoT, Security aspects in IoT. **04 Hours**

Unit-2

Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. Software Components- Programming API's (using Python / Node.js / Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

05 Hours

Unit-3

Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices. **05 Hours**

Unit-4

IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation

Programming for the below mentioned applications

- Familiarization with Arduino/Raspberry Pi and perform necessary software installation.
- To interface LED/Buzzer with Arduino/Raspberry Pi and write a program to turn ON LED for 1 sec after every 2 seconds.
- To interface Push button/Digital sensor (IR/LDR) with Arduino/Raspberry Pi and write a program to turn ON LED when push button is pressed or at sensor detection.
- To interface DHT11 sensor with Arduino/Raspberry Pi and write a program to print temperature and humidity readings.
- To interface motor using relay with Arduino/Raspberry Pi and write a program to turn ON motor when push button is pressed.
- To interface OLED with Arduino/Raspberry Pi and write a program to print temperature and humidity readings on it.
- To interface Bluetooth with Arduino/Raspberry Pi and write a program to send sensor data to smartphone using Bluetooth.

12 Hours

Unit-5

Understanding applications of IoT through programming and interfacing

- To interface Bluetooth with Arduino/Raspberry Pi and write a program to turn LED ON/OFF when '1'/'0' is received from smartphone using Bluetooth.
- Write a program on Arduino/Raspberry Pi to upload temperature and humidity data to thingspeak cloud/ Cooja simulator
- Write a program on Arduino/Raspberry Pi to retrieve temperature and humidity data from thingspeak cloud/Cooja simulator
- To install MySQL database on Raspberry Pi and perform basic SQL queries.
- Write a program on Arduino/Raspberry Pi to publish temperature data to MQTT broker

- Write a program on Arduino/Raspberry Pi to subscribe to MQTT broker for temperature data and print it.
- Write a program to create TCP server on Arduino/Raspberry Pi and respond with humidity data to TCP client when requested.
- Write a program to create UDP server on Arduino/Raspberry Pi and respond with humidity data to UDP client when requested.

12 hour

TEXT BOOKS:

1. Vijay Madisetti, Arshdeep Bahga, Internet of Things, "A Hands on Approach", University Press
2. Dr. SRN Reddy, Rachit Thukral and Manasi Mishra, "Introduction to Internet of Things: A practical Approach", ETI Labs

REFERENCES

1. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press
2. Jeeva Jose, "Internet of Things", Khanna Publishing House, Delhi
3. Adrian McEwen, "Designing the Internet of Things", Wiley
4. Raj Kamal, "Internet of Things: Architecture and Design", McGraw Hill
5. Cuno Pfister, "Getting Started with the Internet of Things", O Reilly Media

MOOCs:
NPTEL: https://nptel.ac.in/courses/106105166/
Course era: https://www.coursera.org/specializations/iot
https://www.mooc-list.com/tags/iot

COURSE OUTCOMES
Upon completion of this course, student will be able to:

CO 1	Understand internet of Things and its hardware and software components
CO 2	Interface I/O devices, sensors & communication modules
CO 3	Remotely monitor data and control devices
CO 4	Develop real life IoT based projects

Scheme of Examination:
Answer Five full questions selecting one from each unit.
Two questions to be set from Units 4 & 5 and One question to be set from Units 1, 2 & 3

Course		Credits : 03			Marks	
Name	**Machine Learning**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME6DEMCL**	**3**	**0**	**0**	**50**	**50**

PRE- REQUISITES:
Statistics, Set theory, Probability, Applied Mathematics

SYLLABUS:

UNIT – 1

Introduction to Learning Problems, Well Posed Learning Problems, Designing a Learning System, Perspective and Issues in Machine Learning. **04 Hours**
Concept Learning and General to Specific Ordering: Concept Learning, Concept Learning as Search, Finding Maximal specific Hypothesis, Candidate Elimination Algorithm and Version Spaces, Inductive Bias, Simple numericals. **06 Hours**

UNIT – 2

Decision Tree Learning: Introduction, Representation, Decision Tree learning Algorithm, Hypothesis Space search in decision tree learning, Inductive Bias in decision tree learning, Issues in decision tree learning **04 Hours**
ANN: Introduction, Representations, Perceptions, Multilayer networks and Back Coc propagation Algorithm, Face recognition. **04 Hours**

UNIT – 3

Hypotheses Evaluation: Introduction, Estimating Hypothesis Accuracy, Bayesian learning, Bayesian Theorem and concept learning, Least Square error hypothesis and maximum likelihood, maximum likelihood hypothesis for probabilities, minimum description length principle, Bayes Optimum classifier and Gibbs Algorithm, Naive Bayes classifier, Bayesian Belief networks, The EM algorithm **10 Hours**

UNIT – 4

Instance Based Learning:- introduction, k-nearest Neighbour learning, Locally weighted regression, Radial basis functions, Case based reasoning. **06 Hours**

UNIT – 5

Instance Based Learning: Genetic Algorithms, Genetic Programming, Lamarckian evolution, Baldwin Effect. Reproduction **05 Hours**

Text Books:

1. Tom Mitchell, Machine Learning, McGraw-Hill Science 1997
2. Alex Smola and S.V.N. Vishwanathan, Introduction to Machine Learning, Cambridge Press, 2008.
3. S Rajasekaran, G S Vijayalakshmi P, Neural Networks, Fuzzy Logic and Genetic Algorithms-Synthesis and Applications, PHI Learning, 2014

Reference Books:

1. Christopher M Bishop, M. Jordan J. Kleinberg B. Scholkopf, Pattern Recognition and Machine Learning, Springer 2006
2. V.K. Jain, Machine Learning, Khanna Publishing House

MOOCs:
https://www.coursera.org/learn/machine-learning
https://www.edx.org/learn/machine-learning

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

CO 1	Apply the principles of Machine learning to decision making in image recognition.
CO 2	Evaluate hypothesis and various probabilities for supporting decision making.
CO 3	Develop data sets and apply the sequential based approach to variables for definite outputs.
CO 4	Organize data and use data for structured programming.
CO 5	Design algorithms using various approaches of learning to be applied to machines.

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Units 2, 4 & 5 and two questions each from Units 1 & 3.

VII Semester Syllabus

Course		Credits : 03			Marks	
Name	**Mechatronics**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DCMCT**	**2**	**0**	**1**	**50**	**50**

SYLLABUS:

UNIT – 1

Introduction: Definition of mechatronics. Mechatronics in manufacturing, products and design. Review of fundamentals of electronics. **3 Hours**

UNIT – 2

Mechatronics Elements: Data conversion devices, sensors, micro-sensors, transducers, signal processing devices, relays, contactors and timers. **7 Hours**

UNIT – 3

Drives and Mechanisms of an Automated System: Drives: stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, and transfer systems. **6 Hours**

UNIT – 4

Hydraulic System: Hydraulic systems: flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, pumps. Design of hydraulic circuits. **7 Hours**

UNIT – 5

Pneumatic System: Pneumatics: production, distribution and conditioning of compressed air, system components and graphic representations **3 Hours**

TEXT BOOKS:

1. Boucher, T. O., **Computer automation in manufacturing - an Introduction,** Chapman and Hall, 1996.
2**. HMT ltd. Mechatronics,** Tata McGraw-Hill, New Delhi, 1988

REFERENCE BOOKS:

1. Deb,S. R., **Robotics technology and flexible automation**, Tata McGraw-Hill, New Delhi, 1994.
2. Bolton, W., **Mechatronics: electronic control systems in mechanical and electrical engineering**, Longman, Singapore, 1999.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 3 & 5 and two questions each from units 2 & 4.

MECHATRONICS LABORATORY

Part A: Experiments on Applied Electronics

Realization of following logic circuits using applied electronics trainer kit

1. Basic gates
2. J-K Flip-flop
3. Half and Full Adders
4. Half & Full Subtractors
5. 4:1 Multiplexer
6. 4 – 16 line Decoder

Part B: Programming on 8085 Microprocessor

1. ALP for addition of 8- bit and 16-bit binary numbers
2. ALP for subtraction of 8- bit and 16-bit binary numbers
3. ALP for multiplication of 8-bit binary numbers
4. ALP for division of 8-bit binary numbers

5. ALP for block data transfer
6. ALP to count number of 1's or 0's in a given 8-bit data

Part C: Experiments on Hydraulics & Pneumatics

1. Performance characteristics of a variable displacement vane pump
2. Construction and verification of speed control of a double acting hydraulic cylinder (Meter-in & Meter-out)
3. Construction and verification of speed control of a bi-directional hydraulic motor (Meter-in & Meter-out)
4. Construction and verification of sequencing of two double acting hydraulic cylinders
5. Construction and verification of synchronizing between two double acting hydraulic cylinders
6. Study on ladder logic and programming in PLC
7. Construction and verification of actuation of a double acting pneumatic cylinder using electro-pneumatic valves
8. Automatic reciprocation of a pneumatic cylinder through electro-pneumatic valves or PLC

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Understand and define elements of mechatronics system, various types of transducers and their applications and signals and processing.
CO 2	Apply the principles of mechatronics and automation for the development of productive and efficient manufacturing systems
CO 3	Analyze the hydraulic and pneumatic systems employed in manufacturing industry
CO 4	Design Hydraulic Circuits
CO 5	Write assembly language programs using ladder logic diagrams, pneumatics
CO 6	Simulation of hydraulic and pneumatic circuits using GUI
CO 7	Rig up circuits for hydraulic and pneumatic applications

Course		Credits : 02			Marks	
Name	**Project Management**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DCPRM**	**2**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT 1

INTRODUCTION TO PROJECT MANAGEMENT: Introduction, description of project work, understanding projects, project roles **04 Hours**

UNIT 2

ORGANIZATIONAL CAPABILITY- Structure, Culture, and Roles: Types, organizational culture and its impact, project life cycle, project executive role, management role and team role

SCOPE PLANNING: Plan scope management, collect requirements, define scope, WBS **06 Hours**

UNIT 3

PROJECT SCHEDULING: Plan schedule management, purpose, develop project schedules, PERT and CPM, crashing-simple numericals. **08 Hours**

UNIT 4

BUDGETING PROJECTS: Plan Cost Management, Estimate Cost, Determine Budget, Establishing Cost Control **04 Hours**

UNIT 5

Project Supply Chain Management: Introduction, plan procurement management, conduct procurements, contract types, improving project supply chain **04 Hours**

TEXT BOOK:

1. Project Management, Timothy J Kloppenborg, Cengage Learning,3rd Edition 2009.

REFERENCE:

1. **Project Management**, A systems approach to planning scheduling and controlling by Harold Kerzner, CBS publication.
2. Project Management: S. Choudhury, McGraw Hill Publications

COURSE OUTCOMES:

Upon completion of this course, the student will be able to:

CO 1	Understand organization structure, project life cycle and project roles, describe projects
CO 2	Classify projects
CO 3	Develop project schedules.
CO 4	Planning cost management, procurement
CO 5	Determining and establishing control.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 4 & 5 and Two questions each from Units 2 & 3.

