

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM OF

BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

2023 ONWARD UNDERGRADUATE ADMISSION BATCH



V0:

First Year Curriculum Recommended by members of UGAC	19.08.2023
First Year Curriculum Approved by the Chairman, Senate	19.08.2023
First Year Curriculum & Syllabus ratified in the 71st Senate meeting (Item No. 71.5(b))	18.12.2023
Entire Curriculum and Syllabus Recommended by UGAC	09.12.2024
Entire Curriculum and Syllabus Approved by the 73 rd Senate (Item No. 73.8)	23.03.2025

CURRICULUM AND SYLLABUS FOR B.TECH. IN MECHANICAL ENGINEERING**DEPARTMENT OF MECHANICAL ENGINEERING****Program Name: Bachelor of Technology in Mechanical Engineering****DETAILED CURRICULUM****CURRICULUM OF 2023 ONWARD UNDERGRADUATE ADMISSION BATCH FOR MECHANICAL ENGINEERING- B.TECH.****L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional/ practical hour/ week****C= Subject credit point; H= Subject contact hour/ week.****GROUP I:**

Semester - I							
Sl. No	Code	Subject	L	T	S	C	H
1	MAC01	Mathematics - I	3	1	0	4	4
2	CSC01	Computer Programming	2	1	0	3	3
3	XEC01	Engineering Mechanics	2	1	0	3	3
4	XEC02*	Basic Electrical and Electronics Engineering	3	0	0	3	3
5	ESC01	Ecology and Environment	2	0	0	2	2
6	CYC01	Engineering Chemistry	3	0	0	3	3
7	CSS51	Computer Programming Laboratory	0	0	3	2	3
8	XES52	Basic Electrical and Electronics Engineering Laboratory	0	0	3	2	3
9	CYS51	Engineering Chemistry Laboratory	0	0	2	1	2
		TOTAL	15	3	8	23	26

***From the AY2025-26, L-T-P of XEC02 is 3-1-0, Credit = 4**

Semester – II							
Sl. No	Code	Subject	L	T	S	C	H
1	MAC02	Mathematics - II	3	1	0	4	4
2	CSC02	Data Structure and Algorithms	2	1	0	3	3
3	PHC01	Engineering Physics	2	1	0	3	3
4	HSC01	Professional Communication	2	0	2	3	4
5	CSS52	Data Structure and Algorithms Laboratory	0	0	3	2	3
6	XES51	Engineering Graphics	0	1	3	3	4
7	PHS51	Engineering Physics Laboratory	0	0	2	1	2
8	XXS51	Extra Academic Activities	0	0	2	1	2
		TOTAL	9	4	12	20	25

GROUP II

Semester – I							
Sl. No	Code	Subject	L	T	S	C	H
1	MAC01	Mathematics - I	3	1	0	4	4
2	CSC01	Computer Programming	2	1	0	3	3
3	XEC01	Engineering Mechanics	2	1	0	3	3
4	PHC01	Engineering Physics	2	1	0	3	3
5	HSC01	Professional Communication	2	0	2	3	4
6	CSS51	Computer Programming Laboratory	0	0	3	2	3

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7	XES51	Engineering Graphics	0	1	3	3	4
8	PHS51	Engineering Physics Laboratory	0	0	2	1	2
9	XXS51	Extra Academic Activities	0	0	2	1	2
TOTAL			11	5	12	23	28

Semester – II

Sl. No	Code	Subject	L	T	S	C	H
1	MAC02	Mathematics - II	3	1	0	4	4
2	CSC02	Data Structure and Algorithms	2	1	0	3	3
3	XEC02*	Basic Electrical and Electronics Engineering	3	0	0	3	3
4	ESC01	Ecology and Environment	2	0	0	2	2
5	CYC01	Engineering Chemistry	3	0	0	3	3
6	CYS51	Engineering Chemistry Laboratory	0	0	2	1	2
7	CSS52	Data Structure and Algorithms Laboratory	0	0	3	2	3
8	XES52	Basic Electrical and Electronics Engineering Laboratory	0	0	3	2	3
TOTAL			13	2	8	20	23

*From the AY2025-26, L-T-P of XEC02 is 3-1-0, Credit = 4

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Semester–III							
Sl. No	Code	Subject	L	T	S	C	H
1	MAC331	Mathematics - III	3	1	0	4	4
2	MEC301	Solid Mechanics	3	1	0	4	4
3	MEC302	Theory of Machines and Mechanisms	3	1	0	4	4
4	MEC303	Fluid Mechanics	3	1	0	4	4
5	MEC304	Engineering Thermodynamics	3	1	0	4	4
6	MES351	Machine Drawing & Solid Modeling	0	0	3	2	3
7	MES352	Fluid Mechanics Lab	0	0	3	2	3
8	WSS381	Workshop Practice-I	0	0	3	2	3
9	XXS381	Co-curricular Activities - III (Optional)	0	0	0	0	0
		TOTAL	15	5	9	26	29

Semester – IV							
Sl. No	Code	Subject	L	T	S	C	H
1	MEC401	Design of Machine Elements-I	3	1	0	4	4
2	MEC402	Casting, Forming and Welding	3	1	0	4	4
3	MEC403	Heat & Mass Transfer	3	1	0	4	4
4	MEC404	Dynamics of Machines	3	0	0	3	3
5	MEC405	Fluid Machines	3	0	0	3	3
6	MES451	Solid Mechanics Lab	0	0	3	2	3
7	MES452	Mechanism Lab	0	0	3	2	3
8	WSS481	Workshop Practice-II	0	0	3	2	3
9	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0	0
		TOTAL	15	2	9	24	27

Semester –V							
Sl.	Code	Subject	L	T	S	C	H
1	MEC501	Machining and Machine Tools	3	1	0	4	4
2	MEC502	IC Engine & Gas Turbine	3	0	0	3	3
3	MEC503	Design of Machine Elements-II	3	1	0	4	4
4	MEC504	Computer Aided Manufacturing & Robotics	3	1	0	4	4
6	MEE510- MEE519	Depth Elective -- 1	3	0	0	3	3
7	MES551	Hydraulic Machines Laboratory	0	0	3	2	3
8	MES552	Heat Transfer Laboratory	0	0	3	2	3
9	MES553	Robotics, AI & Mechatronics Lab.	0	0	3	2	3
10	XXS581	Co-curricular Activities - V (Optional)	0		0	0	0
		TOTAL	15	2	9	24	27

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Semester – VI							
Sl.	Code	Subject	L	T	S	C	H
1	MEC601	Power Generation Technologies	3	0	0	3	3
2	HSC631	Economics and Management Accountancy	3	0	0	3	3
3	CSCXXX	AI & ML	3	0	2	4	5
4	MEE610- MEE619	Depth Elective -- 2	3	0	0	3	3
5	MEE620- MEE629	Depth Elective -- 3	3	0	0	3	3
6	MES651	Power Generation Laboratory	0	0	3	2	3
7	MES652	Machine Design Sessional	0	0	3	2	3
8	MES653	Manufacturing Laboratory	0	0	3	2	3
9	XXS681	Co-curricular Activities - VI (Optional)	0	0	0	0	0
10	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0	0
		TOTAL	15	0	11	22	26

Semester-VII							
Sl.	Code	Subject	L	T	S	C	H
1	MSC731	Principle of Management	3	0	0	3	3
2	MEC701	Industrial Engineering & Engineering Measurement	3	1	0	4	4
3	MEE710- MEE719	Depth Elective -- 4	3	0	0	3	3
4	MEE720- MEE729	Depth Elective -- 5	3	0	0	3	3
5	YYO74*	Open Elective – 1	3	0	0	3	3
6	MES751	Machine Dynamics Laboratory	0	0	3	2	3
7	MES752	Engineering Measurement Laboratory	0	0	3	2	3
8	MES753	Summer Internship and Seminar	0	0	2	1	2
9	MES754	Project - I	0	0	3	1	3
		TOTAL	15	1	11	22	27

Semester-VIII							
Sl.	Code	Subject	L	T	S	C	H
1	MES851	Project – II / Industry Internship	0	0	14	6	14
2	MES852	Comprehensive Viva-Voce	0	0	0	1	
		TOTAL	0	0	14	7	14
DepartmentalCore:15			Non-departmentalCore:05(IncludingAI& ML)				
DepartmentalElectives:05			OpenElectives:01				

CREDIT UNIT OF THE PROGRAM:

Semester	I + II	III	IV	V	VI	VII	VIII	TOTAL
Credit Unit	43	26	24	24	22	22	7	168

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT.

5th Semester

DEPARTMENT OF MECHANICAL ENGINEERING	
MEE510	Convective Heat and Mass Transfer
MEE511	Advanced Solid Mechanics
MEE512	Multi-Phase Flow and Heat Transfer
MEE513	Tribology
MEE514	Material Science and Engineering
MEE515	Operation Research
MEE516	Mechatronics
MEE517	Advanced Foundry Engineering
MEE518	Engineering Optimization

6th Semester

DEPARTMENT OF MECHANICAL ENGINEERING	
MEE610	Non-Conventional Machining
MEE611	Design and Optimization of Thermal Systems
MEE612	Control Systems
MEE613	Fundamentals of Combustion
MEE614	Modelling and Simulation of Dynamic Systems
MEE615	Non-Linear Vibration
MEE616	Mechanics of complex fluids
MEE620	Automobile Engineering
MEE621	Gas Dynamics and Propulsion
MEE622	Mechanics of Composite and Functionally Graded Materials
MEE623	Finite Element Methods
MEE624	Additive Manufacturing
MEE625	Mechanics of Forming and Press Working
MEE626	Advanced Welding Technology
MEE627	Computer Aided Design

7th Semester

DEPARTMENT OF MECHANICAL ENGINEERING	
MEE710	Machine Tool Engineering and Automation
MEE711	Fracture Mechanics
MEE712	Micro and Nano Manufacturing
MEE713	Aerospace Engineering
MEE714	Advanced Mechanical Vibration

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MEE715	Solar Energy
MEE720	Advanced Machining and Surface Engineering
MEE721	Microfluidics
MEE722	Refrigeration and Air Conditioning
MEE723	Computational Fluid Dynamics and Heat Transfer
MEE724	Theory of Plates
MEE725	Energy Conversion Systems
MEE726	Advanced Robotics

LIST OF OPEN ELECTIVE SUBJECTS:: ADMISSION BATCH 2023 & ONWARDS

7th Sem	DEPARTMENT OF MECHANICAL ENGINEERING
MEO741	Product Development and Value Engineering
MEO742	Energy Management and Auditing
MEO743	Dynamical Systems Theory
XEO744	Design Thinking, Innovation and Entrepreneurship

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC01	MATHEMATICS - I	PCR	3	1	0	4	4
Pre-requisites		Basic concepts of function, limit, differentiation and integration.					
Course Outcomes	• CO1: learn the fundamentals of differential calculus of single and several variables. • CO2: learn the basic concepts of convergence of infinite series. • CO3: understand the basic concepts of integral calculus along with its various applications. • CO4: acquire the theoretical knowledge of vector calculus and its engineering applications.						
Topics Covered	Functions of Single Variable: Review of limit, continuity and differentiability. Mean value theorems: Rolle's Theorem, Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's theorem, Taylor's and Maclaurin's series. (8) Functions of several variables: Limit, continuity and differentiability of functions of several variables, partial derivatives and their geometrical interpretation, derivatives of composite and implicit functions, derivatives of higher order and their commutativity, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof). (11) Sequences and Series: Real sequences and their convergence, Series of positive terms, Necessary and sufficient condition for convergence, p-series, geometric series, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) Integral Calculus: Review of the idea of integration as a limit of a sum, Mean value theorems of integral calculus, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms, Improper integrals and their convergence, Beta and Gamma functions. (12) Multiple Integrals: Evaluation of double and triple integrals, Change of order of integration, Change to better coordinates, Area and volume by double integration, Volume by triple integration. (10) Vector Calculus: Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their engineering applications. (9)						

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Text Books, and/or reference material	Text Books: 1. Kreyszig, E., Advanced Engineering Mathematics: 10th edition, Wiley India Edition, 2010. 2. Murray, D.A., Differential and Integral Calculus, FB & C Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. 4. Murray Spiegel, Schaum's Outline of Vector Analysis, Tata McGraw Hill .1980 ,Education Reference Books: 1. Tom Apostol, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Edition, Addison Wesley.
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Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC01	COMPUTER PROGRAMMING	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic knowledge of computer.		CT+MT+EA					
Course Outcomes	• CO1: To understand basics of computer programming, program flow, and programming constructs. • CO2: Develop concepts on basic and complex data types, conditional and iterative statements. • CO3: Exercise the concepts of user defined functions to solve real time problems. • CO4: Inscribe C programs that use Pointers to access arrays, strings and functions. • CO5: Exercise user defined data types including structures and unions to solve problems.						
Topics Covered	Introduction to C: Phases of developing a running computer program in C. (2L) Data types, size and values. Char, Unsigned and Signed data types. Number systems and representations. Constants, Overflow. (3L) Data concepts in C: Constants, Variables, Expressions, Operators, and operator precedence in C. (2L) Statements: Declarations, Input-Output Statements, Compound statements, Selection Statements. (2L) Conditions, Logical operators, Precedences. Repetitive statements, While construct, Do-while Construct. For construct. (3L)						

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	Arrays. Strings. Multidimensional arrays and matrices. (3L) Pointers: Pointer variables. Declaring and dereferencing pointer variables. Pointer Arithmetic. Examples. Accessing arrays through pointers. Pointer types, Pointers and strings. String operations in C. (6L) Dynamic memory allocation. (2L) Modular Programming: Functions: The prototype declaration, Function definition. (3L) Function call: Passing arguments to a function, by value, by reference. Scope of variable names. Recursive function calls, Tail recursion. (4L) Sorting problem: Sorting in arrays with an example of Bubble sort. Sorting in strings. (3L) Search problem: Linear search and binary search. (2L) More Data-types in C: Structures in C: Motivation, examples, declaration, and use. Operations on structures. Passing structures as function arguments. type defining structures. (4L) File input-output in C. Streams. Input, output and error streams. Opening, closing and reading from files. Programming for command line arguments. (3L)
Text Books, and/or reference material	Text Books: 1. P. Deitel, H. Deitel. C How to Program. Pearson Education India, 7th Ed. 2. B. W. Kernighan, Dennis M. Ritchie. The C Programming. Prentice Hall Software Series, 2nd Ed. Reference Books: 1. P. Dey and M. Ghosh. Computer fundamentals and programming in C. Oxford press, 2013. 1. Y. Kanetkar. Let Us C. BPB Publications, Sixteenth edition, 2017.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	2	2	1	-	1	2	-	-	-	-	-	-
	CO2	3	2	1	-	1	1	1	-	-	-	-	-
	CO3	2	2	1	-	-	2	-	-	-	-	-	-
	CO4	3	2	2	-	-	1	-	-	-	-	-	-
	CO5	3	1	2	-	1	2	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P) [#]	Total Hours	
XEC01	ENGINEERING MECHANICS	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams. • CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis. • CO3: Ability to calculate centroid, moments of inertia for various shapes. • CO4: Learn momentum and energy principles. • CO5: Knowledge on virtual Work Principle and its application						
Topics Covered	Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of						

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	equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5] Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]
Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC01	Engineering Physics	PCR	2	1	0	3	3
Pre-requisites:		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	• CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems. • CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. • CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. • CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.						
Topics Covered	Harmonic Oscillations - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and Forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, [8] Wave Motion: Longitudinal waves, Transverse waves, Wave equation, phase velocity and group velocity, Maxwell's equations, Electro-magnetic waves in free space. [3] Introductory Quantum Mechanics - Inadequacy of classical mechanics, Blackbody						

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	radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] Interference & Diffraction - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] Polarisation - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] Laser and Optical Fiber - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]
Text Books, and/or reference material	TEXT BOOKS: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. REFERENCE BOOKS: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud, New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC01	Engineering Chemistry	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: Students will get the knowledge of fundamentals as well industrial applications of polymer, petroleum products, organometallic compounds and others. • CO2: Students will be able to elucidate the structure of different organic compounds and to analyze the structure-property correlation. • CO3: Students will be aware on the role played by different metals in biological systems and also the ecological impact of metals.						