Course		Credits : 02			Marks	
Name	**Biology for Engineers**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20BI7BSBFE**	**2**	**0**	**0**	**50**	**50**

SYLLABUS:

Unit 1

Introduction: Science and Engineering- Fundamental difference, (Aircrafts & birds, Eyes and Camera, Hearing Aids and Ear drum, Robotic arm and elbow of a human hand), Development of Biology along 18th Century, Need for Biology in Engineering(Examples from Brownian motion and the origin of thermodynamics by referring to the original observation of Robert Brown and Julius Mayor).
Chemistry of Life: Basic structures of life, basic processes of life, compounds of life

05 Hours

UNIT 2

Cell Biology: Cell Variations, Cell Structure, Movement Through Cell Membranes
Cellular Growth and Reproduction, Protein Synthesis, Cell Growth and Reproduction

05 Hours

UNIT 3

Thermodynamics as applied to biological systems. Exothermic and endothermic versus endergonic and exergonic reactions. Concept of K_{eq} and its relation to standard free energy. Spontaneity. ATP as an energy currency. Photosynthesis, Energy Charge, Glycosis, Krebs Cycle, Energy charge. Metabolism, Types of metabolism, thermo regulation **06 Hours**

UNIT 4

Neural Basis of Movement: Overview of the Nervous System, Divisions of the Nervous System, Nervous System Cells, Repair of Nerve Fibers, Impulse Conduction, Synapses, Structure of the Spinal Cord, Spinal Nerves, Somatic Reflexes, General Structures of the Brain, Divisions of the Brain, Functions of the Cerebral Cortex, Cranial Nerves, Visceral Reflexes, Structure of the Autonomic Nervous System, Divisions of the Autonomic Nervous System, Effects of the ANS on Target Organs **06 Hours**

UNIT 5

Biological Engineering Solutions: Bionics, Biomimetics, Biotechnology, Biomedical Engineering **04 Hours**

TEXT BOOK:

1. Biology for Engineers, Wiley Editorial, Wiley 2018 Edition
2. Biology for Engineers, Arthur T Johnson, CRC Press 2016
3. Understanding Anatomy and Physiology, Gale Sloan Thompson

REFERENCE:

1. Design of Biomedical Devices and Systems, Paul H. King, Richard C. Fries, Arthur T. Johnson, CRC Press 2014
2. John Essigmann, Darrell Irvine, Forest White, Atissa Banuazizi, Harlan Breindel, and Mya Poe. *20.380J Biological Engineering Design.* Spring 2010

E-BOOKS:

1. Massachusetts Institute of Technology: MIT OpenCourseWare, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.
2. Douglas Lauffenburger, Paul Matsudaira, Biological Engineering Faculty, and Angela Belcher. *20.010J Introduction to Bioengineering (BE.010J).*
3. https://www.oreilly.com/library/view/biobuilder/9781491907504/ch01.html

COURSE OUTCOMES:
Upon completion of this course, the student will be able to

CO 1	Understand the biological concepts from an engineering perspective.
CO 2	Understand development of artificial systems mimicking human action.
CO 3	Integrate biological principles for developing next generation technologies

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Units 1, 2 & 5, and two questions from Units-3 & 4.

Course		Credits : 03			Marks	
Name	**Project Work – Phase 1**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DCPW1**	**0**	**0**	**3**	**50**	**50**

1. Every student in a group shall take up a project in the beginning of seventh semester in consultation with the guide and the project must be completed in eighth semester.
2. Maximum group size is 4 students in a group. However, if the project complexity demands a maximum group size of 5 students, then, it is subject to approval from a project evaluation committee, which should be convinced about such complexity and scope of the work.
3. A project proposal must be submitted to the department in this semester. While submitting project proposal care should to be taken that project will be completed within the available time of two terms i.e., 6 hours per week for seventh semester and 20 hours per week for eighth semester (a total time of 6*13 + 20*13 = 338 hours per project group student).
4. The final title of the project work should be submitted by the end of seventh semester. The project title should be precise and clear.
5. Selection and approval of the topic:
   a. Topic should be related to real life application in the field of Mechanical, OR
   b. Investigation of the latest development in a specific field of Mechanical, OR
   c. Software development project related to Mechanical OR
   d. Interdisciplinary.

(Interdisciplinary projects will be whole-heartedly encouraged and supported.)

6. The group should maintain a logbook of activities. It should have entries related to the work done, problems faced, solution evolved etc., duly signed by the guide.
7. The group is expected to complete, literature review, problem definition, detailed project plan, methodology of work and estimated project cost, in seventh semester, and submit the same in the form of a report (one report per group). The project report must be submitted in the prescribed format only. No variation in the format will be accepted.
8. One guide will be assigned at the most two project groups.
9. The guides should regularly monitor the progress of the project work.
10. Assessment of the project for the award of CIE marks shall be done by the guide and a departmental committee as per the guidelines given below:

Assessment of 20ME7DCPW1 Project Work Phase 1

Title of the Project: _____

Name of the Guide: _____

Sl.No	**USN**	**Name of the student**	**Assessment by Guide (70%)**					**Assessment by Departmental Committee (30%)**			**Grand Total (50)**
			Literature survey (10)	Topic Selection (05)	Documentation (15)	Attendance (05)	Total (35)	Evaluation (10%) (05)	Presentation (20%) (10)	Total (15)	

Sign of Guide Sign. Of Committee Members Sign of HOD

11. The guide should be an internal examiner for oral examination.
12. The other examiner (external) should be from the related area of the concerned project.
13. The evaluations of the final oral examination should be done jointly by both the

examiners.

COURSE OUTCOMES:

Upon successful completion of the course, student will be able to:

CO 1	Apply critical thinking in identifying problems & develops innovative and creative ideas/solutions/options employing appropriate quantitative methods and use relevant information technology
CO 2	Exhibit honesty and integrity and sensitive to ethical and diversity issues and behaves in an ethical and professional manner
CO 3	Demonstrate effective leadership abilities for the purpose of organizational growth and change.
CO 4	Effective interpersonal skills and the ability to work successfully in teams of diverse composition
CO 5	Construct coherent written forms of communication and present effective oral forms of communication.
CO 6	Understand the implication of solutions provided on society and environment.

Electives – Group 5

Course		Credits : 03			Marks	
Name	**Hydraulics & Pneumatics**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DEHAP**	**3**	**0**	**0**	**50**	**50**

PREREQUISITES:
1. Fluid Mechanics
2. Engineering Mechanics

Syllabus:

UNIT-1

HYDRAULIC POWER COMPONENTS

Introduction to fluid power systems; structure of fluid power systems; working medium and its properties. Hydraulic Power Generators – Hydraulic Pumps: Pumping theory and classifications; Gear pumps (external and internal), Vane pumps (balanced and unbalanced), Piston pumps (radial, bent axis and swash plate), Pump performance, selection criteria and problems on pump performances.

Linear Actuators: Classification, Constructional features of single and double acting cylinders, Telescopic cylinder, Mechanics of Hydraulic Cylinder loading; Rotary Actuators: Classification, Gear motors, Vane motors, Piston motors, Hydraulic motor performance evaluations.

8 Hours

UNIT-2

CONTROL AND REGULATING ELEMENTS

Classification, Pressure control valves: relief valve (direct and pilot operated types), sequence valve, pressure reducing valve (direct and pilot operated types), unloading valve, counterbalance valve. Flow control valves: needle valve, globe valve and pressure and temperature compensated valve, check valve. Directional Control Valves: Constructional features, sliding and rotary types. **7 Hours**

UNIT-3

Hydraulic Circuit Design and Analysis

Control of single and double acting hydraulic cylinder, regenerative circuit, pump unloading circuit, double pump hydraulic system, counter balance valve circuit, hydraulic cylinder sequencing and synchronizing circuits, speed control of hydraulic cylinder, speed control of hydraulic motors, hydraulic braking circuit, safety circuits and accumulator circuits, earth mover circuits - design and selection of components - safety and emergency mandrels.

8 Hours

UNIT-4

PNEUMATIC SYSTEMS AND CIRCUITS

Compressed air: Characteristics and Production of compressed air – compressors, preparation of compressed air; Driers, Filters, Regulators, Lubricators. Pneumatic Actuators: Linear cylinders – Types, conventional type of cylinder working, end position cushioning. Rod–less cylinders, types, working advantages. Rotary cylinder types, construction and application. Design parameters, selection. Basic pneumatic circuits, hydro pneumatic circuits. Design of simple pneumatic circuits and components for material handling and packaging applications.