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	CO4: Students will be able to understand and analyze thermodynamical, kinetic as well as electrochemical aspects of chemical systems and apply the understanding in the technical field.
Topics Covered	ORGANIC CHEMISTRY Polymer chemistry and polymer engineering: Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber and plastic materials; vulcanization, structure-property correlation: Concept of Molecular weight of polymer, Glass transition temperature. Engineered polymer: Thermally stable, flame retardant, Conducting polymer. (5L) Petroleum Engineering and oil refinery: Origin of petroleum, separation principle and techniques of distillation of crude oil, thermal and catalytic cracking of petroleum, uses of different fractions, knocking, anti-knock compounds, octane number and cetane number. High octane and Aviation fuel. Bio-diesel. (3L) Structure elucidation of organic compounds by modern spectroscopic methods: Application of UV-Visible (Lambert-Beers law), concept of chromophore, auxochrome, hypso-, hyper-, bathochromic, red shift. FT-IR spectroscopy and Mass spectroscopy (including instrumentation). (4L) INORGANIC CHEMISTRY Coordination Chemistry: Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, LMCT, MLCT, IVCT. Isomerism and stereochemistry. (5L) Bioinorganic Chemistry: Metal ions in biological systems: Fe, Cu (2L) Industrial application of Organometallic complexes: π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes, Various catalytic cycles of industrial importance. (4L) Environmental Chemistry: Metal toxicity (As, Hg, Pb and Cd) and its remediation (1L) PHYSICAL CHEMISTRY Chemical Thermodynamics: 2nd law of thermodynamics: Concept of thermodynamic engine (Carnot and reverse Carnot cycle), entropy, free energy. Temperature and pressure dependence of entropy and free energy. Change in phase: phase diagram of single component system. Cryogenics: Joule Thomson experiment. (5L) Chemical Kinetics: Rate expression of Reversible reaction, parallel reaction, and Consecutive reaction with proper examples. Temp effect on reaction rate. (3L) Catalysis: Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis. (2L) Electrochemistry: EMF, Nernst Equation, Application of electrochemistry in chemical processes. Electrochemical cell, Fuel cell, Li-ion battery (3L).
Text Books, and/or reference material	<u>Suggested Text Books:</u> - Physical Chemistry by P. Atkins, Oxford - A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu. - Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall <u>Suggested Reference Books:</u> Organic Chemistry: - Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press - Engineering Chemistry: Wiley - Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan Inorganic Chemistry: - Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education - Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introduction and Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. - Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford

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	Physical Chemistry: (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit
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Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P) [#]	Total Hours	
ESC01	Ecology and Environment	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	• CO1: Understand the importance of environment and ecosystem. • CO2: Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system. • CO3: Understand the scientific basis of local and as well as global issues. • CO4: Apply of knowledge to develop sustainable solution.						
Topics Covered	UNIT – I: INTRODUCTION (2) Multidisciplinary nature of Environmental Studies: Definition, Scope, and Importance. UNIT–II: FUNDAMENTALS OF ECOLOGY (9) Definition, Components of Environment; Fundamentals of Ecology and Ecosystem; Components and Classification of Ecosystem; Energy flow in Ecosystem: Tropic level, Food Chain, Food Web, Ecological Pyramid; Biogeochemical cycles: Carbon, Nitrogen, Sulphur, Phosphorus, and Water Cycle; Biosphere and Biodiversity; Conservation. UNIT–III: FUNDAMENTALS OF ENVIRONMENT (10) Environmental Pollution: Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Solid Wastes, and Natural hazards: Floods, earthquakes, cyclones, and landslides. Environmental Issues: Climate change and global warming; acid rain; and ozone layer depletion. Environment Quality: Ambient air quality standards, Water quality parameters and standards: pH, Turbidity, Hardness, Sulphate, Phosphates, Iron, Dissolved Oxygen, BOD, and COD. UNIT– IV: NATURAL RESOURCES (3) Mineral Resources, Energy Resources: Conventional and Non-Conventional.						

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	UNIT- V- GREEN TECHNOLOGY & ENVIRONMENTAL ETHICS (4) Sustainability: Carbon Sequestration, Green building practices, Green computing; Carrying capacity; and Environment Protection Acts/laws.
Text Books, and/or reference material	1. A Basic Course in Environmental Studies. Deswal&Deswal. Pub. DhanpatRai& Sons 2. Ecology. Odum. Pub. Oxford & IBH 3. Environmental Engineering. Peany et.al. Pub. McGraw Hill 4. A Text Book of Environmental Engg. VenugopalRao. Pub. PHI 5. A Basic Course in Environmental Studies. Deswal&Deswal. Pub. DhanpatRai& Sons 6. Environmental Studies. Bharucha. Pub. University of Press 7. Environmental Chemistry and Pollution, S. S. Dara& D. D. Mishra, S. Chand Publishing

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSC01	Professional Communication	PCR	2	0	2	4	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	• CO1: Learners will acquire linguistic proficiency in terms of improvement in their listening, speaking, reading, and writing skills. • CO2: Learners will acquire better communicative ability. • CO3: The course will help learners improve their social connectivity skill.						
Topics Covered	Vocabulary 1. Word Formation, Use of Prefixes and Suffixes (1) 2. Synonyms, Antonyms (1) 3. Prefixes and Suffixes from Foreign Languages, Words from Foreign Languages (1) 4. Abbreviations and Acronyms (1) 5. Technical Vocabulary (1) Grammar 1. Identifying Common Errors in Articles and Prepositions (1) 2. Common Errors in Noun-Pronoun Agreement and Subject-Verb Agreement (1) 3. Misplaced Modifiers and Tenses (1) 4. Redundancies and Clichés (1) Reading 1. Reading and Its Importance, Techniques of Effective Reading (1) 2. Improving Comprehension Skills, Techniques for Good Comprehension (1) 3. Skimming and Scanning (1)						

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	4. Comprehension, Intensive and Extensive Reading (2) Writing 1. Sentence Structures, Phrases and Clauses, Punctuation (2) 2. Organising Principles of Paragraphs (2) 3. Formal Letters, Letters of Complaint, Requisition Letters, Job Application, and Résumé (2) 4. Nature and Style of Sensible Writing, Defining, Describing, Classifying, Providing Examples and Evidence (2) 5. Essay Writing (2) 6. Précis Writing (2) 7. Report Writing (2) Oral Communication 1. Listening Comprehension (4) 2. Pronunciation, Intonation, Stress, and Rhythm (4) 3. Communication at the Workplace (4) 4. Everyday Conversation (4) 5. Group Discussion (4) 6. Interviews (4) 7. Formal Presentations (4)
Text Books, and/or reference material	Text Book: 1. English for Engineers –Sudharshana&Savitha (Cambridge UP) Reference Books: 2. <i>English</i>—Kulbhushan Kumar (Khanna Book Publishing) 3. <i>Remedial English Grammar</i>—F. T. Wood (Macmillan)

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSC01	CO1	1	--	--	1	--	1	--	1	2	3	1	--
	CO2	1	--	--	1	--	2	--	2	2	3	2	--
	CO3	--	--	--	1	--	3	--	3	3	3	2	--

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC02	MATHEMATICS - II	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of set theory, differential equations, and probability.		CT+MT+EA					
Course Outcomes	• CO1: learn the basic concepts of linear algebra and be able to apply the same to solve various engineering problems. • CO2: understand fundamentals of ordinary differential equations and their applications. • CO3: acquire the theoretical knowledge of Fourier Series, Fourier & Laplace transforms, and learn about their applications. • CO4: learn the basic concepts of probability theory.						
Topics Covered	Introduction to Algebraic structures: Group, subgroup, ring, subring, integral domain, and field. (3) Linear Algebra: Vector spaces over field, linear dependence and independence of vectors, linear span of a set of vectors, basis and dimension of finite dimensional						

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	vector space, elementary row/column operations, rank of a matrix, solutions of system of linear (homogeneous and non-homogeneous) equations, eigenvalues and eigenvectors, characteristic polynomials, Cayley-Hamilton theorem (without proof), Diagonalization of matrices. (15)
	Ordinary Differential Equations (ODE): Review of first order ODE, Picard's theorem (Statement Only), ODE of first order and of the first degree (exact ODE, rules for finding integrating factors), ODE of first order and of the higher degree (ODE solvable for x, solvable for y; Clairaut's equation, singular solution), homogeneous and non-homogeneous linear ODE with constant coefficients and variable coefficients (Euler–Cauchy type), linear dependence of solutions, Wronskian determinant, Solution of simultaneous ODEs ($dx/P = dy/Q = dz/R$; $dx/dt = ax + by$, $dy/dt = cx + dy$), properties of nonlinear ODEs, phase plane analysis. (18) Fourier series: Piecewise smooth and periodic functions, Fourier series of a function in an interval, Dirichlet conditions, Convergence of Fourier series, Fourier sine and cosine series, Complex form of Fourier series. (4) Fourier Transforms: Fourier Integral Theorem (statement only), Different forms of Fourier Integrals, Fourier Transform and its inversion formula, Properties of Fourier Transform, Convolution. (7) Laplace Transforms: Laplace transforms and its Properties, Inverse Laplace transforms, Convolution theorem, Applications to ODE. (4) Probability: Random variables and probability distributions (discrete and continuous), Binomial, Poisson, Uniform and Normal distributions. (5)
Text Books, and/or reference material	Text Books: 1. Kreyszig, E., Advanced Engineering Mathematics: 10th edition, Wiley India Edition (2010). 2. Strang, G., Linear algebra and its applications (4th Edition), Thomson (2006). 3. Murray, D.A., Introductory Course in Differential Equations, Khosla Publishing House (2021). 4. Debnath, L., Integral Transforms and Their Applications, CRC Press (1995). 5. Baisnab, A.P., Jas, M., Elements of Probability and Statistics, McGraw Hill Education (2017). Reference Books: 1. Kumaresan, S., Linear algebra - A Geometric approach, ChaukhambaAuriyantalaya (2017). 2. Ross, S.L., Differential Equations, 3rd Edition, Wiley Student Edition (2017). 3. Shivamoggi, A., Integral Transforms for Engineers, PHI (2003). 4. Grinstead, C.M., Snell, J.L., Introduction to probability, American Mathematical Society (2012).