8 Hours

UNIT-5

ELECTROPNEUMATICS AND MAINTENANCE OF FLUID POWER SYSTEMS

Design and constructional aspects, poppet valves, slide valves spool valve, suspended seat type slide valve. Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, use of memory valve. Speed control of cylinders supply air throttling and exhaust air throttling, use of quick exhaust valve, Servo valves, and use of microprocessors for sequencing - PLC, Low cost automation.

Accumulators (mechanical and hydro-pneumatic types), filters (disc and cartridge types), reservoir system, pressure switches, sealing devices, heaters and heat exchangers, hydraulic oils- desirable properties and type of fluids. Problem caused by gases in hydraulic fluids, wear

of moving parts due to solid particle contamination, temperature control, trouble shooting.

8 Hours

Text Books:

1. Anthony Esposito, Fluid Power with applications, Fifth edition, Pearson Education Inc. 2000.
2. R. Srinivasan, Hydraulic and pneumatic controls, Second edition, Vijay Nicole Imprints Ltd. 2011.

Reference Books:

1. S.R. Majumdar, Oil Hydraulic Systems - Principles and Maintenance, Tata Mc Graw Hill Publishing company Ltd. 2001.
2. Dudleyt, A. Pease and John J. Pippenger, "Basic fluid power", Prentice Hall, 1987.
3. Andrew Parr, "Hydraulic and Pneumatics" (HB), Jaico Publishing House, 1999.
4. Bolton. W., "Pneumatic and Hydraulic Systems ", Butterworth –Heinemann, 1997.
5. K.Shanmuga Sundaram, "Hydraulic and Pneumatic Controls: Understanding made Easy", S. Chand & Co Book publishers, New Delhi, 2006 (Reprint 2009).

E-RESOURCES

- https://nptel.ac.in/courses/112/105/112105047/ (Fundamentals of Industrial Oil Hydraulics and Pneumatics)
- https://www.coursera.org/learn/fluid-power? (Fundamentals of Fluid Power)
- www.redoaksys.com (for animations)
- www.boschrexroth.com
- www.eaton.in (Vickers)
- www.compair.com/products/compressor_training_animations.aspx

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Understand the operating principle of control elements and selection procedure of hydraulic elements, pneumatic systems and their control
CO 2	Select appropriate pumps and actuators for variety of applications.
CO 3	Design hydraulic and pneumatic circuits for the given application.
CO 4	Identify various components of Electro-pneumatic system & troubleshooting of the pneumatic and hydraulic systems.
CO 5	Evaluate performance of hydraulic devices
CO 6	Virtual simulation of safety circuits and its effectiveness.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Unit 2, 3 & 4 and Two questions each from Units 1 & 5.

Course		Credits : 03			Marks	
Name	**Tool Engineering Design**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DETED**	**3**	**0**	**0**	**50**	**50**

Use of Tool Design Data Handbook is permitted in the examination
SYLLABUS:

Unit-1

Design of SINGLE POINT Cutting Tools: Force and power requirement in turning, Drilling and Milling. Types of single point tools, design of shank dimensions based on strength and rigidity, numerical problems on shank dimensions, tool signature (ASA), selection of tool geometry, influence of tool geometry on tool life, inserts and chip breakers. **05 Hours**

Unit-2

Design of DRILL: Force and power requirement in drilling, Types of drills, tool angles, design of twist drill, numerical problems on design of twist drill, influence of tool geometry on tool life.
Design of MILLING CUTTER: Force and power requirement in milling, Types of milling cutters, tool angles, design of plain milling cutter, numerical problems on design of plain milling cutter, influence of tool geometry on tool life.
DESIGN OF TOOLS FOR INSPECTION AND GAUGING: Introduction, work piece quality criteria, principles of gauging, types of gages and their applications, amplification and magnification of error, gage tolerances, selection of material for gages, indicating gages, automatic gages, gauging positionally tolerance parts, problems. **11 Hours**

Unit-3

JIGS AND FIXTURES: Differences between jigs and fixtures, Design principles, Economic analysis, Principles of location: 3-2-1 and 4-1-1 types of location, types of locators, redundant location, **Clamping:** clamping principles, types of clamps, devices - mechanical, hydraulic, vacuum and magnetic.
DRILL JIGS: template, plate, channel, diameter, leaf, box, pot, local, angular, turnover, indexing jigs. Drill bushes, turning and milling fixtures.
FIXTURES: Turning and milling fixtures, indexing type of fixtures. **06 Hours**

Unit-4

PRESS TOOLS: Sheet metal operations, Classification, components of simple die, drive Mechanisms, die accessories, press features, press working dies- simple, progressive, and compound, and combination, punch and die clearances, shear action**.** **06 Hours**

Unit-5

PRESS TOOLS DESIGN: Center of pressure. Scrap strip layout, Computation of capacities/tonnage requirements, Design of blanking die and progressive die
Bending-bend allowance, spring back, edge bending die design
Drawing-Single, double and triple action dies, factors affecting drawing, drawing die design, forming limit criteria, deep drawing & redrawing methods, defects in formed parts.
11 Hours

Text Books:
1. **Tools Design C Donaldson-** G.H. Le CAIN V.C Goold, TMH -1976.
2. **Metal Cutting and Tool design** - Dr. B.J. Ranganath, Vikas Publishing house, 1993.

Reference Books:
1. **Metal cutting theory and Tool Design**- Arshinav MIR Publications
2. **Jigs & Fixtures**- Grant – 1976.
3. **Introduction to Jigs & Fixtures**- Kempster. ELBS, Edn. 1974.
4. **Fundamentals of Tools Design**- ASTME – Prentice Hall India Publications – 1983.

MOOCS:
http://nptel.ac.in/courses/112105126/35

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Analyse cutting forces in turning, milling and drilling
CO 2	Select appropriate inspection tools based on application
CO 3	Design cutting tools, drill bit, milling cutter, jigs and fixtures and press tools
CO 4	Compute press tool tonnage for drawing, bending and blanking

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

To set one question each from units 1, 3 and 4 and two questions each from units 2 and 5.

Course		Credits : 03			Marks	
Name	**Tribology**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DETRI**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT 1

Introduction to Tribology: Historical background, practical importance, and subsequent use in the field. Lubricants: Types and specific field of applications. Properties of lubricants, viscosity, its measurement, effect of temperature and pressure on viscosity, lubrication types, standard grades of lubricants, and selection of lubricants.
Friction: Origin, friction theories, measurement methods, friction of metals and non-metals.
Wear: Classification and mechanisms of wear, delamination theory, debris analysis, testing methods and standards. Related case studies. **10 Hours**

UNIT 2

Hydrodynamic journal bearings: Friction forces and power loss in a lightly loaded journal bearing, Petroff's equation, mechanism of pressure development in an oil film, and Reynold's equation in 2D. **05 Hours**

UNIT 3

Introduction to idealized journal bearing, load carrying capacity, condition for equilibrium, Sommerfeld's number and its significance; partial bearings, end leakages in journal bearing, numerical examples on full journal bearings only.
Plane slider bearings with fixed/pivoted shoe:
Pressure distribution, Load carrying capacity, coefficient of friction, frictional resistance in a fixed/pivoted shoe bearing, center of pressure, numerical examples. **12 Hours**

UNIT 4

Hydrostatic Lubrication: Introduction to hydrostatic lubrication, hydrostatic step bearings, load carrying capacity and oil flow through the hydrostatic step bearing, numerical examples.
Bearing Materials:
Commonly used bearings materials, and properties of typical bearing materials. Advantages and disadvantages of bearing materials. **07 Hours**

UNIT 5

Introduction to Surface engineering: Concept and scope of surface engineering. Surface modification – transformation hardening, surface melting, thermo chemical processes. Surface Coating – plating, fusion processes, vapor phase processes. Selection of coating for wear and corrosion resistance. **05 Hours**

TEXT BOOKS:

1."Introduction to Tribology", B. Bhushan, John Wiley & Sons, Inc., New York, 2002
2. "Engineering Tribology", Prasanta Sahoo, PHI Learning Private Ltd, New Delhi, 2011.
3."Engineering Tribology", J. A. Williams, Oxford Univ. Press, 2005.

REFERENCE BOOKS:

1. "Introduction to Tribology in bearings", B. C. Majumdar, Wheeler Publishing.
2. "Tribology, Friction and Wear of Engineering Material", I. M.Hutchings, Edward Arnold, London,1992.
3. "Engineering Tribology", G. W. Stachowiak and A. W. Batchelor, Butterworth-Heinemann,1992.
4. "Friction and Wear of Materials", Ernest Rabinowicz, John Wiley & sons,1995.
5. "Basic Lubrication Theory", A. Cameron, Ellis Hardwoods Ltd., UK.
6. "Handbook of tribology: materials, coatings and surface treatments", B.Bhushan, B.K. Gupta, McGraw-Hill,1997.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Understand the fundamentals of tribology and associated parameters.
CO 2	Apply concepts of tribology for the performance analysis, principles of surface engineering for different applications of tribology.
CO 3	Design hydrodynamic journal and plane slider bearings for a given application, hydrostatic bearing.
CO 4	Select appropriate bearing materials and lubricants for a given tribological application.
CO 5	Estimate power lost in friction in various bearings.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.

Course		Credits : 03			Marks	
Name	**Non Destructive Testing**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DENDT**	**3**	**0**	**0**	**50**	**50**

SYLLABUS

UNIT – 1

Visual Inspection and Eddy Current Testing

Scope and advantages of NDT, Comparison of NDT with DT, classifications of NDT Visual Inspection Equipment– Borescope , Flexible Fiber Optic Borescope , Endoscope, Video Imagescope.