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

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CSC02	Data Structure and Algorithms	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CSC01 (Computer Programming)		CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]					
Course Outcomes	- CO1: Understanding the fundamental concepts of abstract data types, data structures, algorithms and time complexity analysis of algorithms. - CO2: Implementation of different abstract data types (array, linked list, stack, queue, tree, graph). - CO3: Implementation of different sorting and searching techniques along with their performance evaluation. - CO4: Analysis of the suitability/compatibility of different data structures based on the types of applications. - CO5: Design and development of algorithms for real-life applications.						
Topics Covered	Introduction: Abstract Data Type (ADT), Data Structures, Concept of static and dynamic memory allocation, Algorithm, Analysis of time and space complexity of algorithms, Asymptotic notations: Big Oh, Big Omega and Big Theta notations, Impact of data structure on the performance of an algorithm. (6L) Array: Array as an ADT, Single and multi-dimensional array, Memory representation (row major and column major) of array, Address calculation for array elements. (2L)						
	Linked list: Linked list as an ADT, Memory allocation and deallocation for a linked list, Linked list versus array, Types of linked lists: singly linked list, doubly linked list and circular linked list, Operations on linked list: creation, display, insertion and deletion (in different positions), Concatenation, Searching, Sorting, Applications of linked list: Representations and operations on polynomials, sparse matrices, etc., Array vs. Linked List. (6L)						
	Stack: Stack as an ADT, Push and pop operations on stacks, Array implementation of stack, Linked list implementation of stack, Applications of stack: Recursion, Function call, Evaluation of postfix expression using stack, Conversion of infix to postfix using stack. (5L) Queue: Queue as an ADT, Enqueue and dequeue operations, Array implementation of queue, Limitation of array implementation, Circular queue, Linked list implementation of queue, Priority queue. (4L) Binary Tree: Binary Tree, Definition and properties, Representation of binary tree in memory: linked representation, array representation, Binary tree traversal (Preorder, Inorder and Postorder), Binary search tree, Heap (8L) Searching Algorithms: Linear search and binary search. (2L) Sorting Algorithms: Selection sort, Insertion sort, Quick sort, and Merge sort. (5L) Graphs Algorithms: Graph representation using Adjacency matrix and Adjacency list, Breadth First Search and Depth First Search algorithms. (4L)						
Text Books, and/or reference material	Text Books: 1. R. F. Gilberg and B. A. Forouzan, "Data Structures: A pseudocode approach with C", 2nd Edition, CENGAGE Learning. 2. A. V. Aho, J. D. Ullman and J. E. Hopcroft, "Data Structures and Algorithms", Addition Wesley. 3. Lipschutz, "Data Structures (Schaum's Outline Series)", Tata Mcgraw Hill. 4. E. Horowitz, S. Sahni, S. Anderson-Freed, "Fundamentals of Data Structures in C", Universities Press; Second edition (2008). Reference Books: 1. Y. Langsam, M. J. Augenstein and A. N. Tanenbaum, "Data Structures using C and C++", Pearson, 2006. 2. Knuth, Donald E. The Art of Computer Programming. 3rd ed. Vols 1&2. Reading, MA: Addison-Wesley, 1997. ISBN: 0201896834. ISBN: 0201896842. ISBN: 0201896850. 3. Kleinberg and Eva Tardos. Algorithm Design. Addison-Wesley 2005 ISBN-13:						

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978-0321295354.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC02	CO1	3	-	1	1	1	-	-	-	-	-	-	-
	CO2	3	2	1	2	2	-	-	-	-	-	-	1
	CO3	3	2	1	2	2	-	-	-	-	-	-	1
	CO4	3	3	2	3	3	-	-	-	-	-	-	1
	CO5	3	3	3	3	3	-	-	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XEC02	Basic Electrical and Electronics Engineering	PCR	3	0	0	3	3
Pre-requisites			Course Assessment methods				
(10+2) level mathematics and physics			CT+MT+EA				
Course Outcomes	CO1: Learn the fundamentals of electric circuits and analyze the circuits using laws and network theorems. CO2: Gain the knowledge about magnetic circuits, electromagnetism and the basics of generation of alternating voltage. CO3: Understand the behaviour of single phase and poly-phase AC circuits. CO4: Understand the fundamentals of semiconductor devices. CO5: Analyze the design and characteristics of transistor-based electronic circuits. CO6: Evaluate operational amplifier-based circuits and logic gates.						
Topics Covered	1. Introduction to Electrical systems, Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (4) 2. Network theorems (DC): Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem. (5) 3. Magnetic circuits: Review of fundamental laws of electromagnetic induction, Self and mutual inductances, Solution of magnetic circuits. (3) 4. Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behaviour of AC circuits, Resonance in series and parallel R-L-C circuits. (6) 5. Poly-phase system, Advantages of 3-phase system, Generation of 3-phase voltages, Voltage, current and power in a star and delta connected systems, 3-phase balanced and unbalanced circuits. (3) 6. Semiconductor Devices: Construction, working and V-I characteristics of diode, Zener diode, Zener diode as a voltage regulator, LED. (6) 7. Transistors:Introduction to BJT, FET, MOSFET; CMOS, working principle, and V-I characteristics of Transistors, biasing of BJT circuits-fixed bias, emitter bias, feedback bias, voltage divider bias, transistor as an amplifier. (8) 8. Operational amplifier:Introduction, applications: inverting, non-inverting amplifier, unity follower, integrator, differentiator, summing circuit .(4) 9. Introduction of logic gates, memory: ROM, RAM. (3)						
Text Books,	TEXT BOOKS						

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and/or reference material	1. Electrical & Electronic Technology by Hughes, Pearson Education India. 2. Introduction Electronic Devices & Circuit Theory, 11/e, 2012, Pearson: Boylestad&Nashelsky. 3. Electronics: Fundamentals and Applications By D. Chattopadhyay, P. C. Rakshit; New Age Int. Publication. REFERENCE BOOKS 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd. 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Edu. India. 3. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill. 4. Electronics - Circuits and Systems, Fourth Edition by Owen Bishop. 5. Electronics Fundamentals: Circuits, Devices & Applications (8e) by Thomas L. Floyd & David M. Buchla.
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Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC02	CO1	3	3	3	3	3	1	1	1	1	1	1	1
	CO2	3	3	3	3	2	1	2	1	1	1	1	1
	CO3	3	3	3	3	3	2	2	1	1	1	1	1
	CO4	2	3	2	2	-	1	-	-	-	-	-	1
	CO5	3	2	1	2	2	1	-	-	2	-	-	1
	CO6	3	2	2	2	3	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS51	COMPUTER PROGRAMMING LABORATORY	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: To understand the principle of operators, loops and branching statements. CO2: Implementation of function, recursion, arrays, and pointers based several types of assignments. CO3: To detail out the operations of strings. CO4: To understand structure and union. CO5: Application of C-programming to solve various types of problems.						
Topics Covered	List of Experiments: 1. Programs on expression evaluation. 2. Programs on conditional statements and branching 3. Programs on iterations/loops. 4. Applications of Arrays 5. Programs on basics of functions and pointers. 6. Programs on string using array and pointers. 7. Programs on recursion. 8. Programs on structures, union. 9. Programs on File Operations. 10. Case Studies.						
Text Books, and/or reference material	Text Books: 1. Y. Kanetkar, "Let Us C", BPB Publications, Sixteenth edition, 2017. 2. B. S. Gottfried, "Programming with C", McGraw Hill Education, 4 th Ed., 2018. 3. E. Balagurusamy, "Computing Fundamentals and C Programming", McGraw Hill Education; Second edition, 2017. Reference Books:						

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	1. P. Dey and M. Ghosh, "Computer fundamentals and programming in C", Oxford press, 2013. 2. R. Thareja, "Computer fundamentals and programming in C", Oxford press, 2013. 3. Schaum's Outline, Programming with C.
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Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS51	CO1	3	3	2	-	-	2	-	-	-	-	-	-
	CO2	2	2	1	-	-	1	-	-	-	-	-	-
	CO3	3	2	2	-	-	1	-	-	-	-	-	-
	CO4	2	3	2	-	-	2	1	-	-	-	-	-
	CO5	3	3	3	-	1	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS51	Physics Laboratory	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					
Course Outcomes	CO1: To realize and apply different techniques for measuring refractive indices of different materials. CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. CO4: To understand interference, diffraction and polarization related optical phenomena. CO5: To acquire basic knowledge of light propagation through fibers.						
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus. 8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.						
Text and/or reference material	SUGGESTED BOOKS: 1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

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Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	CHEMISTRY LABORATORY	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	- CO1: To learn basic analytical techniques useful for engg applications. - CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance. - CO3: Learn chromatographic separation methods. - CO4: Applications of spectroscopic measurements.						
Topics Covered	- Experiments based on pH metry: Determination of dissociation constant of weak acids by pH meter. - Experiments based on conductivity measurement: Determination of amount of HCl by conductometric titration with NaOH. - Estimation of metal ion: Estimation of Fe²⁺ by permangnometry - Estimation of metal ion: Determ. of total hardness of water by EDTA titration. - Synthesis and characterization of inorganic complexes: e. g. Mn(acac)₃, Fe(acac)₃, cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p. , FTIR etc. - Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone. - Synthesis of polymer: polymethylmethacrylate - Verification of Beer-Lamberts law and determination of amount of iron present in a supplied solution. - Chromatography: Separation of two amino acids by paper chromatography - Determination of saponification value of fat/ vegetable oil						
	<u>Suggested Text Books:</u> - Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall - Advanced Physical Chemistry Experiments: By Gurtu&Gurtu - Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra <u>Suggested Reference Books:</u> - Practical Chemistry By R.C. Bhattacharya - Selected experiments in Physical Chemistry By N. G. Mukherjee						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CURRICULUM AND SYLLABUS FOR B.TECH. IN MECHANICAL ENGINEERING

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES51	ENGINEERING GRAPHICS	PCR	1	0	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Ability of mental visualization of different objects • CO2: Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects • CO3: Able to read/interpret industrial drawing and to communicate with relevant people						
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1st, 2nd, 3rd and 4th quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6] Dimensional techniques; international and national standards (ISO and BIS). [3] Freehand graphics. [3]						
Text and/or reference material	1)... Engineering Drawing and Graphics – K Venugopal 2)... Engineering Drawing – N D Bhat 3)... Practical Geometry and Engineering Graphics – W Abbott						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES52	Basic Electrical and Electronics	PCR	0	0	3	3	2

CURRICULUM AND SYLLABUS FOR B.TECH. IN MECHANICAL ENGINEERING

	Laboratory						
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: Learn to analyse the electric circuits using network theorems. CO2: Understand the characteristics of fluorescent lamp and compact fluorescent lamp. CO3: Analyze the behaviour of single phase and three phase AC circuits. CO4: Understand the application of electronics components, diode circuits as rectifier circuits and voltage regulators. CO5: Evaluate and study the performance of the transistor as a switch. CO6: Create inverting and non-inverting amplifier circuits using Op-Amp.						
Labs Conducted.	1. Verification of the network theorems (DC). 2. Study of the characteristics of fluorescent and compact fluorescent lamp. 3. Analysis of the three phase system for star and delta connected load. 4. Study of the series and parallel R-L-C circuit. 5. Identify and understand the use of different electronic and electrical instruments, various electronic components. 6. Study of half-wave and full-wave (bridge) rectifier with and without capacitor filter circuit. Zener diode as a voltage regulator. 7. Study the performance of a transistor as a switch through NOT gate. 8. Realization of Inverting and Non-inverting amplifier using Op-Amp.						
Text Books, and/or reference material	TEXT BOOK 1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru , J M Chuma, H U Ezea. 2. Experiments Manual for use with Electronic Principles (Engineering Technologies and the Trades) by Albert Paul MalvinoDr., David J. Bates, et al. REFERENCE BOOKS 1. Laboratory Courses in Electrical Engineering (5 th Edition) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Publications). 2. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill. 3. Electronic Principles. by Albert Paul MalvinoDr. and David J. Bate.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES52	CO1	3	3	3	3	3	1	1	1	2	2	2	3
	CO2	3	3	2	3	3	3	1	1	2	2	2	3
	CO3	3	3	2	3	3	2	1	1	2	2	2	3
	CO4	3	3	3	3	3	1	1	1	2	2	2	3
	CO5	3	2	1	2	2	1	-	-	2	-	-	-
	CO6	3	2	2	2	3	-	-	-	2	-	-	-
	CO7	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS52	DATA STRUCTURES AND ALGORITHMS	PCR	0	0	3	3	2

CURRICULUM AND SYLLABUS FOR B.TECH. IN MECHANICAL ENGINEERING

	LABORATORY						
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: Understanding the suitability and compatibility of array and linked list implementations for different application problems. CO2: Understanding the concept of abstract data types from real-life scenarios and their implementation in computing system. CO3: Identify, design and implementation of stack, queue, binary tree, and graph as applicable for given problem. CO4: Implementation of different searching and sorting techniques using appropriate data structures and perform efficiency analysis. CO5: Create efficient algorithms for real-life applications.						
Topics Covered	List of Experiments: 1. Application of arrays using dynamic memory allocation. 2. Implementation and Applications of linked lists. 3. Implementation of stack, and applications of stack. 4. Implementation of queue, applications of queue: Priority queue. 5. Implementation of Binary tree, Binary tree traversal: Preorder, Inorder and Postorder traversal. 6. Implementation of binary search tree and operations on it. 7. Implementation of linear search, binary search (recursive, non-recursive). 8. Implementation of different sorting algorithms. 9. Implementation of graph algorithms: Breadth first search, Depth first search. 10. Case Studies.						
Text Books, and/or reference material	Text Books: 1. S. Lipschutz, "Data Structures (Schaum's Outline Series)", McGraw Hill Education; First edition (2017). 2. E. Horowitz, S. Sahni, S. Anderson-Freed, "Fundamentals of Data Structures in C", Universities Press; Second edition (2008). 3. E. Balagurusamy, "Programming in ANSI C", McGraw Hill Education India Private Limited, Seventh edition (2017). Reference Books: 1. B. S. Gottfried, "Programming with C", McGraw Hill Education, 4thEd. (2018).						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS52	CO1	-	1	1	1	-	-	-	-	-	-	-	-
	CO2	-	1	1	3	-	-	-	-	-	-	-	-
	CO3	2	2	3	2	1	-	-	-	-	-	-	-
	CO4	2	2	2	1	1	-	-	-	-	-	-	-
	CO5	3	3	3	3	3	-	1	1	-	-	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS51	Extra Academic Activities	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course	• CO1: Social Interaction through the medium of sports						

CURRICULUM AND SYLLABUS FOR B.TECH. IN MECHANICAL ENGINEERING

Outcomes	CO2: Team building and self defence
Topics Covered	YOGA - Introduction of Yoga- Suryanamaskar. 1L - Sitting Posture / Asanas – Padmasana, Vajrasana, ArdhaKurmasana, Ustrasana, Janusirshasana, Gomukhasana, Bhadrasana. 7L - Mudra- Gyana Mudra, Chin Mudra. 1L - Laying Posture/ Asana-PavanaMukhtasana, UttanaPadasana, Sarpasana, Bhujangasana (Cobra Pose), EkaPadaSalabhasana, Dhanurasana, Chakrasana, Viparitkarani, ArdhaHalasana (Half Plough Pose), Naukasana (Boat Posture), Shavasana (Relaxing Pose) , Makarasana. 7L - Meditation-Om Chant.1L - Standing Posture / Asana-Tadasana (Mountain Pose), Vrikshana (Tree Pose), ArdhaChandrasana, Padahasthasana, ArdhaChakrasana (Half Wheel Posture). 5L - Pranayama-Deep Breathing, AnulomVilom, Shitali, Bhramari. 5L - Kriya- Kapalbhati 1L TAEKWONDO - Introduction About Taekwondo- Meaning Of Taekwondo, Korean Language Of Dress, Fighting Area, Punch, Block, Kicks Etc. 1L - Stance- Ready Stance, Walking Stance, Front Stance, Back Stance. 2L - Punch Technique- Front Fist Punch, Double Fist Punch, With Stance Etc. Blocks- Upper Blocks, Middle Block, Side Block, Suto Etc. 4L - Foot Technique- Standing Kick, Front Kick, Doliyo, Back Kick Etc. 6L - Poomsae (Forms)- Jang, Yi Jang. 6L - Self Defense Technique- Self Defense from Arms, Fist and Punch. 4L - Sparring (Kyorugi)- One Step Sparring 2L - Combination Technique- Combined Kick And Punch. 2L - Project Work 1L