Eddy Current Testing- Principle, Advantages, Disadvantages - Factors Affecting Eddy Current Response : Material Conductivity, Permeability, Frequency, Geometry, Proximity (Lift off) – Elements of Eddy current testing - Types of Probes - Typical Applications. **09 Hours**

UNIT – 2

Liquid Penetrant Testing

Liquid penetration testing – Introduction, Principle, Equipment, Procedures- Characteristics of penetrates – developers – Evaluation – hazards Precautions, advantages, limitations and applications. **07 Hours**

UNIT – 3

Magnetic Particle Testing

Principle of Magnetic Particle Testing – different methods to generate magnetic fields – Magnetic Particle Testing Equipment – Magnetic Particle Testing Procedures - Method of De-Magnetization – Magnetic Particle Medium – Evaluation of Indications and Acceptance Standards – magnetic particle test – applications, advantages and limitations. **07 Hours**

UNIT – 4

Radiographic Testing

X – ray radiography principle, equipment and methodology – Type of Industrial Radiation sources and Application – GAMA Ray and X – Ray Equipment – Radiographic Procedure – Radiograph Interpretation, Radiography Image Quality Indicators – Radiographic Techniques – Film Processing – Methods of Viewing Radiographs – Radiographic Testing Procedures for welds. Precautions against radiation hazards. **07 Hours**

UNIT – 5

Ultrasonic Testing

Introduction, Principle of operation Type of Ultrasonic Propagation – Ultrasonic probes-Types of Transducers – Ultrasonic Testing Techniques. Method for Evaluating Discontinuities – Ultrasonic Testing Procedures for different component –Applications in inspection of castings, forgings, Extruded steel parts, bars, pipes, rails and dimensions measurements - Documentation - Advantages and limitations - Design a solution for practical society problem using NDT methods. **09 Hours**

TEXT BOOKS

1. J Prasad, C G K Nair, “Non – Destructive Testing and Evaluation of Materials”, Tata McGraw Hill Education Private Limited.

REFERENCES

1. American Metals Society, “Non – Destructive Examination and Quality Control”, Metals Hand Book, Vol. 17, 9th Ed, Metals Park, OH, 1989.
2. Bray, Don E and Stanley, Roderic K, “Non – Destructive Evaluation: A Tool in Design, Manufacturing and Service, Revised”, CRC Press New York, Edition 1997.
3. www.ndt-ed.org
4. www.krautkramer.com.au

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Understand the working principle, Advantage and Applications of various Non-Destructive methods available for testing engineering components.
CO 2	Classify various NDT methods
CO 3	Compare and Select appropriate NDT method or a combination of NDT methods for a given application.
CO 4	Conduct a suitable NDT on a component with defect and compare it with a defect free component.

Scheme of Examination (SEE):

Students to answer five full questions selecting one from each unit.
To set one question each from Units 2, 3 & 4 and two questions each from Units 1 & 5.

Course		Credits : 03			Marks	
Name	**Advanced Heat Transfer**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DEAHT**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
1. Thermodynamics
2. Fluid Mechanics
3. Fundamentals of Heat Transfer

SYLLABUS:

Unit -1

Conduction: Derivation of energy equation for conduction in three dimensions, Initial and boundary conditions. Transient conduction - Concept of Biot number, Lumped capacitance, formulation unsteady conduction from a semi-infinite solid-solution by similarity transformation method. Solution of the general 1D unsteady problem by separation of variables, Laplace equation for steady state conditions: solution by variable separable method and principle of superposition

Numerical solution for 1-D and 2-D conduction problems -Basic ideas of finite difference method, forward, backward and central differences, Discretization for the unsteady heat equation **10Hours**

Unit -2

Forced Convection: Governing equations, 2D laminar Couette flow, non-dimensional numbers, scaling analysis, concept of Adiabatic wall temperature. Integral methods for momentum and thermal boundary layers. Pipe flow – concept of developed temperature profile and solutions for constant wall flux and constant wall temperature boundary conditions. Solution of entry length problem for constant wall and constant wall flux boundary conditions.

Natural convection: Governing equations, scaling analysis, solution techniques: similarity and approximate, correlations for flat and cylindrical surfaces at different orientations.

10 Hours

Unit-3

Radiation: Introduction. Concept of black body, discussion on black body radiation laws, Shape factor formulations. Radiosity, Irradiation method for gray and non-gray surfaces, Radiation combined with conduction and convection using electrical analogy technique.

07 Hours

Unit -4

Boiling and Condensation: Boiling regimes, correlations for bubble growth, nucleate boiling, and critical heat flux and film pool boiling.

Condensation: Film wise and drop wise condensation, laminar and turbulent film condensation, correlations for different orientations of plates and tubes. **06 Hours**

Unit – 5

Bio Heat Transfer:

Introduction, Hypothermia and hyperthermia, thermal models for blood-Perfused tissues, Pennes bio heat Equation, and continuum Models: Wulff, Klinger, and Chen and Holmes, Mathematical modelling of Bioheat Equation using Porous-Media Theory, Energy Equation, Momentum Equations, main Characteristics of bio heat Models. **5 Hours**

Text Books:

1. **Fundamentals of heat and mass transfer,** Frank P. Incropera and David P. Dewitt, John Wiley and Son's.
2. **Heat transfer, a practical approach,** Yunus A- Cengel, 5th Edition, Tata Mc Graw Hill
3. **Heat Transfer**, Holman, Mc Graw Hill
4. **Fundamentals of Heat & Mass Transfer** by Thirumaleshwar, Pearson

Reference books:

1. Poulikakos, Conduction Heat transfer, Prentice Hall.
2. G.E. Mayers, Analytical methods in Conduction Heat Transfer, McGraw Hill.
3. Kays W M and Crawford M E, Convective Heat and Mass Transfer, McGraw Hill Int Edition,
4. Spalding D B, Introduction to Convective Mass Transfer, McGraw Hill.
5. R. Siegel and J.R. Howell, Thermal Radiation Heat Transfer, Taylor and Francis.
6. Patrick H. Oostuizen and David Naylor, An Introduction to Convective Heat Transfer Analysis, McGraw Hill Int Edition,
7. Adrian Bejan, Convective Heat Transfer, Wiley student edition
8. Bio-heat transfer references:

a) Advances in Heat Transfer, Vol 22, Science direct.
b) Analysis of tissue and arterial blood temperatures in the resting human fore arm, Harry H. Pennes.
c) *Synthesis of Mathematical Models Representing Bio-heat Transport,* K. Khanafer and K. Vafai.

E-Books/Web references:

1. A Text book of Heat Transfer, John H Lienhard, 4th Edition,
2. NPTEL Heat Transfer course for Mechanical Engineering, http://nptel.ac.in/courses/112101097/
3. Heat Transfer, Chris Long & Naser Sayma, Bookboon.com

MOOCs:

1. Fluid flow, Heat and Mass Transfer- http://ocw.tudelft.nl/courses/applied-earth-sciences/fluid-flow-heat-mass-transfer/course
2. Heat transfer course- https://legacy.saylor.org/me204/Intro/

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Analyse the concept of unsteady heat transfer
CO 2	Solve heat transfer problem using numerical techniques
CO 3	Discuss free and forced convection heat transfer
CO 4	Inspect the radiation shape factors for different orientations
CO 5	Compare different boiling and condensation phenomenon
CO 6	Apply the concepts of heat transfer to various applications

Scheme of Examination (SEE):

Answer Five full questions selecting one from each unit.
To set one question each from Unit 3, 4 & 5 and two questions each from Units 1 & 2

Course		Credits : 03			Marks	
Name	**Advanced Robotics**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DEARB**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
Fundamentals of Robotics

Syllabus:

UNIT – 1

Velocities and Static Forces: linear velocity, angular velocity, velocity propagation, velocity elipse, static force analysis, Jacobians in the force domain
Dynamics: Newton- Euler Formulation: Linear and angular acceleration, linear and angular momentum, Inertia tensor, Newton's equation, Euler's equation, iterative newton -euler dynamic formulation
Lagrangian formulation: Lagrange equations, Kinetic energy, potential energy, equations of motion, Christoffel symbols, Cartesian space dynamics

12 Hours

UNIT – 2

Control: nonlinear dynamic decoupling, feedforward control, task-oriented control, force control, hybrid force – position control, adaptive control

8 Hours

UNIT – 3

Vision: Digital images, histograms, thresholding, convolution mask, connectivity, noise reduction, edge detection, segmentation, binary and grey morphology operations, object recognition by features, depth measurement, applications, computational stereo

8 Hours

UNIT – 4

Design: Task requirements, kinematic configuration, quantitative measure of workspace attributes, mechanism considerations, selection of actuators and sensors, control hardware, interfacing, microprocessor control, pulse width modulation, directional control with H-bridge

6 Hours

UNIT – 5

Case studies: Case studies of real-world robots

5 Hours

Text Books:

1. **Introduction to robotics: mechanics and control**, Craig J J, 3/E,Pearson Education India,2008

Reference Books:

1. **Robotics: Fundamental concepts & analysis**, Ghosal A, Oxford University Press, 2006
2. **Introduction to robotics: Analysis, systems, applications**, Niku S B, Pearson Education, 2008
3. **Robot Modeling and Control**, M W Spong, S Hutchinson, M Vidyasagar, Wiley, 2005

E-Books:

1. Harry Asada, and John Leonard. **2.12** Introduction to Robotics**, Fall 2005**. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu (Accessed 8 Feb, 2016). License: Creative Commons BY-NC-SA

MOOCs:

1. https://www.edx.org/course/robot-mechanics-control-part-i-snux-snu446-345-1x
2. https://www.edx.org/course/robot-mechanics-control-part-ii-snux-snu446-345-2x

COURSE OUTCOMES

Upon completion of this course, student will be able to:

CO 1	Solve for velocity and static forces in manipulators
CO 2	Formulate dynamic equations of robot manipulators
CO 3	Design controllers for robot motion
CO 4	Apply the techniques of computer vision to robot manipulation
CO 5	Select proper actuators, drives and sensors for robot design
CO 6	Design and build simple robots

Scheme of Examination (SEE):

- Students to answer five full questions selecting one from each unit.
- To set one question each from Units 3, 4 & 5 and two questions each from Units 1 & 2.