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	2	-	-	1
	CO2	-	-	-	-	-	-	-	2	3	-	-	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CURRICULUM AND SYLLABUS FOR B.TECH. IN MECHANICAL ENGINEERING

THIRD SEMESTER

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC331	MATHEMATICS-III	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic knowledge of topics included in MAC01 & MAC02							
Course Outcomes	- CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering. - CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems. - CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts. - CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.						
Topics Covered	Partial Differential Equations (PDE): Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogeneous and Nonhomogeneous linear PDE with constant coefficients; Complementary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14] Numerical Methods: Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange's interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson's 1/3 rule for numerical integration; Euler's method and modified Euler's methods for solving first order differential equations. [14] Complex Analysis: Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy's integral theorem; Cauchy's integral formula; Taylor's theorem, Laurent's theorem (Statement only); Singular points and residues; Cauchy's residue theorem. [17] Optimization: Mathematical Preliminaries: Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2] Linear Programming Problem (LPP): Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [9]						
Text Books, and/or reference material	Text Books: 1. An Elementary Course in Partial Differential Equations - T. Amarnath 2. Numerical Methods for scientific & Engineering Computation - M.K. Jain, S.R.K. Iyengar & R.K. Jain. 3. Foundations of Complex Analysis - S. Ponnuswami 4. Operations Research Principles and Practices - Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics - E. Kreyszig Reference Books: 1. Complex Analysis - L.V. Ahlfors 2. Elements of partial differential equations - I.N. Sneddon 3. Operations Research - H.A. Taha						

CURRICULUM AND SYLLABUS FOR B.TECH. IN MECHANICAL ENGINEERING

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC301	Solid Mechanics	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and End Assessment (EA))					
Engineering Mechanics		CA: CT + EA					
Course Outcomes	CO1: Basic understanding about elastic properties of materials, analysis of stress and strains, strain energy in solid bodies. CO2: Exposure towards structural members subjected to tensile, shear, bending and torsional loads. CO3: Idea about analyzing for deflection of beams. CO4: Evaluate failure criteria of structural members under various combined loading conditions. CO5: Acquire the fundamentals about structural members subjected to compressive loads, internal or external pressure.						
Topics Covered	Simple Stress and Strain04 Introduction to stress and strains, Generalized Hooke's Law, Relationship among different elastic coefficients. Analysis of Beams24 Theory of bending, Shearing forces and Bending moments in beams, SF and BMD Diagrams. Bending and Shear stresses in Beams, Flexural rigidity, Section modulus. Deflection of Beams: Double-Integration method, Area-Moment method. Statically indeterminate beam problems. Complex Stress and Strain08 Transformations of stress and strain using analytical and graphical methods, Mohr's Circle for a 2-D state of stress, Stress, strain and displacement relationship, Strain rosette. Torsion of Circular Members05 Torsional deformation of a circular C/S member, Shafts in series and parallel connection, TDD, Statically indeterminate shafts, Strain energy in torsion and pure shear, Design of transmission shafts, Stress concentrations in torsion. Theories of Failures05 Combined loading cases and associated stresses, Theories of failure for ductile and brittle materials. Columns04 Fundamental concepts of buckling and stability of column using Euler's theory, Critical load, buckling shape, and critical stress for various columns, Limitation of Euler's formula. Thin Pressure Vessels04 Stresses in thin cylinder, Deformation analysis of thin cylinder, Design of thin cylindrical shells. Energy Method02 Elastic strain energy, Castigliano's Theorems and its applications.						
Text Books, and/or reference material	Text Books: 1. Mechanics of Materials by F.P. Beer, E.R. Johnston, J.T. DeWolf, D.F. Mazurek, McGraw-Hill Education. 2. Engineering Mechanics of Solids by E.P. Popov, Prentice Hall. 3. Mechanics of Materials by B.J. Goodno and J.M. Gere, Cengage Learning. Reference Books: 1. A Textbook of Strength of Materials by D. Ghosh and K. Dutta, New Age International Publishers. 2. Strength of Materials: Part I, II by S. Timoshenko, CBS Publishers. 3. Strength of Materials by S.S. Rattan, McGraw-Hill Education. 4. Introduction to Solid Mechanics, I.H. Shames and J.M. Pittarresi, PHI.						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core(PCR)/ Electives(PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial(T)	Practical (P)	Total Hours	
MEC302	Theory of Machines and Mechanisms	PCR)	3	1	0	4	4
Pre-requisites		Course Assessment methods					
XEC01		Continuous(CT)+Mid Term(MT)+End Term assessment(EA)					
Course Outcomes	CO1 Understand the principles of different lower and higher kinematic pairs and mechanisms CO2 Analyze the mechanisms for position, velocity and acceleration CO3 Analyze the dynamics of IC engine and its components CO4 Synthesize planar four bar, slider crank mechanisms and cam profile for specified design requirements						
Topics	Introduction to Mechanisms Kinematic links, pairs, chains, mechanisms and inversions; degrees of freedom, Gruebler's criterion; Four bar mechanisms and slider crank mechanisms, Spatial Mechanisms, Micro-mechanisms, Compliant mechanisms						3
	Kinematic Analysis of Planar Mechanisms Displacement analysis, Velocity analysis, Acceleration analysis, Computer Aided Kinematic analysis						5
	Kinematic Analysis of Spatial Mechanisms Displacement analysis, Velocity analysis, Acceleration analysis of mechanisms with open kinematic chains						5
	Kinematic Synthesis of Planar Linkages Type, number and dimensional synthesis for function generation, Analytical linkages synthesis						4
	Gears & Gear trains Classification, Gear terminology, fundamental law of gearing, form of teeth, velocity ratio, path of contact, arc of contact, Kinematic analysis of Gear trains: simple, compound and epicyclic gear trains						4
	Cam Mechanisms Cam terminology, kinematic analysis of follower, graphical layout of cam profile						3
	Review of Kinetics of Rigid Bodies in 3D Planar motion of rigid bodies:						4
	Dynamic Analysis of Linkages Dynamic force analysis for slider crank mechanism; inertia forces in reciprocating parts; primary and secondary inertia forces; simple engine mechanism – gas force, piston effort, gudgeon pin load, crank effort for turning moment; single and double acting engine; inertia force analysis considering mass of the connecting rod; force analysis for a four bar mechanism						7
	Flywheels: Turning moment diagram, indicator diagrams – mean effective pressures for suction, compression, expansion and exhaust strokes; overall mean effective pressure for the cycle; mean resisting torque; fluctuation of energy and speed.						5
Governor Mechanisms: Types, characteristics of centrifugal governors; conical pendulum type governors – Watt, Porter, and Proell; Spring loaded type of governors – Hartnell; controlling force, effort, power, sensitiveness, isochronism, stability and hunting of governors						8	
Text Books, and/or reference material	Text Books: 1. Theory of Machines and Mechanisms, Uicker J.J., Pennock G.R., Shigley J.E. 2. Theory of Mechanisms and Machines, Ghosh A., Mallik A.K.						
	Reference Books: 1. Introduction to the mechanics of machines, Morrison J.L.M., Crossland B.						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC303	Fluid Mechanics	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Nil		CT+EA					
Course Outcomes	CO1 Fundamental of Engineering fluid mechanics						
Topics Covered	I. Introduction: 08 Definition of fluid; Concept of continuum and Knudsen number; Concept of velocity, pressure and stress fields; Stress tensor; Fluid properties; Slip and no-slip; Compressibility and bulk modulus; Vapour pressure; Surface tension; Capillary rise and depression. II. Kinematics of flow and flow measurements: 08 Definition of flow field; Lagrangian and Eulerian description of fluid motion; Substantial derivative; Reynold's Transport Theorem; Integral form of conservation equations of fluid motion; Acceleration field; Pathline, streamline, streakline, timeline and stream tube; Pure translation, rotation and linear and angular deformation of fluid element; angular velocity; vorticity and circulation; Free and forced vortex flows; Euler's equation along streamline; Bernoulli's Equation; Static, stagnation and dynamic pressures; Application of Bernoulli's Equation. III. Differential analysis of fluid motions: Differential control volume: 08 Conservation of mass; conservation of momentum; Stokes' hypothesis; Navier-Stokes equation; Euler's equation of motion of an ideal fluid; Exact solutions of NS equations for steady incompressible flow: plane Poiseuille flow, Couette Flow, falling film flow, . IV. Incompressible Flow through pipes and ducts: 06 Hagen-Poiseuille flow, Darcy-Weisbach Equation, Major and minor losses, Surge control; V. Dimensional Analysis: 04 Measurement and dimension; Variables and functions; Dimensional homogeneity; Pi Theorem; Dimensionless parameters; Scaling rules, dimensionless numbers; Similitude; Similarity solutions and transformations; Geometric and dynamics similitude. VI. Boundary layer flows: 06 Boundary layer concepts; Prandtl's boundary layer equations; Blasius Equation for flow over a flat plate; Momentum integral equations for boundary layers; Wall shear stress; Separation of boundary layers; Fluid flows about immersed bodies. VII. Potential flow: 06 Irrotational flow; Velocity potential and stream function; Stream function for two-dimensional incompressible flow; Laplace equation; Method of solution; Complex potential for fundamental flows; Superposition of elementary flows; Flow about a half body; Uniform flow past a source and a sink, a doublet, and a cylinder with circulation; Aerofoil theory. VIII. Compressible flow: 06 Propagation of sound wave; Types of flow regimes: Mach cone; Stagnation and critical states; Isentropic flow of an ideal gas; area variation; Isentropic flow in converging and converging-diverging nozzle; normal shock.						
Text Books, and/or reference material	Text Books: 1. Introduction to Fluid Mechanics: Fox 2. Fluid Mechanics: Munson and Okiish 3. Fluid Mechanics: Robert Granger						
	Reference Books: 1. Fluid Mechanics: Frank M. White 2. Mechanics of Fluids: B.S. Massey						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC304	Engineering Thermodynamics	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods { Continuous (CT) and end assessment (EA) }					
Nil		CT+EA					
Course Outcomes	CO1 To gain knowledge of thermodynamic systems CO2 To learn the Laws of thermodynamics CO3 To solve problems using the properties and relationships of thermodynamic systems CO4 To analyse air standard cycles, vapour power cycles, Compressors, refrigeration and air-conditioning systems						
Topics Covered (Total Hours 50)	Basic definitions - microscopic and macroscopic approaches, engineering thermodynamics systems. Thermodynamic properties - definition and units, intensive, extensive properties, specific properties. Thermodynamic state-state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic processes. Thermodynamic equilibrium; definition, mechanical equilibrium, thermal equilibrium, chemical equilibrium, Zeroth law of thermodynamics and the concept of temperature. Measurement of temperature. Thermodynamic definition of work and heat, sign convention. Displacement work-expression through p-v diagrams. Shaft work; Electrical work. Other types of work. 4L Joule's experiment and the first law of thermodynamics for cyclic and non-cyclic processes. Energy - modes. First law of thermodynamics for control volumes - steady flow energy equation (SFEE) and applications. Limitations of first law of thermodynamics and introduction to the second law of thermodynamics. Heat engine – concept of efficiency. Concept of refrigerator and heat pump – coefficient of performance. Statements of second law and their equivalence- PMMI and PMMII. Carnot cycle. 6L Definitions of a reversible process and irreversible process - reversible heat engine. Causes of irreversibility. Unchecked expansion of Carnot's engine. Internal and external reversibility. Definition of the thermodynamic temperature scale. Entropy- Clausius inequality, change of entropy, entropy as a quantitative test for irreversibility, principle of increase in entropy, entropy as a coordinate. Available (Exergy) and Unavailable energy. Exergy analysis. Irreversibility and second law efficiency. 4L Air Standard Cycles: Carnot, Otto, Diesel, Dual Cycles, Joule-Brayton, Reversed Carnot, Reversed Joule-Brayton Cycles 5L Properties of Pure Substances: Steam Tables, Mollier Diagram, P-h Chart 6L Vapour Power Cycles: Rankine, Reheat, Regenerative Cycles, Binary Vapour Cycles 8L Reciprocating Air Compressor: Single Stage Air Compressor, Isothermal Efficiency, Volumetric Efficiency, Two Stage and Multistage Compression, Intercooler, Indicator Diagram, Mean Effective Pressure, Mechanical Efficiency 4L Rotary Compressor: Roots Blower, Vane Type Blower, Rotary Dynamic Compressor, Centrifugal Compressor, Momentum Principles, Euler's Equation for Energy Transfer, Static and Total Head Quantities, Velocity Diagrams 3L Refrigeration and Air Conditioning Basics, VCRS, Refrigerants: Types, Properties, Environmental Impact, Gas Reforming, Psychrometric Chart: Basic and Applications, Vapour Absorption Refrigeration System (VARS): Principles and Components, Component Design and Working in Refrigeration and Air Conditioning Systems, Design of Components: Compressors, Condensers, Evaporators, Design of Components: Compressors, Condensers, Evaporators 10L						

TextBooks, and/or reference material	TextBooks: 1. M.J.Moran,H.N.Shapiro,Fundamentals of Engineering Thermodynamics,Wiley. 2. R. E. Sonntag, C. Borgnakke, G. J. Van Wylen, Fundamentals of Thermodynamics,Wiley. 3. P.K.Nag,Engineering Thermodynamics,McGraw-Hill. 4. Arora.C.P.,Refrigeration and Air Conditioning,Tata McGraw Hill ReferenceBooks: 1.Engineering Thermodynamics: Work and Heat Transfer by Gordon FrederickCrichtonRogers, YonRichardMayhew
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Department of Mechanical Engineering							
Course Code	Title of the course	Program Core(PCR)/ Electives(PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial(T)	Practical (P)	Total Hours	
MES351	Machine Drawing and Solid Modeling	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods					
NIL		Continuous(CT)+End Term assessment(EA)					
Course Outcomes	CO1 To develop the ability of mental visualization of different objects CO2 To impart knowledge regarding standard conventions on lettering, dimensioning, symbols etc CO3 To introduce with the theory of orthographic projection to solve problems on one/two/three dimensional objects CO4 To prepare for the higher semester departmental drawings CO5 To give exposure to read/interpret industrial drawing and to communicate with relevant people						
Topics Covered	<u>Part-I:</u> 1. Elevation, Plan and side views and Isometric view. 2. Different types of auxiliary projection. 3. Dimension methods and different notations and different rules of dimensioning. 4. Different systems of sectional drawing – section planes, section lines and conventions. 5. Conventions used in machine drawing to represent some specific aspects of machine elements with their dimensioning like gears, shafts, thread etc. 6. Concept of true size and true shape. 7. Concept of missing lines and missing views. 8. Assembly drawing of a machine component and part drawing of different parts of machine component – their relative positions and spacing. 9. Selection of suitable representative scales. 10. Name plate and bill of materials. <u>Part-II:</u> a. Part modeling using CAD software b. Assembly modeling using CAD software c. Automatic drafting using CAD software						
Text Books, and/or reference material	1. Engineering Drawing and Graphics – K Venugopal 2. Engineering Drawing – ND Bhat						

Department of MechanicalEngineering							
Course Code	Title of the course	Program Core(PCR)/ Electives(PEL)	TotalNumber ofcontacthours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES352	Fluid Mechanics Laboratory	PCR	0	0	3	3	2
Pre-requisites		CourseAssessmentmethods(Continuous(CT) and end assessment(EA))					
FluidMechanics(MEC303)		CT+EA					
CourseOut comes	CO1:To impart knowledge on how the flow energy of one form is transformed into other form following Bernoullie’s principle. CO2:To impart expertise in calibration and efficient application of several devicesforflowmeasurementthroughclosed conduits aswellasopenchannels. CO3:To give basic knowledge on how to estimate the loss of flow energy over acertainlengthof pipe andacrossa pipe-bend. CO4:To give the idea of the extent of impulsive force of a fluid jet which can beutilizedfor hydro-power generation. CO5:Toenhanceskillandknowledgetodealwiththeissues inengineeringorindustrialflowapplication.						
TopicsC overed	1. VerificationofBernoullie’sTheorem. (CO1,CO5) 2. CalibrationofVenturimeter. (CO2,CO5) 3. CalibrationofOrificemeter. (CO2,CO5) 4. CalibrationofV-notch. (CO2,CO5) 5. Determinationoffrictionfactorinflowthroughpipes. (CO3,CO5) 6. Determinationofcoefficientofbendlossinflowthroughpipe.(CO3,CO5) 7. ExperimentonImpactofjet. (CO4,CO5)						
Text Books,and/o rreferencem aterial	TextBooks: 1. MechanicsofFluids:Massey,B.S. 2. FluidMechanics–J.F.Douglas,J.M.Gasiorek,J.A.Swaffied,L.B.Jack 3. IntroductiontoFluidMechanicsandFluidMachines-S.K.Som, <i>etal.</i> 4. HydraulicMachinery-JagdishLal ReferenceBooks: FluidMechanics—F.M.White						

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Course Code	Title of the course	Program Core(PCR)/ Electives(PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
WSS381	Workshop Practice I	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment(EA))					
		CT+EA					
Course Outcomes	CO1: - Understand different manufacturing techniques and identify their uses.CO2: - Apply the different welding technique to produce joining effect between different parts. CO3: - Understand the foundry and forging techniques and use them to produce parts. CO4:-Select carpentry and fitting process to make different products.						
Topics Covered	Welding Shop 2×3=6hrs • Introduction to equipment & tools, electrode, welding process (GTAW, SMAW, MIG, Gas Welding), different welding joints and welding symbols. • Electric Arc formation. • Demonstration and formation of weld bead by SMAW on mild steel flat.						

	- Construction of diagrams & recording the procedure in document. - Safety precautions needed at Welding shop. Foundry Shop $2 \times 3 = 6$ hrs - Introduction to Foundry Technology. - Introduction to Pattern and its allowances, ingredients of moulding sand. - Foundry tools and their purposes. - Preparation of green sand mould using solid pattern. - Preparation of green sand core using split core box. - Aluminium casting of the above mould. - Safety precautions needed at Foundry shop. - Blacksmithy Shop $3 \times 3 = 9$ hrs - Introduction to Smithy & Forging – Tools, Machines, Furnaces & its accessories. - Forgeability of various metals & alloys - Making of bars of different cross-sections and measuring of temperature using digital pyrometer. - Safety precautions needed at Blacksmithy shop. Carpentry Shop $2 \times 3 = 6$ hrs - Introduction to woods – types, structure, disease & defects of wood. - Introduction to wood working machines and tools. - Making of dovetail joint. - Making of bridle joint. - Safety precautions needed at Carpentry shop. Fitting Shop $2 \times 3 = 6$ hrs - Introduction & demonstration to hand metal cutting tools with specifications and materials used, nomenclature and their use. - Use of Digital measuring tools and conventional tools. - Fitting of different types of joints using mild steel flats. - Safety precautions needed at Fitting shop. - Viva Voce $1 \times 3 = 3$ hrs.
Text Books, and/or reference material	Text Books: Reference Books: 1. The Elements of Workshop Technology - Vol I & II, S.K. Hajra Choudhury, A.K. Hajra 2. Manufacturing Science -- A. Ghosh, A.K. Mallik 3. Principles of Foundry Technology -- P.L. Jain Reference Books:

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Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS381	Co-curricular Activity-III	Optional	0	0	0		0
Pre-requisites							
Course Outcomes							
Topics Covered							
Text Books, and/or reference material		Text Books: Reference Books:					

FOURTH SEMESTER

CourseCode	Titleofthecourse	Program Core(PCR)/ Electives(PEL)	TotalNumber ofcontacthours				Credit
			Lecture (L)	Tutorial(T)	Practical (P)	Total Hours	
MEC401	Design ofMachineElem ents-I	PCR	3	1	0	4	4
Pre-requisites		CourseAssessmentmethods					
MEC301(SolidMechanics)		Continuous(CT)+MidTerm(MT)+EndTermassessment(EA)					
CourseOut comes	CO1:To understandthebasicprinciplesofdeignofmachineelements CO2:To understandthefundamentals ofmaterialselectionandmanufacturingconsiderationsindesign CO3:To Analyzesteadyandvariable stressesinducedinmachineelementsfordifferentapplications CO4:To Applytheprinciplesandskillsfor thedesignofvariousmachineelementslike shaft,keys,keyway,coupling,threadedfasteners, helicalandleafspringetc. forspecificapplications.						
TopicsC overed	Introduction:Reviewof stressanalysis,Theoriesoffailure,MachineDesignincontinuationo f strengthof materials.						2
	GeneralPrinciplesandProceduresofdesignofmachineelements,FactorofsafetyandServic e Factor						2
	ReviewofmechanicalpropertiesofEngineeringMaterials						1
	DesignunderStaticload:C-frames andCranehooks						3
	Designforvariableloading						6
	DesignofHelicalspringsandLeafsprings						7
	DesignofShaftunderstaticloads&fatigueload.						6
	DesignofKeys,Rigidandflexiblecouplings						4
	Designofnon-permanentjoint-Boltedjoints						5
	Designofpermanentjoints-RivetedandWeldedjoints						5
	Designofthickcylindersandpressurevessels						4
	Designofconnectingrods.						3
Text Books,and/o rreferencem aterial	TextBooks: Mechanical Engineering Design – J.E. ShigleyDesign of Machine Elements – V.B. BhandariDesignofMachineElements– M.F.Spotts MachineComponentDesign-Juvinall&Marshek						
	ReferenceBooks: MachineDesign–BlackandAdams MachineDesign:AnIntegratedApproach-Norton						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC402	Casting, Forming and Welding	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1. Learn different types of casting process. CO2. Select suitable manufacturing process for typical components. CO3. Learn the various welding process. CO4. Explain the concept of forging, rolling process and drawing.						
Topics Covered	Casting (20 hrs) Foundry: foundry materials-moulding and cores and binders-additives; sand preparation-sand control tests 2 pattern and pattern making 3 mould and core making, expendable and non-expendable moulds, 3 mould assembly; solidification of pure metals and alloys, grain growth. 1 Casting processes-sand casting, shell moulding, investment casting, slush casting, gravity and pressure die casting, centrifugal casting; continuous casting 5 casting design, gateway system design, riser design 3 casting defects-inspection, testing-destructive and non-destructive. 3 Welding (18 hrs) Metal joining- classification, welding heat sources, 1 arc welding machines, arc production, arc characteristics, metal transfer, 5 welding electrode, 2 resistance welding, thermit welding, soldering and brazing, 3 gas welding, 1 Welding metallurgy, weldability of ferrous and non-ferrous metals, 3 Welding defects, testing of welded joints 3 Other non-conventional welding methods like, ultrasonic welding, electron beam welding, laser beam welding etc. 3 Forming (18 hrs) Metal forming-cold, warm and hot working. Forging: processes and its classification-drop forging and press forging, open die, impression die, closed die and precision forging processes. 4 grain flow in a forged product, 2 Specific forging operations like, coining, piercing, hubbing, heading, Swaging, roll forging, orbital forging, incremental and isothermal forging. 1 Forging defects. 5 Rolling: Strip rolling-recrystallisation and process details, Rolling mills, ring rolling, gear and thread rolling, various rolled sections, defects in rolled products. 4 Drawing: drawing terms and their definitions, circular drawing die, rod and wire and tube drawing. 2 Extrusion: processes-direct and indirect extrusion, impact and hydrostatic extrusion, metal extrusion practice, metal flow during extrusion. 2						
Text Books, and/or reference material	Text Books: 1. Manufacturing Processes for Engg. Materials-Kalpajian 2. Production Technology (vol I & II)—R.K. Jain and S.C. Gupta 3. Manufacturing Processes: H.S. Shan, Vol.1 4. A text book of Production Technology –P.C. Sharma						
	Reference Books: 1. Manufacturing Science--A. Ghosh, A.K. Mallik 2. Principles of Foundry Technology--P.L. Jain						

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Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC403	Heat and Mass Transfer	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Nil		CT+EA					
Course Outcomes	CO1 Understand the relation between thermodynamics and heat transfer CO2 Analyze problems involving steady and unsteady heat conduction CO3 Estimate heat transfer for natural and forced Convection CO4 Analyse radiation problem in different configurations CO5 Solve engineering problems of Heat and mass transfer equipment						
Topics Covered	Introduction, basic concepts and modes; relationship to thermodynamics. 1 Conduction: Mechanism; Fourier law of heat conduction in 3-D, 1-D steady state conduction with heat generation, composite plane wall, cylinders and spheres, thermal resistance network. Critical thickness of insulation; Use of analytical, numerical and graphical methods, thermal diffusivity, Heat Transfer from extended surface, Fin effectiveness and fin efficiency, Transient conduction, Lumped capacitance method, Fourier number 16 Conservation principles: various conservation equations, Relation between system and control volume approach: Momentum Theorem, Entropy generation minimization as a general heat transfer objective, Basic convective configurations, Fluid flow and heat transfer aspect of internal flow, Fluid flow and heat transfer aspect of external flow, Visualization of convection, Flow over a flat plate, Concept of thermal and hydrodynamic boundary layers, Laminar and turbulent boundary layers, Scaling analysis, Natural, forced, mixed and turbulent convection, Dimensional analysis in correlations for convective heat transfer, Relation between fluid friction and heat transfer, Analysis of heat exchanger: LMTD, effectiveness-NTU method. 15 Radiation: physical mechanism, radiation properties, blackbody radiation, greybody, spectral dependence of radiation properties, Wien's displacement law, Kirchhoff's law. Shape factor, heat exchange between infinite parallel planes, and Gray bodies; radiation shields, network representation. 8 Mass Transfer: Diffusive and Convective mass transfer, Evaporation process in the atmosphere, Basic concept of boiling and condensation, Fick's law and its applications. 8						
Text Books, and/or reference material	Text Books: 1. F. P. Incropera, D. P. Dewitt, T. L. Bergman, A. S. Lavine, Incropera's Principles of Heat and Mass Transfer, Wiley. 2. J. P. Holman, S. Bhattacharyya, Heat Transfer, McGraw Hill Education 3. Y. A. Cengel, A. J. Ghajar, Heat and Mass Transfer: Fundamentals and Applications, McGraw Hill. 4. J. H. Lienhard V, J. H. Lienhard IV, A Heat Transfer Text Book, Dover. 5. A. Bejan, Heat Transfer: Evolution, Design and Performance, Wiley. Reference Books: 1. S. Kakac, Y. Yener, C. P. Naveira-Cotta, Heat Conduction, CRC Press. 2. U. Grigull, H. Sandner, Heat Conduction, International Series of Heat and Mass Transfer. 3. T. Cebeci, P. Bradshaw, Physical and Computational Aspects of Convective Heat Transfer, Springer. 4. A. Bejan, Convection Heat Transfer, Wiley. 5. M. F. Modest, S. Mazumder, Radiative Heat Transfer, Academic Press. 6. E. R. G. Eckert, R. M. Drake, Analysis of Heat and Mass Transfer, McGraw Hill.						