Course		Credits : 03			Marks	
Name	**Refrigeration and Air-conditioning**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DERAC**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:

1. Basic and Applied Thermodynamics
2. Fundamentals of Heat Transfer
3. Fluid mechanics

SYLLABUS:

UNIT – 1

Introduction to Refrigeration –Basic Definitions, ASHRAE Nomenclature, Joule Thompson coefficient and Inversion Temperature.
Refrigerants: Types of Refrigerants, Selection of Refrigerants, Requirements of Refrigerants, Effects of lubricants in Refrigerants, substitutes of CFC Refrigerants, Properties of refrigerants, Mixture Refrigerants - azeotropic mixtures. **05 Hours**

UNIT – 2

Refrigeration cycles: Evaporative refrigeration, Air Refrigeration Cycles-reversed Carnot cycle, Bell-Coleman cycle analysis, Aircraft refrigeration cycles, Numericals.
Non-conventional refrigeration system: Thermoelectric refrigeration, pulse tube refrigeration, thermo acoustic refrigeration, vortex refrigeration, cooling by adiabatic demagnetization. **06 Hours**

UNIT – 3

Psychrometry: Introduction, Psychrometric properties and relations, Psychometric chart and its applications, First law applied to psychrometric process, numericals.
Psychometric processes: Basic processes in air conditioning, Adiabatic mixing of air streams, Psychrometric process in air conditioning equipments: Bypass factor, Adiabatic dew point, air washer, steam injection, heating coil, hygroscopic solution in air washer, adiabatic dehumidifier, numerical. **10 Hours**

UNIT – 4

Refrigeration and Air conditioning equipments: Refrigeration Equipments: Compressors, condensers and cooling towers, evaporators, expansion devices, electric motors. Air conditioning Equipments: air cleaning and air filters, humidifiers, de-humidifiers heating and cleaning equipments. **06 Hours**

UNIT – 5

Design Load Conditions: Choice of inside and outside design conditions, comfort chart, choice of supply design condition, need for ventilation, Load Calculations: Internal heat gains, system heat gains, break up of ventilation load, cooling and heating load estimate, grand sensible heat factor, effective sensible heat factor, design of air conditioning apparatus for cooling and dehumidification, Evaporative cooling, numerical.
Transmission and Distribution of Air: Room air distribution, Types of supply air outlets, mechanism of flow through outlet, considerations for selection and location of outlets, Distribution patterns of outlets. **12 Hours**

Text Books:

1. Refrigeration and Air conditioning by Arora C.P, Tata Mc Graw Hill Pub.
2. Refrigeration and Air Conditioning, Wilbert F. Stoecker, McGraw-Hill Pub.
3. Norman C. Harris, N. C., Modern Air Conditioning Practice, Third edition, McGraw- Hill Pub.
4. Refrigeration and Air-Conditioning., R. K. Rajput, S. K. Kataria & Sons Pub.

Reference Books:

1. Levenhagen, J. L., Spethmann, D. H., Heating Ventilating and Air conditioning Controls and Systems, McGraw Hill Pub.
2. Refrigeration and Air conditioning by P. L. Ballaney, Hanna Pub.
3. Refrigeration and Air conditioning by Manohar Prasad, Wiley Eastern Pub.
4. Refrigeration and Air conditioning by Domkundwar, Dhanpat Rai Pub.
5. Refrigeration and Air conditioning by, Anantnarayan, Tata MC Graw Hill Pub.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	**Understand** the basic concepts of refrigeration process
CO 2	**Analyse** the performance of various refrigeration cycles, Psychometric processes
CO 3	**Examine** various refrigeration and Air conditioning equipments
CO 4	**Analyse** the heat load based on heat source
CO 5	**Design** the air duct for difference heat load and working conditions

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Units 1, 2 & 4 and two questions each from Units 3 & 5.

Electives – Group 6

Course		Credits : 03			Marks	
Name	**Additive Manufacturing**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DEADM**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT-1

Introduction to Additive Manufacturing (AM), Need for AM, Comparison of AM with Subtractive Manufacturing, Applications of AM, Development in CAD Technologies, Reverse Engineering, Generic AM Process, Development of AM technology, Classification of AM, VAT Polymerization techniques, UV curable photopolymers, Photopolymer chemistry, Resin formulations and reaction mechanism, Laser Scan photo polymerization. **04 Hours**

Photo polymerization process modelling- Irradiance, Exposure, Laser-resin interaction, photo speed, time scales, Vector scan VP machines, Weave Patterns Star, Weave and ACES patterns, Process benefits and Drawbacks. **06 Hours**

UNIT-2

Powder Bed Fusion Process(PBF), Working, Materials, Mechanisms, Process Parameters and Modelling, Simple Problems on Applied Energy Correlation, Powder Handling, PBF-Commercial machines, Process benefits and drawbacks. EBM, PLS. **05 Hours**

Extrusion Based Systems, Basic Principles, Plotting and Path Control, Yardimci equation of thermal process, Commercial Machines, Materials, Extrusion, extrusion velocity equations, Flow through rectangular channel derivation and simple problems, bio extrusion, melt extrusion, Scaffold architecture, Contour crafting, RepRap revolution. **05 Hours**

UNIT-3

Material Jetting Fundamentals, Materials used in Material Jetting, Process variables and total gauge pressure, with viscous losses Hagen-Poiseuille law considering length, Reynolds and weber number for printing conditions, simple problems. Commercial material jetting machines, process benefits and drawbacks. **04 Hours**

Binder Jetting working principle, Materials used in Binder Jetting, BJ Machines, Process benefits and Drawbacks in Binder Jetting. **02 Hours**

UNIT-4

Sheet Lamination process- Adhesive Bonding, Offset Fabbing, CAM-LEM process, Materials in Sheet lamination, Thermal Bonding, Sheet metal clamping, Ultrasonic AM, UAM process parameters, UAM materials, UAM applications **03 Hours**

Laser Powder DED Process, Powder feeding and wire feeding, Commercial machines, Electron Beam Based Deposition Process, DED Benefits and Drawbacks, Rosenthal equation of temperature w.r.t time, Cooling rate equation, Normalized Melting temperature, Solidification velocity derivations only. **03 Hours**

UNIT-5

Direct Write Technologies, Ink based DW, Nozzle dispensing process, Quill type process, Aerosol DW, Laser Transfer DW, MAPLE, Thermal Spray DW, Laser CVD, Focused Ion Beam CVD, Liquid Phase Direct Deposition, and Applications of DW. **03 Hours**

Selection of AM operation, Post Processing- Support removal, Surface texture and accuracy improvements, Machining Strategy, Cost estimation, Cost model, Build time model simple problems on costing of AM parts. **04 Hours**

TEXT BOOKS:

1. **Rapid Prototyping:Principles and Applications in Manufacturing**, Chua Chee Kai, Leong Kah Fai, Chu Sing Lim, World Scientific 2010
2. **Additive Manufacturing Technologies-** Dr. Ian Gibson, Dr. David W. Rosen, Dr. Brent Stucker

REFERENCE BOOKS:

1. **Rapid Prototyping,** Terry Wohlers Wohler's Report 2000" Wohler's Association 2000.
2. **Rapid Prototyping Materials,** Gurumurthi, IISc Bangalore.
3. **Rapid Automated,** Lament wood. Indus press New York

MOOCS:

1. NPTEL: http://www.nptel.ac.in/syllabus/112104156/

COURSE OUTCOMES:

At the end of the course the student is expected to:

CO 1	Classify, Compare and Choose appropriate Additive manufacturing processes in various scenarios.
CO 2	Solve time, cost and material related issues in AM processes.
CO 3	Derive and solve equations related to material flow, thermal characteristics of AM based processes.
CO 4	Define variables, materials that are used in various AM processes in the industries.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Units 3, 4 & 5, and two questions from Units-1 and 2.