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Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC404	Dynamics of Machines	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Theory of Machines and Mechanisms (MEC302)		CT+EA					
Course Outcomes	CO1 Analyse the gyroscopic effect on mechanical systems CO2 Minimise unbalance of rotating and reciprocating machines CO3 Introduction of single and two body lumped mass system with compliant elements and its application in design of mechanical systems.						
	Theory Component						
Topics Covered	Gyroscope Spinning, precession and gyroscopic couple; gyroscopic effect on automobiles, ships and aeroplane; Application of Gyroscope 10 Balancing Internal and external balancing; Balancing of rotating masses - single plane balancing and two plane balancing, Balancing of reciprocating masses – single cylinder engine, Vee cylinder engine, and multi-cylinder in line engine. 10 Vibration Longitudinal vibration, free vibration, damped vibration, and forced damped vibration of SDOF system; Torsional vibration, free vibration of rotor system and torsional equivalent shaft; Introduction to 2 DOF systems, vibration absorbers. Critical speed of shaft with single rotor with and without damping. Whirling of shaft, Critical speed of shaft having multiple rotor. Free vibration of elastic bodies, Vibration of strings, Longitudinal vibration of bars, Transverse vibration of beam, Torsional vibration of shaft. 22						
Text Books, and/or reference material	Text Books: 1. Theory of Machines and Mechanisms, Uicker J.J., Pennock G 2. Theory of Mechanisms and Machines, Ghosh A., Mallik A.K. 3. Mechanism and Machine Theory, J.S. Rao and R.V. Duggipati,						
	Reference Books: 1. Dynamics of machinery: Holowenko, Alfred R						

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Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC405	Fluid Machines	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 303		CT+EA					
Course Outcomes	CO1: To acquire an in depth knowledge of hydraulic machines used in the Industry CO2: To learn the basic design procedure for different hydraulic machines						
Topics Covered	Principles of Similarity, Specific Speed and Unit Quantities (4) General classification of hydraulic machines - basic principles, torque, power and efficiency. (2)						
	A Brief introduction of 2 D Cascade Theory for Rotodynamic Machines (4) Hydraulic Turbines: (12) Classification and types of Turbines. Impulse Turbine: - Pelton Wheel; . Reaction Turbine: - Francis, Propeller and Kaplan turbines; Effective head, Available head and efficiency; Force, Torque, Power, Efficiency and Operation of Turbines; Principles of similarity; Specific speed; Cavitation; Setting of turbines; Draft tubes; Penstocks; Surge tanks; Performance characteristics curves; Selection of types and speeds of turbines; Governing of turbines. Pumps: (12) Pumps: Classification; Rotodynamic pumps: - Centrifugal and Axial flow pumps; Torque, Power, Efficiency and Operation; Performance Characteristics; Principles of Similarity and Specific speed; Energy losses in pumps; Cavitation; Priming; Power requirements; Homologous operation; Series and Parallel operation; Multistage pumps; Selection and installation of pumps of various duties; Testing of pumps. Cavitation and setting height of turbomachines Reciprocating pumps: - Types; Working principle; Instantaneous discharge and average discharge; Slip; Negative slip, Coefficient of discharge and volumetric efficiency; Work done and overall efficiency; Indicator diagram: - effect of inertia and friction on suction and delivery pipes; Separation head; Effect of bend on delivery pipe; Air vessels; Power saved by air vessels in overcoming pipe friction; Discharge in and out of air vessel. Hydraulic coupling; Torque converter (2)						
Text Books, and/or reference material	Text Books: 1. Mechanics of Fluids: Massey, B.S. 2. Introduction to Fluid Mechanics and Fluid Machines - S.K. Som, et al. 3. Hydraulic Machinery - Jagdish Lal						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES451	Solid Mechanics Laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Engineering Mechanics (XEC01), Solid Mechanics (MEC301)		CT+EA					
Course Outcomes	CO1: Graphical and experimental verification of the solid Mechanics and Engineering mechanics						
Topics Covered	• Mohr's Circle on strain Rosette-Graphical Solution. • Mohr's Circle on Moment of Inertia -Graphical Solution. • Mechanical testing of Engineering Materials. • Experiments on the principles of strength of materials. • Instrumentation for measurement of deflection under loading.						
Text Books, and/or reference material	Text Books: 1. Strength of Materials – A. Pytel and F. L. Singer 2.						
	Reference Books: 1. Elements of Strength of Materials – S. P. Timoshenko and D. H. Young 2. Strength of Materials – S. S. Rattan						

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES452	Mechanism Laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Engineering Mechanics (XEC01)		CT+EA					
Course Outcomes	CO1: Students will be able to solve kinematics of mechanism by graphical method CO2: Students will be able to analyze mechanism by computer aided tools CO3: Students will be able to solve mechanism synthesis problems using computer aided tools CO4: Students will be able to demonstrate model of few planar mechanisms						
Topics Covered	- Determination of velocity and acceleration of various mechanisms by semi-graphical methods. - Analysis of inertia forces. - Computer Aided Kinematic Analysis of planar mechanisms - Computer Aided Mechanism Synthesis of planar mechanisms - Modeling & simulation of mechanisms using Computer Aided Tools - Model making						
Text Books, and/or reference material	Text Books: 1. Theory of machines and mechanisms – Uicker, Penrock and Shigley 2. Theory of mechanisms and machines – Ghosh & Mallick 3. Theory of machines – S.Rattan						
	Reference Books: 1. Theory of machines – Thomas Bevan 2. Introduction to the mechanics of machines – Morrison and Crossland						

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Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
WSS481	Workshop Practice II	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1:- Understand machining process in conventional machine tools like lathe, shaper, milling etc. CO2:- Apply the conventional machining process like turning, facing, milling, chamfering etc to produce simple parts. CO3:- Identify CNC milling machine and describe its working. CO4:- Execute G code and M code in CNC milling machine programming to produce simple jobs. CO5:- Demonstrate different electrical equipment and identify their uses.						

Topics Covered	M/CShop 5X3= 15 hrs. • Introduction to various machine tools- Lathe, Shaper, Milling, Surface Grinder, Planner, Radial Drilling etc. • Concept of cutting tool movement and job position. • Concept of different operation in a centre lathe. • Concept of simple indexing in a milling machine.
	• Job in a centre lathe using mild steel cylindrical bar comprised of facing, parallel turning & chamfering. • Job in a milling machine using cast iron to prepare a spur gear. • Job in a shaper machine. • Safety precautions needed at m/c shop. CNCShop 3×3=9hrs • Introduction of CNC milling machines along with its advantages/disadvantages over conventional machines. • Introduction to various parts of CNC milling machine and key/button/switch/mode of operating systems. • Introduction to G-codes (G00, G01, G02, G03, G04, G17, G18, G19, G54 TO G59, G70, G71, G90, G91) and M-codes (M01, M03, M04, M05, M08, M09, M30). • Zero offset setting. • Programming and job operation on plain surface milling/slot cutting by face milling cutter/end milling cutter. ElectricalShop 3×3=9hrs • Introduction & Demonstration regarding Procedure, Use, Hazards & Safety precautions of House Wiring system, Earthing System, Testing System / DOL Starter / Automatic Star Delta Starter / Soldering along with Tools, Materials & Instruments used. • Individually Practiced 3 types of connections of House Wiring, following the drawn circuit of below given problems by using tools & materials. Problem-1: Controlling a lamp, fan and two pin plug socket separately by using required switches placed in a board in PVC Conduit Wiring system. Problem-2: Controlling a lamp independently from two different places by using required switches in PVC Casing Capping wiring system. Problem-3: Controlling a calling bell placed inside the apartment along with IN&OUT marked two indicating lamps placed outside of that apartment for the information regarding house owner's presence by using required switches in Conduit Wiring system. Provided that any one lamp will glow only when the visitor will press the push switch. No lamp will glow 24 hours. Calling bell should be connected justifiably.
Text Books, and/or reference material	Text Books: Reference Books: 1. The Elements of Workshop Technology - Vol I & II, S.K. Hajra Choudhury, A.K. Hajra 2. Manufacturing Science--A. Ghosh, A.K. Mallik 3. Principles of Foundry Technology--P.L. Jain Reference Books:

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Course Code	Title of the course	Program Core(PCR)/ Electives(PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS481	Co-curricular Activity-IV	Optional	0	0	0		0
Pre-requisites							
Course Outcomes							
Topics Covered							
Text Books, and/or reference material		Text Books: Reference Books:					
		Reference Books:					

FIFTH SEMESTER

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC501	Machining and Machine Tools	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: Knowledge of fundamental machining processes and the underlying sciences of machining and the related processes CO2: Various machine tools, their operations and the mechanisms in machine tools						
Topics Covered	<u>Machining</u> (28 hrs) Introduction to Manufacturing processes and Metal cutting, Types of basic motions, Speed, feed and depth of cut, Shapes produced by different combination of motions, representation of chip formation in 3D. 2 Cutting Tools: Single point, Multi point, Left hand and Right hand cutting tool. Single point cutting tool nomenclature and representation in 3D, Tool geometry in ASA and ORS systems, Effect of tool geometry on performance. 2 Experimental observations in metal cutting- chip thickness, width of cut, primary deformation zone, shear angle concept, Piispanen's model, types of chips and the conditions of their formation, strain hardening, heat generation and dissipation, cutting fluid. Orthogonal and Oblique cutting- 2D and 3D representation, effect on chip formation and on mechanics of chip formation. Concept of undeformed chip thickness, chip reduction coefficient determination- experimentally from chip length. Analytical determination of shear angle and shear strain from simple geometry of chip formation. 4 Forces in Metal cutting: Free body diagram and mechanics of chip formation, direction and Representation of forces on basic plane and orthogonal plane, 3D representation of forces on cutting tool, Merchant's Circle Diagram representation of forces, transformation of forces, kinematic coefficient of friction, total work done and its distribution, different specific energies, power estimation, Merchant's first shear angle relationship and its deviation from experimental observations. 4 Tool life: Different way of tool failure, types of tool wear- their causes and remedies, features of flank and face wear, characteristic of wear growth, definition of tool life, factors affecting tool life, Taylor's tool life equation, effect of tool geometry on tool life. 4 Grinding- Machines and processes, Transverse grinding and plunge grinding, creep-feed grinding, centreless grinding, truing and dressing of grinding wheels, balancing of grinding wheels, Details of grinding wheels- Manufacturing and specifications, grinding wheel wear, grinding temperature. 6 Nonconventional machining processes: Working principles, processes and mechanics of process parameters and applications. ECM, EDM, AJM, USM 6 <u>Machine tools</u> (28 hours) Fundamentals of Machine tools, Machine tool elements. 1 General feature of construction and working of Lathe, Different parts of a Lathe, Types of Lathe and specification. Back gear arrangement, Work holding devices. Screw cutting, Tap turning, Form turning and various other operations performed by a Lathe. Feed, speed, depth of cut and machining time calculation. 6						

	General feature of construction and working of Drilling machine, Different parts of a Drilling machine, Types of Drilling machine and Specification. Reaming, Threading and various other operations performed by a Drilling machine. Types of Drill bits. Feed, speed and machining time calculation. 4 General feature of construction and working of Milling machine, Different parts of a Milling machine, Types of Milling machine and Specification. Dividing head and Indexing method. Upmilling, Downmilling, Spiral milling and other operations performed by a Milling machine. Types and choice of Milling cutter. Machining time calculation. 6 General feature of construction and working of Shaping machine and Slotting machine. Quick return mechanism. Whitworth mechanism, Feed mechanism. Types of tools. Machining time calculation. 4 Gear manufacture-milling, hobbing and shaping, Gear finishing processes 4 Turret and Capstan Lathe: Types, parts, equipments and tools for use on turret and capstan lathe, operational planning and turret tool layout. 4
Text Books, and/or reference material	Text Books: 1. Machining and Machine Tools – A.B. Chattopadhyay 2. Theory of metal cutting – G. Koppuswamy 3. Manufacturing Processes – H.S. Shan, Vol.2 4. A text book of Production Engineering – P.C. Sharma 5. Production Engineering Sciences – Pandey and Singh Reference Books: 1. Manufacturing Science – A. Ghosh, A.K. Mallik 2. Theory of metal cutting – Sen and Bhattacharya

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Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC502	IC Engine and Gas Turbines	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC304, MEC403		CT+EA					
Course Outcomes	CO1: Explain the fundamental concepts (basic structure and operating principles) of IC engines. CO2: Understand the working principle of different types of gas turbines, Jet propulsive engines, and Rockets. CO3: Evaluate the performance of IC engines based on conventional and alternative fuels. CO4: Analyze the combustion phenomenon in SI and CI engines.						
Topics Covered	Introduction: Basic Engine components and terminology, Classification of engines, The working principle of engines, Comparison of 2-stroke and 4-stroke engines; CI and SI Engines, Ideal and actual working cycles and their analysis, Valve timing diagram. 4 Thermochemistry and Fuels: Combustion reaction, Stoichiometric, lean and rich combustion, Engine exhaust analysis, Chemical structure of hydrocarbon fuels, Properties of SI and CI Engine fuels, Self-ignition and ignition delay, Fuel Ratings; Octane Number, Cetane Number, Alternative fuels for I.C. Engines. 8 Air and Fuel Induction: Parts of intake system, Intake manifold, Intake valve, Fuel injectors, Carburetor, Factors affecting volumetric efficiency, Supercharging, Turbocharging, stratified charge engine, Intake for two-stroke engine, scavenging, Induction in CI engine. 6						

	Combustion: Combustion in SI and CI Engines, Engine operating characteristics, Normal and Abnormal Combustion in SI and CI Engines, Stages of Combustion, Detonation and Knocking. 4 Engine Performance: Testing of IC Engines, Engine Power, Engine Efficiencies, Performance Characteristics, Variables Affecting Performance Characteristics, Methods of Improving Engine Performance, Heat Balance, Supercharging and turbocharging. 5 Engine friction and lubrication: Engine friction, effect of engine parameters on engine friction, determination of engine friction, properties of lubricants, types of lubricants, lubrication systems. 3 Engine cooling: Necessity of engine cooling, cooling systems, and components of liquid cooling systems. 3 Emission and Air Pollution: Exhaust of IC engines, Composition of exhaust gases, Causes of HC, CO, NO_x emission, Particulate matter and other emissions. After treatment: Thermal converter, Catalytic converter, Particulate trap, EGR, Non-exhaust emission. 3 Gas Turbine and Jet Propulsion: Introduction to Gas Turbines, Classification, and Application of Gas Turbines, Ideal and Actual Cycles; Effect of Inter cooling, Reheating, Regeneration, Combined cycle, and Cogeneration. Criteria of performance, Intake, and propelling nozzle efficiencies, Simple Turbojet Cycle, turbo-prop engine, Thrust augmentation, Gas turbine combustion systems, Combustion chamber designs, Gas Turbine Emissions, Rocket engine. 6
Text Books, and/or reference material	Text Books: 1. Internal Combustion Engine – V. Ganesan 2. I.C. Engine Fundamentals – Heywood 3. Engineering Fundamentals of IC Engine – W.W. Pulkrabek Reference Books: 1. I.C. Engines – P.W. Gill, Smith, Zury 2. I.C. Engine Fundamentals – Obert

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Course Code	Title of the course	Program Core (PCR)/Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC503	Design of Machine Elements-II	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Theory of Machines and Mechanisms (MEC302), Design of Machine Element I (MEC401)		CT+EA					
Course Outcomes	CO1 Detail analysis of members under fatigue loads CO2 Design procedures for some machine elements used in mechanical drives CO3 Exposed to the importance of engineering tolerances and its use CO4 Introduction to different types of bearings and lubrications CO5 To understand the basics of gear mechanics						

Topics Covered	Manufacturing considerations in Design: Fits and Tolerances.	4
	Beltdrives: Flatbelts and V-belts.	5
	Power screw	5
	Bearings: Sliding contact bearing; Rolling contact bearings- Construction, Types and selection, Constructional details, Types of lubrication.	7
	Toothed Gear Drive: Spurgear-Contact forces, Materials, Static design by Lewis equation.	7
	Dynamic loads on gears– Buckingham's method. Types, Terminology, Geometrical proportions, Analysis of contact, Materials, Analysis of Force, and Design of Helical,	
	Bevel and Worm gears. Check for dynamic load and wear strength. Design of gearboxes.	15
	Brakes: Band brakes and Shoe brakes	5
	Clutch: Friction clutches and Jaw clutches.	4
Text Books, and/or reference material	Text Books: 1. Mechanical Engineering Design–J.E. Shigley 2. Design of Machine Elements–M.F. Spotts 3. Design of Machine Elements–V.B. Bhandari	
	Reference Books: 1. Machine Design–Black and Adams	

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC504	Computer Aided Manufacturing and Robotics	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Machining, Machine Tools, Knowledge on Mechanisms		CT+EA					
Course Outcomes	CO1 Knowledge of fundamentals of NC and CNC machines CO2 Various machine tools, their operations and the mechanisms in machine tool processes CO3 CNC programming for carrying out Drilling, Milling and turning. CO5: Students will be able to analyse and solve problems on kinematics and dynamics of industrial robots, joint trajectory for motion planning. CO6: Students will be able to describe and compare various robot sensors and actuators						

Topics Covered	<u>NC and CNC machines Fundamentals (20 hours)</u> CAM - concept and definition, NC (Numerical Control), CNC (Computerized Numerical Control) and DNC (Direct Numerical Control) - concept, features and differences, Advantages and limitations of CNC, Selection criteria for CNC machines. :5 Overview of Automation: Definition, application, advantages and disadvantages, Introduction to Automation of different manufacturing processes, need of automation and components. Types of automation: fixed automation (automatic machines, transfer devices and semi-automatics), Programmable automation (NC, CNC and machining centers, DNC, adaptive control machines, Industrial robots, CAD/CAM, CIM) and flexible automation (FMS). : 7 NC and CNC Technology: Types, Classification, Specification and components, Construction Details, Controllers, Sensors and Actuators, CNC hardware: Recirculating ball screw, anti-friction slides, step/servo motors. Axis designation, NC/CNC tooling Elements of CNC machines - Types, sketch, working and importance of - i. Slideways. ii. Recirculating ball screw. iii. Feedback devices (transducers, encoders). iv. Automatic tool changer (ATC). v. Automat: 8 <u>CNC Programming (16 Hours)</u> Fundamentals of Part programming Types of format, ISO G and M codes for turning and milling - meaning and application of important codes. :5 Simple part programming for turning using ISO format having straight turning, taper turning (linear interpolation) and convex/concave turning (circular interpolation) :3 Part programming for - Drilling, Milling, Turning; Importance, types, applications and format for: i. Canned cycles. ii. Macro. iii. Loops. iv. Subroutine :8
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	Future Trends in CAM (6 Hours) Interfacing standards for CAD/CAM-Types and applications, Adaptive control-definition, meaning, block diagram, sources of variability and applications. Flexible Manufacturing System (FMS) - concept, evaluation, main elements and their functions, layout and its importance, applications.:3 Computer Integrated Manufacturing (CIM)- Concept, definition, areas covered, benefits. Robotics- definition, terminology, classification and types, elements and applications. Rapid prototyping- Concept and application:3 Robotics (14 Hours) Introduction to Robotics: Basic structure, classification, applications of robots, Fundamentals of industry 4.0 and Robotic additive manufacturing (2hrs) Robot Arm Kinematics: Forward and Inverse kinematics, velocity and acceleration analysis of serial manipulator (5hrs) Trajectory Planning of Manipulator: Joint space scheme, Cartesian space scheme (2hrs) Introduction to Dynamics of Serial Manipulators: Lagrange-Euler formulation (3hrs) Robot Sensors and actuators (2hrs)
Text Books, and/or reference material	Text Books: 1. CNC Machines, Pabla B.S., Adithan M., New Age International, New Delhi, 2014 (reprint). 2. CAD/CAM, Principles and Applications – PNRao, McGraw Hill, 2010 3. Computer Aided Manufacturing - Rao, Tewari, Kundra, McGraw Hill, 1993 Text Books (for Robotics): 4. Saha, S.K., Introduction to Robotics, TMH Publishing Company Ltd., New Delhi, 2008. 5. Pratihari, D.K., Fundamentals of Robotics, Narosa Publishing House, India, 2017 Reference Books: 1. Computer Numerical Control, Quesada Robert, Prentice Hall 2014. 2. CAD/CAM: computer aided design and manufacturing. Groover Mikell P, Zimmer W Emory, Prentice Hall 2011 Reference Books (for Robotics): 3. Ghosal, A., Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2nd reprint, 2008.

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES551	Hydraulic Machines Laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Fluid Mechanics (MEC303) Fluid Machines (MEC504)		CT+EA					
Course Outcomes	CO1: To experience and gain knowledge on the working principle of rotodynamic and positive displacement machines. CO2: To impart expertise in operation and performance evaluation of centrifugal and reciprocating pump. CO3: To give basic knowledge on working principle and operational characteristics of impulse hydro-turbine. CO4: To impart expertise in working with the reaction turbines and understand their performance characteristics. CO5: To enhance skill and knowledge to deal with the issues in hydraulic machines for hydro-electric power generation application.						
Topics Covered	1. Centrifugal pump. (CO1, CO2, CO5) 2. Reciprocating pump. (CO1, CO2, CO5) 3. Performance test of Pelton wheel turbine. (CO1, CO3, CO5) 4. Performance test of Francis wheel turbine. (CO1, CO4, CO5) 5. Performance test of Kaplan turbine. (CO1, CO4, CO5)						
Text Books, and/or reference material	Text Books: 5. Mechanics of Fluids: Massey, B.S. 6. Fluid Mechanics—J.F. Douglas, J.M. Gasiorek, J.A. Swaffield, L.B. Jack 7. Introduction to Fluid Mechanics and Fluid Machines—S.K. Som, <i>et al.</i> 8. Hydraulic Machinery—Jagdish Lal						
	Reference Books: Fluid Mechanics—F.M. White						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES552	Heat Transfer Laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Engineering Thermodynamics (MEC304), Heat and Mass Transfer (MEC403)		CT+EA					
Course Outcomes	CO1: Fundamental concepts of Temperature measurement systems CO2: Test on heat transferring apparatus CO3: Knowledge on conduction heat transfer CO4: Knowledge on convection heat transfer CO5: Knowledge on Radiation heat transfer						

Topics Covered	Various types of temperature measuring and controlling instruments. Thermocouples, Thermostats etc. Fundamental concept and function of Multi-channel temperature indicator, <u>Experiments on-</u> Determination of forced convection heat transfer coefficient through pin fin for variable flow rates of fluid at different inlet temperature. Determination of LMTD and effectiveness for parallel and counter flow heat exchanger. Verification of the laws of radiation with the help of radiation laboratory unit.
Text Books, and/or reference material	Text Books: 1. Heat Transfer--J.P. Holman 2. A Course in Heat and Mass Transfer--S. Domkundwar 3. A Course in Internal Combustion Engines--R.P. Sharma, M.L. Mathur 4. I.C. Engines--P.W. Gill, Smith, Zury

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES553	Robotics, AI and Mechatronics Laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods { Continuous (CT) and end assessment (EA) }					
Basic understanding of electronics, mechanical engineering principles, and control systems.		CT+EA					
Course Outcomes	CO1 To understand and analyze Robotics & Mechatronic Systems: CO2 To design, assemble, and program a basic mechatronic system, integrating sensors, actuators, and control algorithms						
Topics Covered()	Fundamentals of robotic and mechatronic systems Interfacing mechanical, electrical, and computer systems Overview of sensors and actuators Building simple robotic and mechatronic systems Closed loop PID (Proportional Integral Derivative) response of step input Autonomous systems using embedded controllers Demonstration of RoboAnalyzer software Programming using PLC (Programmable Logic Controller)						
Text Books, and/or reference material	Text Books: 1. De Silva, Clarence W., et al., eds. <i>Mechatronics: fundamentals and applications</i> . CRC Press, 2015						
	Reference Books:						
Text Books, and/or reference material	Text Books: 2. De Silva, Clarence W., et al., eds. <i>Mechatronics: fundamentals and applications</i> . CRC Press, 2015						
	Reference Books:						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS581	Co-curricular Activity-V	Optional	0	0	0		0
Pre-requisites							
Course Outcomes							
Topics Covered							
Text Books, and/or reference material	Text Books: Reference Books:						
	Reference Books:						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE510	Convective Heat and Mass Transfer	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Engineering Thermodynamics (MEC304), Heat and Mass Transfer (MEC403)		CT+EA					
Course Outcomes	CO1: Acquire an idea about convective transport mechanism CO2: To learn the basics of heat and mass transfer CO3: To learn about forced and natural convections and heat transfer in phase change. CO4: Introduced to physics of thermal system design.						
Topics Covered	Fundamental principles: Basic laws of fluid mechanics and thermodynamics, scale analysis. 4						
	Laminar Boundary Layer: Concept of velocity and temperature boundary layers, integral solutions, similarity solutions, different wall heating conditions. 5						
	Laminar Duct Flow: Heat transfer to developed and developing duct flows. 5						
	External natural convection. 4						
	Internal natural convection. 4						
	Transition to turbulence. 2						
	Turbulent boundary layer flow and duct flow. 4						
	Free turbulent flows: shear layer, jets and plumes. 4						
	Convection with change of phase. 4						
	Mass transfer. 6						
Text Books, and/or reference material	Text Books: 1. Convection Heat Transfer – A. Bejan 2. Convective Heat Transfer – L. C. Burmeister 3. Principles of Convective Heat Transfer – M. Kaviany						
	Reference Books: 1. Convective Heat and Mass Transfer – Kays and Crawford 2. Convective Heat and Mass Transfer – S. M. Ghiaasiaan 3. Heat Convection – L. M. Jiji						

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Course Code	Title of the course	Program Core(PCR) / Electives(PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE511	Advanced Solid Mechanics	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and End Assessment (EA))					
Solid Mechanics		CA+ EA					
Course Outcomes		CO1: To recall the 2-d state of stress and to learn the 3-d state of stress and strain problems. CO2: Use/utilized the concept of 3-D stress and strain to formulate the mathematical model of thick pressure vessels, unsymmetrical bending, curved beams and torsion of non-circular bar. CO3: To employ energy methods to formulate mathematical models for different solid mechanics problems. CO4: To solve the thick pressure vessels, curved beams and unsymmetrical bending of beam problems. CO5: To analyze the above mentioned structural members					
Topics Covered		1. Three dimensional state of stress analysis: Concept of tensor, Rectangular Stress Components, Stress Components on an arbitrary plane, Equality of cross shear, Principal Stresses, Stress invariants, Mohr's Circles, Maximum, octahedral shear and normal stress, The state of pure shear, Plane state of stress, Equations of equilibrium, Equations of equilibrium in cylindrical coordinate system. Axisymmetric and plane stress problem. 8 2. Three dimensional state of strain analysis: Rectangular Strain Components, Strain displacement relation for Cartesian coordinate system, Cauchy strain tensor, Principal strains, Strain invariants, Plane state of strain, Compatibility conditions 6 3. Energy Methods: Work done by different type of loading and Elastic Strain Energy for different type of loading, Superposition of Elastic strain energy, Theorem of virtual work, Derivation of equations of equilibrium and thin beam equation from Principle of virtual work theorem, First theorem of Castigliano's, Second theorem of Castigliano's, Statically indeterminate problem, Fictitious load method. 8 4. Analysis of axisymmetric Problems: Thick-walled cylinder subjected to internal and external pressures-Lame's Problem, Stresses in composite tubes-Shrink fit, rotating disc of uniform thickness. 7 5. Unsymmetrical bending of beams. 5 6. Bending of Curved Beams 4 7. Torsion of non-circular bar 4					
Text Books, and/or reference material		Text Books: 1. Advanced Solid Mechanics By L.S. Srinath 2. Advanced Strength of Materials By D. Ghosh Reference Books: 1. A text book of Strength of Materials By D. Ghosh and A.K. Dutta 2. Engineering Mechanics of Solids By Popov					