Course		Credits : 03			Marks	
Name	**Power Plant Engineering**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DEPPE**	**3**	**0**	**0**	**50**	**50**

Pre-Requisites:
1. Thermodynamics
2. Heat and mass Transfer
3. Fluid Mechanics

Syllabus:

UNIT – 1

Introduction to power plant: requirements of a power plant, different layouts, Comparison of site selection criteria, **02 Hours**

Steam Power Plant: Different Types of Fuels used for steam generation, Equipment for burning coal in lump form, stokers, different types, Oil burners, Advantages and Disadvantages of using pulverized fuel, Equipment for preparation and burning of pulverized coal, unit system and bin system. Pulverized fuel furnaces, cyclone furnace, Coal and ash handling, Generation of steam using forced circulation, high and supercritical pressures. **04 Hours**

Chimneys: Natural, forced, induced and balanced draft, Calculations and numericals involving height of chimney to produce a given draft. Cooling towers and Ponds. Accessories for the Steam generators such as Superheaters, Desuperheater, control of superheaters, Economizers, Air pre-heaters and re-heaters. **05 Hours**

UNIT – 2

Diesel Engine Power Plant: Applications of Diesel Engines in Power field. Method of starting Diesel engines. Auxiliaries like cooling and lubrication system, filters, centrifuges, Oil heaters, intake and exhaust system, Layout of diesel power plant. **06 Hours**

UNIT – 3

Hydro-Electric Plants: Hydrographs, flow duration and mass curves, unit hydrograph and numericals. Storage and pondage, pumped storage plants, low, medium and high head plants, Penstock, water hammer, surge tanks, gates and valves. General layout of hydel power plants. **05 Hours**

Nuclear Power Plant: Principles of release of nuclear energy; Fusion and fission reactions. Nuclear fuels used in the reactors. Multiplication and thermal utilization factors. Elements of the nuclear reactor; moderator, control rod, fuel rods, coolants. Brief description of reactors of the following types-Pressurized water reactor, Boiling water reactor, Sodium graphite reactor, Fast Breeder reactor, Homogeneous graphite reactor and gas cooled reactor. **05 Hours**

UNIT – 4

Energy, Economic And Environmental Aspects of Power Generation: cost per unit power generation**,** Power tariff types, Load distribution parameters, load curve, Greenhouse effect, Flue gas desulphurization(FGD) systems, Electrostatic precipitators (ESP), Radiation hazards, Pollution control technologies including Waste Disposal Options for Coal and Nuclear Power Plants. **06 Hours**

UNIT – 5

Carbon-dioxide(CO_2) based power plant: Introduction, Overview of thermodynamic property trends, supercritical CO_2 power cycle fundamentals, Qualities of supercritical CO_2, Governing relationships, Analysis and applications for CO_2 power cycles. **06 Hours**

Text Books:

1. Power Plant Technology, M.M.El-Wakil, McGraw Hill Education (India) Pvt. Ltd., New Delhi, Edn 2010.

2. Power Plant Engineering, P. K. Nag Tata McGraw Hill 2nd Edn 2001.

Reference Books:

1. Power Plant Engineering, R. K. Rajput, Laxmi publication, New Delhi.
2. Power Plant Engineering, G.R,Nagpal , Khanna Publishers 1998
3. Power Plant Engineering, Domakundawar, DhanpathRai sons. 2003
4. Fundamentals and Applications of SupercriticalCarbon Dioxide (sCO_2) Based Power Cycles by, Klaus Brun, Peter Friedman and Richard Dennis

MOOCs:

1. **NTTP:** https://nptel.ac.in/courses/112/107/112107291/

COURSE OUTCOMES:

Upon completion of this course, student will be able to

CO 1	Identify various equipment required for power generation in different power plants. Design chimneys for power generation.
CO 2	Understand the working of various components used in different power plant with feasibility and comparison of site selection criteria
CO 3	Select appropriate devices for storage and combustion of fuel to improve the plant performance.
CO 4	Evaluate economic and environmental aspects for existing and upcoming power plant.

Scheme of Examination (SEE):

Answer Five full questions selecting one from each unit.
To set one question each from Unit 2, 4 & 5 and two questions each from Units 1 & 3

Course		Credits : 03			Marks	
Name	**High Speed Flow and Experimental Techniques**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DEHSE**	**3**	**0**	**0**	**50**	**50**

Pre-Requisites: Fluid mechanics, Gas dynamics, Mathematics

Course outline:

The course covers advanced theory and experimental aspects in the study of high speed flow and is organized in two parts. First part covers lectures on theoretical aspects of gas dynamics by covering the fundamentals in units 1 and 2, and unsteady nature related mathematical formulation in unit 3. The second part covers various measurement devices and techniques in unit 4 and 5. The experimental facilities in the various speed ranges corresponding to supersonic and hypersonic Mach numbers are covered in unit 4. Important considerations for the design of such facilities, significance of their components and some hard ware details are included. In unit 5, experimentation aspects using the demonstration shock tunnel (with its up gradation) on various parameters like pressure, temperature, velocity etc. are included. Flow visualisation techniques meant for compressible flows are also included in the course.

Syllabus:

UNIT – 1

Fundamental of compressible flow: Definition of Compressible Flow, Flow Regimes, Conservation equations in integral form and deduced differential forms, One dimensional Continuity, momentum and energy equation. Acoustic velocity, Flow parameters, Wave propagation, Alternative forms of energy equations, flow through nozzle, Effect of pressure ratio on Nozzle operation. Convergent nozzle and convergent divergent nozzle, effect of back pressure on nozzle flow **06 Hours**

UNIT - 2

Normal shock waves: Development of shock wave, Shock analysis, working equations for perfect gases, Hugoniot equation, Tables and charts for normal shock.

Oblique shock waves and expansion waves: Oblique shock analysis-perfect gas, Supersonic flow over a wedge, Mach lines, Weak oblique shocks, Supersonic compression and expansion by turning, Reflection and intersection of oblique shocks, Formation of rarefaction waves, Prandtl-Meyer relation, Simple and non-simple regimes, Supersonic air foils. Detached shocks, Mach reflection and Shock expansion theory (discussion only). **11 Hours**

UNIT - 3

Unsteady wave motion: Introduction, Moving normal shock waves, reflected shock wave, Elements of acoustic theory, Incident and reflected expansion waves**,** Method of characteristics (steady conditions), Minimum length nozzle design.

Shock tube: Introduction, Shock tube equations, Comparison between shock heating and isentropic heating, Particle velocity behind moving shock, Dependence of shock strength , Reflected shocks, Viscous effects and the shock tube boundary layer, Observation time in shock tube, Interaction of reflected shock and the contact surface, Shock tube diaphragm and bursting techniques, Measurement of shock speed. **11 Hours**

UNIT - 4

High speed wind tunnels: Types of high speed tunnels, Supersonic wind tunnels, Test section flow parameters, Components of supersonic wind tunnels, Actual flow in the supersonic wind tunnel, Sizing the wind tunnel model, Condensation Liquefaction problems. Hypersonic flow: special characteristics, Hypersonic wind tunnels with air heater, Hypersonic shock tunnels (discussion): Straight through and Reflected mode of shock tunnel, Adiabatic shock tunnel or gun tunnel, Free piston tunnel or stalker tube, Plasma arc tunnels, Ballistic ranges, Low density wind tunnels. **06 Hours**

UNIT 5

Measurement of pressure: Introduction, Pressure measuring devices, Measurement of pressure in flows, Measurement of static pressure, Static pressure probes for subsonic flow, Static pressure probes for supersonic flow, Measurement of stagnation or total pressure in supersonic flows.

Measurement of temperature: Adiabatic wall temperature or recovery temperature, Temperature measurement problems in flows, Conduction error, Radiation error, Velocity effects on temperature measurements, Sensors/probes for measuring stagnation temperature.

Flow visualization: Introduction, Flow visualization by direct injection (Tracer methods), Index of refraction methods, Theoretical background, Schlieren method, Colour schlieren, Shadowgraph method, Interferometer method, Glow discharge visualization for low density flows **05 Hours**

TEXTBOOKS:

1. Fundamentals of Gas Dynamics, R.D. Zucker and O. Biblarz, John Wiley & Sons, Inc. 2nd edition, 2002.
2. Shock Tubes in high temperature chemical physics - Gaydon, A.G. and Hurle, J.R
3. Hypersonic and High-Temperature Gas Dynamics, John D. Anderson, Jr., AIAA, Education series, 2nd edition, 2006.
4. Instrumentation, Measurements, and Experiments in Fluids, E. Radhakrishna, CRC press, 2007

REFERENCE BOOKS:

1. Experimental method for engineers, J.P. Holman, 8th Edition, McGraw Hill Publication, 2001.
2. Elements of Gas Dynamics: Liepmann and roshko, Wiley 1994.
3. High Speed Wind Tunnel Testing - Pope, Alan & Goin
4. Fluid Mechanics measurements - edited by Goldstein

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Compute flow parameters by applying governing equations for 1D flow
CO 2	Analyse the compression and expansion waves characteristics through standard compressible relations and gas tables.
CO 3	Comprehension of different experimental facilities and techniques adopted
CO 4	Estimate high speed flow conditions using wave characteristics fundamental relations and applying the same to the shock tubes.
CO 5	Exploring through experimentation the supersonic flow over a standard geometry and performing pressure, temperature and flow visualization studies using shock tunnel (education model)

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
Setting one question each from Unit 1, 4 & 5 and two questions each from units 2 & 3.

Course		Credits : 03			Marks	
Name	**Fracture Mechanics**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DEFRM**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
Strength of materials, Knowledge of Ordinary & Partial Differential Equations & Theory of Elasticity.

SYLLABUS:

UNIT-1

Fracture mechanics fundamentals: Introduction and historical review, ductile and brittle fracture, Modes of fracture, Fracture mechanics approach to design, NDT methods used in fracture mechanics, Stress concentration due to elliptical hole, Linear elastic fracture mechanics, Stress intensity factor, Solution to crack problems, Determination of Stress intensity factors and plane strain fracture toughness, K1c test technique, numerical method, Effect of finite size, Numerical problems. **11 Hours**

UNIT-2

Plasticity effects: Plastic zone, effective crack length, Irwin plastic zone correction. Dugdale approach, size and shape of the plastic zone for plane stress and plane strain cases, Thickness effect, numerical problems. Energy release rate, Griffith's criteria, Energy release rate, compliance approach, crack resistance, R-curve, Compliance, stable and unstable crack growth, Relationship between Stress intensity factor fracture toughness, mixed mode fracture and simple numerical on finding stress intensity for an angled crack **11 Hours**

UNIT-3

Elastic-plastic fracture mechanics: J-integral, path independence, features and limitations, equivalence, J1c test method, engineering approach, Tearing modulus, Crack-tip opening displacement, experimental determination of CTOD, equivalence. **06 Hours**

UNIT-4

Fatigue and Fatigue Crack Growth Rate: Fatigue loading, various stages of crack propagation, the load spectrum, approximation of the stress spectrum, the crack growth integration, fatigue crack growth laws, crack closure **06 Hours**

UNIT-5

Dynamics of crack: Crack speed and kinetic energy, dynamic stress intensity and elastic energy release rate, crack branching, principles of crack arrest, crack arrest in practice, dynamic fracture toughness. **05 Hours**

TEXT BOOKS:

1. Fracture Mechanics – Fundamentals and Application, T.L. Anderson, CRC PRESS, 1998
2. Fracture of Engineering Brittle Materials, Jayatilake, Applied Science, London, 2001.

REFERENCE BOOKS:

1. Elements of Fracture Mechanics, Prashant Kumar, Tata Mcgraw Hill, Mar-09, ISBN 007056967
2. Introduction to Fracture Mechanics, Karen Hellan, McGraw Hill Pub. 2000
3. Elementary Engineering Fracture Mechanics, David Broek, ArtinusNiihoff, London, 1999
4. Fracture and Fatigue Control in Structures, Rolfe and Barson, Prentice Hall, 2000
5. Principles of Fracture Mechanics, Robert J Sanford, Prentice Hall, 2002
6. Problems of Fracture Mechanics & Fatigue, Gdoutos E.E., RodoPoulus C.A., Yates J.R, Kluwer Academic Publishers
7. Fracture Mechanics for Modern Engineering Design, K.R.Y. Simha, Universities Press, 2000

E-Books:
K. Ramesh, e-Book on Engineering Fracture Mechanics, IIT Madras, 2007. URL: http://apm.iitm.ac.in/smlab/kramesh/book_4.htm

COURSE OUTCOMES
Upon completion of this course, student will be able to:

CO 1	**Apply** concept of linear elastic fracture mechanics in cracked body for stress analysis, energy approach in stress analysis of fatigue cracks, various crack growth laws in to spectrum loading.
CO 2	**Compute** crack tip stress intensity factor for 2-D and 3-D cracked bodies made up of linear elastic materials
CO 3	**Conceptualize** the concept of elastic plastic fracture mechanics
CO 4	**Estimate** the specimen dimension depending on application
CO 5	**Interpret** the various fracture toughness measuring techniques into fracture mechanics

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Unit 2, 4 & 5 and two questions each from Units 1 & 3.

Course		Credits : 03			Marks	
Name	**Artificial Intelligence**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DEARI**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT – 1

Introduction: The AI problem, Underlying assumption, criteria for success, problems, problem spaces and search. Heuristic search techniques – generate and test, Hill climbing and Best-first search. **7 Hours**

UNIT – 2

Knowledge Representation: Knowledge Representation Issues, using predicate logic, representing knowledge using rules. **7 Hours**

UNIT – 3

Statistical Reasoning: Probability and Baye's theorem, certainty factors and rule-based systems, Bayesian networks
Weak Slot and Filler structures: Semantic nets, frames.
Strong Slot and filler structures: Conceptual dependency and scripts. **10 Hours**

UNIT – 4

Game Playing: Overview, minimax search procedure, adding alpha-beta cutoffs, Iterative deepening.
Planning: Overview, the blocks world, components of planning system, goal stack planning, hierarchical planning.
Understanding: Understanding as constraint satisfaction.
Learning: What is learning, learning by taking advice, learning in problem solving, explanation-based learning, formal learning theory, Neural Net learning and Genetic learning.
10 Hours

UNIT – 5

Expert Systems: Representing and using domain knowledge, expert system shells, explanation, knowledge acquisition
Problem solving: Mechanical engineering systems. **5 Hours**

REFERENCES:

Text Books

1. **"Artificial Intelligence"** by Elaine Rich, Kevin Knight and Shivashankar B. Nair, 3rd edition, McGraw Hill.
2. **"Artificial Intelligence – A Modern Approach"** by Stuart J. Russel, Peter Norvig, 3rd edition, Pearson.

E-Books / Web References

1. "**The Quest for Artificial Intelligence-A History of Ideas and achievements**" by Nils J Nilsson, 1 st edition, Cambridge University Press,

MOOCs

1. https://nptel.ac.in/courses/112/103/112103280/
2. https://nptel.ac.in/courses/106/105/106105078/

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Describe the modern view of AI
CO 2	Apply AI search models and search strategies, different learning algorithms for enhancing performance of AI systems

CO 3	Writing for logic of knowledge representation and reasoning of AI systems
CO 4	Solve problems using AI techniques

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
Two questions each to be set from Units 3 and 4 and one question from units 1, 2, and 5.

Course		Credits : 03			Marks	
Name	**Automotive Engineering**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DEAUE**	**3**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT 1

Introduction: Vehicle Structure and Engines-Types of Automobiles, Vehicle Construction – Chassis, Frame and Body ,Aerodynamics, Components of Engine – Their forms, Functions and Materials, Review of Cooling and Lubrication systems in Engine, Turbo Chargers, Engine Emission Control , Electronic Engine Management System. **06 Hours**

UNIT 2

Vehicle performance: Resistance, power and torque curve, driving force against vehicle speed, acceleration and grade-ability in different gears for a typical car or truck plotted from specifications. Calculation and plotting the curves of air, rolling and gradient resistances, driving force, engine power, speed, rear axle ratio. Torque and mechanical efficiency at different vehicle speeds. **06 Hours**

UNIT 3

Engine basic theory: Engine types and their operation, classification, Properties of I.C. engine fuels, combustion phenomenon, two stroke engines, four stroke engine, characteristics of engines, valve timing diagram.
Transmission Systems-Clutch – Types and Construction, Gear Boxes-Manual and Automatic, Over Drives, Transfer Box Fluid flywheel-Torque convertors, Propeller shaft – Slip Joint – Universal Joints, Differential and Rear Axle, Hotchkiss Drive and Torque Tube Drive.
10 Hours

UNIT 4

Propeller shaft and final drive: Functional and design characteristics of propeller shaft, selection criteria for material and cross section of propeller shaft, need for differential and final drive. WHEELS AND TYRES: Use of different types of wheels and tyres, specification, materials.
STEERING AND SUSPENSION: Effort multiplication and geometry in steering, types of springs used in suspension system, need for damping. BRAKES: Distribution of braking force on front and rear wheels, stopping distance and braking efficiency, introduction to ABS.
10 Hours

UNIT 5

Electrical and electronic systems: Application of electricity in automobiles, starting, charging, lighting and accessory systems. Application of basic electronic components in automobiles.
Alternate energy and propulsion systems: Introduction to alternate fuels – LPG, CNG, Bio fuels, Alcohol fuels. Introduction to electric, hybrid and fuel cell vehicles. **07 Hours**

Text books:

1. W H & Anglin D L, “Automotive Mechanics”, Tata McGraw Hill Publishing Company, 2004.
2. Robert Bosch “Automotive Hand book”, 5th edition, 2004.
3. Ganesan V , “Internal Combustion Engines”, Tata McGraw Hill, New Delhi, 2003. 4. Mathur L and Sharma R P, “Internal Combustion Engines”, Dhanpat Rai Publications (P), Ltd, New Delhi, 2002.

References:

1.Heinz Heisler, “Advanced Engine Technology”, SAE 1995.
2. Richard Stone, “Introduction to IC Engines”, 2nd edition, Macmilan,1992.
3. Obert E F, “Internal Combustion Engine analysis and Practice ", International Text Book Co., Scranton, Pennsylvania, 1988.
4. John B Heywood, “Internal Combustion Engine Fundamentals”, McGraw Hill International Editions, 1988.

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

CO 1	Understand the construction and functions of components of IC engine, different engine systems and transmission systems used in IC engines and Propeller shaft and final drive systems, use of basic electronic components in automobiles. Alternate energy and propulsion systems.
CO 2	Estimate Vehicle performance parameters
CO 3	Compare different transmission systems, tyres, wheels, suspension systems and brakes
CO 4	Analyze braking systems for their performance

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Unit 1,2 & 5 and two questions each from Units 3 & 4.

Course		Credits : 03			Marks	
Name	**Computer Graphics**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME7DECOG**	**3**	**0**	**0**	**50**	**50**

PRE-REQUISITES:
Computer fundamentals.

SYLLABUS:

UNIT – 1

Scan Conversion and Clipping Representation: of points, lines, line drawing algorithms: DDA algorithm, Bresenham integer line algorithm, Bresenham circle algorithm, mid-point line and circle algorithms, polygon filling algorithms: scan conversion, seed filling, clipping algorithm–points, lines, text, polygon, Cohen-Sutherland line clipping algorithm. **07 Hours**

Two Dimensional Transformations: Representation of points, homogeneous transformations: rotation, reflection, scaling, translations and concatenations. A geometric interpretation of homogeneous coordinates, over all scaling, reflection through an arbitrary line, problems. **03 Hours**

UNIT – 2

Three Dimensional Transformations and projections, 3D Transformation matrix: general matrix, translation, scaling, shearing, rotation, reflection, multiple transformations, rotation about an axis parallel to coordinate axis, rotation about an arbitrary axis in space, orthographic, parallel projection transformations, perspective projections---one point, two point and three point. **04 Hours**

Plane and Space Curves: representation, non—parametric curves, parametric curves, parametric representation and generation of line, circle, ellipse, parabola, hyperbola, cubic spline, normalized cubic splines, problems, Bezier curves: blending function, properties, generation, B-spline curves, Cox-Deboor recursive formula, properties, open uniform basis functions, non-uniform basis functions. **06 Hours**

UNIT – 3

Virtual Realism-I: Introduction, hidden line removal---visibility of object views, visibility techniques: minimax test, containment test, surface test, Silhouettes, homogeneity test, sorting, coherence, hidden line priority algorithm, hidden surface removal, Z-buffer algorithm, Warnock algorithm, hidden solid removal---ray tracing algorithm. **06 Hours**

UNIT – 4

Virtual Realism-II: shading, shading models---diffuse reflection, specular reflection, ambient light, shading surfaces---constant shading, Gourand shading, Phong shading, shading enhancements, shading solids---ray tracing for CSG, colouring---RGB, CMY, HSV, HSL colour models. **06 Hours**

UNIT – 5

Computer Animation: Introduction, conventional animation-key frame, in betweening, line testing, painting, filming, computer animation---entertainment and engineering animation, animation system hardware, software architecture, animation types---frame buffer, colour table, zoom-pan-scroll, cross bar, real time play back, animation techniques-key frame, skeleton. Path of motion and p-curves. **07 Hours**

Text Books:

1. **CAD/CAM---Theory and Practise,** 2 edition**,** Ibraham Zeid, R Sivsubramanian ,Mc Graw Hill, 2009.
2. **Mathematical Elements of Computer Graphics,** 2 Edition**,** Roger Adams, J. Alan Adams, Mc-Graw Hill, 2017.

Reference Books:

1. Computer Graphics, 2 edition, Zhigang Xiang, Ray Plastock, Schaums outlines, Mc-Graw Hill, 2015.
2. Computer Graphics: Principles and Practice, John .F Hughes, Andres Van Dam, Morgon McGuire, 3rd Edition, 2020, Addison-Wesley Professional.
3. Computer Graphics, Sinha A. N., Udai A. D., Tata Mc-Graw Hill, 2014.
4. Computer Graphics, C Version---Donald Heran, M. Pauline Baker, 2nd Edition, Pearson, 2002.

E-Books:
http://www.hiteshpatel.co.in/ebook/cg/Computer_Graphics_C_Version.pdf

MOOCs:
1. https://www.mooc-list.com/course/cs1841x-foundations-computer-graphics-edx
2. https://www.class-central.com/mooc/2067/coursera-interactive-computer-graphics

COURSE OUTCOMES:
Upon completion of this course, student will be able to:

CO 1	Understanding and application of formulations to render primitive graphical entities.
CO 2	Application of transformations for manipulation of graphic elements.
CO 3	Generation, design and modelling of 2D and 3D graphical elements.
CO 4	Analysing and implementation for virtual realism.
CO 5	Interpret the concepts of animation, underlying hardware and software implementations.

Scheme of Examination (SEE):
Answer five full questions selecting one from each unit.
To set one question each from Units 3, 4 & 5 and two questions each from Units 1 & 2.

VIII Semester Syllabus

Course		Credits : 02			Marks	
Name	**Intellectual Property Rights**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME8HSIPR**	**2**	**0**	**0**	**50**	**50**

SYLLABUS:

UNIT – 1

Introduction to Intellectual Property and Patents: Introduction to concept of property, WIPO, TRIPS, Origin of the term patent, Meaning, Principles underlying the patent law in India, Patentable Invention, Non-Patentable Inventions, Procedure for obtaining Patent **05 Hours**

UNIT – 2

Specifications and Infringements of Patents: Provisional and Complete Specification, Rights Conferred on a Patentee, Transfer of Patent, Revocation and Surrender of Patents, Infringement of Patents, Action for Infringement. **03 Hours**

UNIT – 3

Trademarks: Trademarks- Introduction, Trips and Trade Mark, Meaning of Trade mark, Functions of Trade Mark, Procedure for Registration, Statutory Authorities, Principles of Registration of Trade marks, Rights conferred by registration of trade marks, Infringements and Actions against infringement. Procedure for registration and duration, Licensing in trade mark, Intellectual Appellate Board **07 Hours**

UNIT – 4

Copyrights: Copyrights: Meaning, Characteristics, Features of 1957 Act, Protection in Literary work, Software, Musical Work, Artistic Works, Architecture, Cinematograph, Sound Recording, Ownership of copyright, Piracy and Copyright law, Contract for and contract of service, Rights conferred by copyright.
Term of Copyright, Assignment of license in copyright, Infringement of copyright, Remedies against infringement of copyright, Publication. **07 Hours**

UNIT – 5

Designs and Geographic Indications: Designs Act 2000, Registration of Design, Piracy of registration of design, Introduction to Geographical Indications **04 Hours**

Text Books:

1. **Law Relating to Intellectual Property,** Dr. B L Wadehra, 5th Edition, Universal Law Publishing Co. Ltd., 2012
2. **The Oxford Handbook for Intellectual Property Law,** Rochelle Dreyfuss, Justine Pila, Oxford University Press

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO 1	Understand and explain the importance of IPR, Constitutional aspects of IP, Patent Systems of various countries, Patent system in India, procedure to obtain Patent, Patentable and non- patentable inventions, transfer of Patent and Infringement of Patent, procedure for registering Trademark
CO 2	Illustrate Copyrightable works, understand Indian Copyright Law and infringement of Copyright
CO 3	Identify Trademarks and infringement of Trademark

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 2 & 5 and two questions each from Units 3 & 4.

Course		Credits : 01			Marks	
Name	**Seminar**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME8DCSEM**	**0**	**0**	**1**	**50**	**50**

1. Selection of topic for seminar should be done by students in consultation with concerned guide.
2. Topic should be related to:
   - Internship (minimum of 4 weeks): Done in an industry with official certificate of completion.
   - Training (minimum of 4 weeks): Undergone training programme in Engineering related softwares (ex: Solid Modeling or Analysis) with an official certificate of completion.
   - Research paper: Student has to refer minimum of three full length latest research papers from International journals (ex: Science direct. Com, SAGE, Springer, IEEE, Taylor & Francis, Scientific.net. etc.,) and articulate on his/her own.
3. Seminar topic should not be repeated in the department and registration of the same should be done on first-come-first-serve basis.
4. Student shall individually study the topic chosen by him / her and submit a report and shall deliver a short-lecture / presentation on the topic at the end of the term.
5. Seminar report should be submitted as two paper-bound copies as well as soft copy.
6. Assessment of the seminar for the award of CIE marks shall be done by the guide and a departmental committee as per the guidelines given in the following table:

Assessment of 20ME8DCSEM Seminar

Title of the Seminar: _____
Name of the Guide: _____

Sl.No	USN	Name of the student	Assessment by Guide (70%)					Grand Total (50)
			Topic Selection (5)	Literature Survey (10)	Report Writing (10)	Depth of understanding (10)	Presentation (15)	

Sign of Guide Sign. Of Committee Members Sign of HOD

1) Assessment of Literature survey will be based on:
   a) Collection of material regarding history of the topic.
   b) Implementation
   c) Recent Applications
2) Assessment of depth of understanding will be based on:
   a) Questioning by examiners
   b) What the student understands i,e, conclusion regarding seminar
3) Assessment of presentation will be based on:
   a) Presentation skills
   b) Presentation contents
   c) Questioning and answering

COURSE OUTCOMES:
Upon successful completion of the course, student will be able to:

CO 1	Apply critical thinking in identifying problems & develop an innovative and

	creative ideas/solutions/options employing appropriate quantitative methods and use relevant information technology
CO 2	Exhibit honesty and integrity and sensitive to ethical and diversity issues and behaves in an ethical and professional manner
CO 3	Construct coherent written forms of communication and present effective oral forms of communication.
CO 4	Understand the implication of solutions provided on society and environment.

Course		Credits : 10			Marks	
Name	**Project Work – Phase 2**	**L**	**T**	**P**	**CIE**	**SEE**
Code	**20ME8DCPW2**	**0**	**0**	**10**	**50**	**50**

1. The project group formed in seventh semester will continue their project work in this semester and complete the project in all respects (fabrication / simulation, assembly / analysis, testing, tabulation, test results etc.)
2. The group should maintain a logbook of activities. It should have entries related to the work done, problems faced, solutions evolved etc., duly signed by the guide.
3. The guides should regularly monitor the progress of the project work.
4. The project work along with project report should be submitted as part of the term work in eighth semester on or before the last day of the semester.
5. Project report must be submitted in the prescribed format only. No variation in the format will be accepted.
6. Assessment of the project for the award of CIE marks shall be done by the guide and a departmental committee as per the guidelines given in the following table:

Assessment of 20ME8DCPW2 Project Work Phase 2

Title of the Project: _____
Name of the Guide: _____

Sl.No	USN	Name of the student	Assessment by Guide (70%)					Assessment by Departmental Committee (30%)			Grand Total (50)
			Execution (10)	Results & Discussions (10)	Project Report (10)	Attendance (05)	Total (35)	Evaluation (10%) (05)	Presentation (20%) (10)	Total (15)	

Sign of Guide Sign. Of Committee Members Sign of HOD

7. The guide should be an internal examiner for oral examination.
8. The other examiner (external) should be from the related area of the concerned project.
9. The evaluations of the final oral examination should be done jointly by both the examiners.

COURSE OUTCOMES:
Upon successful completion of the course, student will be able to:

CO 1	Apply critical thinking in identifying problems & develops innovative and creative ideas/solutions/options employing appropriate quantitative methods and use relevant information technology
CO 2	Exhibit honesty and integrity and sensitive to ethical and diversity issues and behaves in an ethical and professional manner
CO 3	Demonstrate effective leadership abilities for the purpose of organizational growth and change.
CO 4	Effective interpersonal skills and the ability to work successfully in teams of diverse composition
CO 5	Construct coherent written forms of communication and present effective oral forms of communication.
CO 6	Understand the implication of solutions provided on society and environment.