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE512	Multi-Phase Flow and Heat Transfer	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Fluid Mechanics (MEC303), Heat and Mass Transfer (MEC403)		CT+EA					
Course Outcomes	CO1: Leads student toward a clear understanding and firm grasp of the basic principles of multiphase flow and heat transfer. CO2: Understands the fluid-dynamic involved in convection and multi-phase heat transfer. CO3: Perform elementary analysis of most gas-liquid two-phase systems and prepare to use more advanced models. CO4: Equips the student with the analytical model to apply the fundamentals to a wide variety of complex engineering problems, formulate them and interpret the results. CO5: Student can analyze Hydrodynamics of three phase flows and compare two phase flow situations.						
Topics Covered	Introduction, Flow Regimes,						5
	Homogeneous Flow, Separated Flow						4
	Condensation,						2
	One dimensional steady separated flow model,						6
	Flow in which inertia effects dominate, energy equations,						3
	These separated flow model for stratified and annular flow,						2
	General theory of drift flux model,						3
	Application of drift flux model to bubbly and slug flow,						4
	Hydrodynamics of solid-liquid and gas-solid flow,						4
	An introduction to three phase flow,						3
	Fluid-Population Balance Technique, Volume of Fluid Method, Lattice Boltzmann Model.						6
Text Books, and/or reference material	Text Books: 1. Ghiaasiaan, S. M., Two-Phase flow, Boiling, and Condensation, Cambridge University Press. 2. Brennen, C.E., Fundamentals of Multiphase Flow, Cambridge University Press Collier, J. G. and Thome, J. R., Convective Boiling and Condensation, 3rd ed., Oxford University Press 3. Wallis, G.B., One Dimensional Two Phase Flow, McGraw Hill Higher Education. 4. Hewitt, G.F., Measurement of Two Phase Flow Parameters. 5. Govier, G.W., and Aziz, k., Flow of Complex Mixtures. 6. Hetsroni, G., Handbook of Multiphase systems.						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE513	Tribology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Solid Mechanics (MEC301), Fluid Mechanics (MEC303)		CT+EA					
Course Outcomes	CO1: Understand the basic knowledge of surface topography and contact between engineering surfaces. CO2: Understand the basic theory and application of friction and wear for different materials CO3: Understand about lubricants and lubrication for different bearings CO4: Apply Micro-Nanotribology for MEMS applications CO5: Apply Bio-tribology for human joints						
Topics Covered	Surface topography: Measurement of surface topography; Quantifying surface roughness; The topography of engineering surfaces. 3 Contact between surfaces: Hertzian contact – sphere on sphere contact and cylinder on cylinder contact; Contact between rough surfaces. 6 Friction and Wear of contact surfaces: Laws and Theories of friction and wear; Friction and Wear of different materials. 12 Lubricant and lubrication: Viscosity of lubricants; Composition and properties of oils and greases; Reynold's equation; Type of lubrications – Hydrostatic lubrication, Hydrodynamic lubrication; Elastohydrodynamic lubrication; Boundary lubrication, and application to bearings. 12 Micro-Nanotribology: Surface forces and adhesion; Atomic force microscopy (AFM); Friction, wear and lubrication on atomic level; Application to MEMS 7 Biotribology: Natural human joints; Structure and properties of articular cartilage; Mechanism of synovial lubrication; Mechanism of articular cartilage damage; Artificial joint replacements 8						
Text Books, and/or reference material	Text Books: 1. Engineering Tribology – Dr. Prasanta Sahoo 2. Introduction to Tribology of Bearings – B.C. Majumder 3. Principles of Tribology – J. Halling 4. Basic Lubrication Theory – Alastair Cameron						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE514	Materials Science and Engineering	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Engineering Physics, Engineering Chemistry.		CT+EA					
Course Outcomes	• CO1: COMPARE crystal structure and CORRELATE imperfections in crystal with mechanical behavior of materials. • CO2: IDENTIFY & ESTIMATE different parameters of the systems viz. phases, variables, component, grains and grain boundary etc. • CO3: ANALYSE heat treatment on properties of materials. • CO4: SELECT appropriate materials for various applications.						
Topics Covered	Historical Development and Classification of Engineering Materials: Introduction to Materials Science and Engineering, Relationship between Processing-Structure-Properties-Performance, Challenges and Factors Aiding in Material Selection, Classification of Materials, Advanced Materials and Modern Materials Needs. (03) At Atomic Structure and Bonding, Crystal Structure and Defects in Solids: Atomic Structure, Atomic Bonding in Solids, Crystal Structure: Unit cells, Metallic crystal structures, Polymorphism and Allotropy, Crystallographic Points, Directions, and Planes, Miller Indices, Crystalline and Non-crystalline Materials, Anisotropy. Defects in Crystalline Materials: Theoretical yield strength, Point (0-D) defects, Line (1-D) defects or Dislocations, Interfacial Defects, Bulk or Volume (2-D) Defects, Atomic Vibrations. (08) Phase diagram and Iron Carbon diagram: Solid Solutions: -Introduction, Types, Hume Rothery rule for substitutional solid solution (03) Solidification: - Nucleation and crystal growth, Solidification of pure metal, solidification of alloys. (02) Phase diagram: -Cooling curves, types of phase diagrams, Gibbs phase rules. (03) Iron Iron Carbon Diagram: -Iron-carbon equilibrium diagrams in detail with emphasis on invariant reactions. (03) Heat Treatments: Austenite transformation in steel: - Time temperature transformation diagrams, Continuous cooling transformation diagram. (04) Heat Treatment Processes: - Introduction, Annealing (Full annealing, Process annealing, Spheroidise annealing, isothermal annealing, stress relief annealing) Normalising, Hardening, Tempering, Austempering, Martempering, Sub-zero treatment, Hardenability. (04) Surface Hardening: - Classification, Flame hardening, Induction hardening, Carburising, Nitriding, Carbonitriding. (02) Properties, Applications and Processing of Materials: Mechanical Properties of Metals. Applications and Processing of Metallic Alloys. Structures, Properties, Applications and Processing of Ceramics. Structures, Characteristics, Applications, and						

	Processing of Polymers. Composite materials. Electrical Properties. Thermal Properties. Magnetic Properties. Optical Properties. (10)
Text Books, and/or reference material	TextBooks: - Material Science & Metallurgy for Engineers :- DR. V. D. Kodgire & S. V. Kodgire - Materials Science and Engineering Introduction :- William D. Callister - Materials Science & Engineering :- Raghvan V.
	ReferenceBooks: - Mechanical Behaviour & Testing of Materials :- A.K. Bhargava, C.P. Sharma - Manufacturing Engineering and Technology :- Serope Kalpakjian, Steven R. Schmid

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE515	Operations Research	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment(EA))					
NIL		CT+EA					
Course Outcomes	CO1: Students will be able to discuss the history, concepts, formulations and applications of operations research. CO2: Students will be able to analyze and solve conflicting problems on constrained linear optimization problems having single and multiple objectives. CO3: Students will be able to apply integer, dynamic programming methods for solving relevant problems.						
Topics Covered	Origin, growth, definition, methodology and application of OR. Linear Programming, Mathematical Modelling, Graphical Method of Solution, Sensitivity Analysis. Simplex Method, Big M and 2-Phase Methods, Duality in LP. Transportation problem. Assignment Problem Sequencing problem. Queuing model and Simulation. Competitive Decision Making, Game Theory. Duality Theory and Sensitivity Analysis. Integer Programming, Binary Integer Programming. Dynamic Programming.						2 8 7 3 3 2 3 4 3 4 3
Text Books, and/or reference material	Text Books: 1. Hillier, Fredrick S. and Lieberman, Gerald J., Introduction to Operations Research, 7th Edition, TMH, 2001. 2. Basu, S.K., Pal, D.K., Bagchi, H., Operation Research for Engineers, 2 nd Edition, Oxford & IBH Publishing Co. Pvt. Ltd., 1998 3. Taha, H.A., Operation Research, McMillan Publishing Co., London, 1982.						
	Reference Books: 1. Churchman, C.M., Ackoff, R.L., Arnoff, E.L., Introduction to Operation Research, Asia Publishing Co., 1962 2. Hanssmann, F., Operations Research in Production and Inventory Control, John Wiley & Sons, Inc., London, 1962.						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE516	Mechatronics	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC301, MEC504		CT+EA					
Course Outcomes	CO1: Students will be able to identify the importance of a amalgamation between the electronics and electro-mechanical systems. CO2: Students will be able to formulate and evaluate behavior of linear time continuous control systems. CO3: Students will be able to formulate the procedure for converting analog signal to digital form and vice-versa. CO4: Students will be able to describe signals and its processing by modern electronic methods. CO5: Students will be able to identify and critically evaluate current developments and emerging trends within the field of mechatronics systems.						
Topics Covered	Mechatronic Systems: Introduction, Application of Mechatronics. 2 Sensors and Transducers- Brief review, Simple electronic elements & Operational Amplifiers. 4 Actuators: Pneumatic, Hydraulic, Electrical & Mechanical actuation system, Micro-actuators. 3 Modelling and Simulation of Physical System: System models, Dynamic responses of the system, System transfer functions. 4 Digital logic: Number systems, Boolean algebra, Logic gates- Application gate, Design of logic of digital logic gates. 5 Microprocessors and Micro-Controllers: Introduction, Microprocessor Architecture, Instruction codes, General requirements for implementation issues, Examples. 6 Programmable Logic Controllers: Basic structure, I/O processing, Programming, Timer, Interrelays and Counters. 6 Signal conditioning & Digital communication system: Basics of signal conditioning, Filtering, Data acquisition and Digital signal processing, Digital communication and Communication interface. 6 Mechatronic Systems, Case Studies. 6						
Text Books, and/or reference material	Text Books: 1. Alciatore, D. G. and Hiestand, M. B., Introduction to Mechatronics and Measurement Systems, McGraw Hill Publications, 4th Edition, 2012. 2. Bolton, W., Mechatronics, Pearson Education India, 2008. 3. Gaonkar, R. S., Microprocessor Architecture, Programming and Applications with 8085, Penram Publishers India, 6th Edition, 2013.						
	Reference Books: 1. Malvino, A. P., and Bates, D. J., Electronic Principles, TMH Publishing Company Ltd., New Delhi, 8th Edition, 2016. 2. Nise, N. N., Control Systems Engineering, 6th Edition, John Wiley & Sons, Inc., USA, 2011.						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core(PCR)/ Electives(PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial(T)	Practical (P)	Total Hours	
MEE517	Advanced Foundry Engineering	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment(EA))					
MEC402(Casting, Forming and Welding)		CT+EA					
Course Outcomes	• CO1 At the end of the course student will be able to get the knowledge about various aspects of casting processes and the underlying science • CO2: various types of casting methods • CO3: Application fields of various casting processes						
Topics Covered	Casting Processes: Classification, characteristics of sand casting processes, metal mould casting process, Pattern materials, types of patterns, Mould and core making materials and their characteristics. (12) Solidification of metals: Nucleation and grain growth, solidification of pure metals, short and long freezing range alloys, Rate of solidification, macrostructure and microstructure. Solidification Contraction, Grain refinement (6) Sand Casting Design: Gating and riser design calculations, Fluidity and its measurement. (6) Investment casting, shell moulding, squeeze casting, vacuum casting, counter-gravity flow-pressure casting, Directional and mono crystal solidification, squeeze casting, semi solid metal casting, rheocasting. (8) Family of cast iron – Ductile Iron, Malleable Cast Iron, (3) Casting defects- inspection and testing, analysis of casting defects, non-destructive testing of casting-dye penetrant testing, magnetic flaw detection, radiography, ultrasonic testing, etc. (4) Near net shape casting processes, Modern foundry practices and special casting method. Continuous casting (3)						
Text Books, and/or reference material	Text Books: 1. John Campbell, “Casting Practice” Elsevier Science Publishing Co., 2004 2. Scrope Kalpakjian, “Manufacturing processes for Engineering Materials”, Addison, Wesley, 1997. 3. P.C. Mukherjee, Fundamentals of metal casting technology-Oxford and IBH 4. Beely, Foundry Technology, Newnes-Butterworths, 1979 Reference Books: 1. Casting properties of metals and alloys-V. Korolkove. 2. ASM Handbook “Casting”, ASM International 1998.						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE518	Engineering Optimization	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: Students will be able to describe and formulate optimization problems CO2: Students will be able to apply knowledge of different optimization methods for solving engineering problems CO3: Students will be able to differentiate between optimization methods and suggest a suitable technique applicable for a specific problem.						
Topics Covered	Introduction: Engineering Application, Statement and Classification of the Optimization Problem , Classification, formulation procedures. 4 Classical Methods: Single Variable Optimization; Multivariable Optimization without any Constraints with Equality and Inequality Constraints, Kuhn–Tucker Conditions; Linear Optimization Methods, One-Dimensional Minimization Method. Unimodal Function. 6 Elimination Methods: Exhaustive search, Fibonacci and Golden Method. 3 Interpolation Method–Quadratic and Cubic Interpolation Method. 2 Unconstrained Minimization Method-- Univariate, Conjugate Directions, Steepest Descent (Cauchy) Method, Newton’s Method, Marquardt Method, Quasi-Newton Method. 6 Constrained Minimization Method, Random Search Methods, Sequential Quadratic Programming. Basic Approach of the Penalty Function Method, Interior Penalty Function Method, Exterior Penalty Function Method. 5 Non-traditional Optimization Techniques - Genetic Algorithms. Simulated annealing. Particle swarm optimization. Ant Colony Optimization. Tabu search. 11 Reduction of size of an optimization problem. Scaling of design variables and constraints. 3 Introduction to optimization Toolbox in MATLAB. 2						
Text Books, and/or reference material	Text Books: 1. S.S.Rao, Engineering Optimization, Theory and Practice, 3rd Enlarged Edition, New Age International Publishers, New Delhi, 2010. 2. Ashok D. Belegundu and Tirupathi R Chandrupatla, Optimization Concepts and Applications in Engineering, Pearson Education 1999, First India Reprint, 2002.						
	Reference Books: 1. G.N. Vanderplaats, Numerical Optimization Techniques for Engineering Design with Applications, McGraw-Hill, New York, 1984. 2. R. L. Fox, Optimization Methods for Engineering Design, Addison- Wesley, Reading, Mass, 1971.						

SIXTH SEMESTER

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC601	Power Generation Technologies	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods {Continuous (CT) and end assessment(EA)}					
MEC304,MEC403		CT+EA					
Course Outcomes	CO1 To remember the basics of power generation cycles CO2 To understand the different energy sources CO3 To analyse and evaluate the performance of different power generation technologies CO4 To design the different components of power generation systems						
Topics Covered (Total hours 39)	Primary and Secondary Sources of Energy, Global trends for per capita consumption of energy, Demand for energy and future availability in usable form, Recent developments in the renovation of energy sources 2 Analysis of Steam Cycles: Steam power plant outline, Effect of steam conditions on thermal efficiency, Regenerative feed heating, feedwater heaters, and optimum degree of regeneration, Deaerator, co-generation of power and process heat 9 Fuels and Combustion: Coal ranking and analysis, fuel oil, natural and petroleum gas, Combustion reactions, Combustion Equipment, and Firing Methods: Fuel bed combustion, Pulverized coal firing, Cyclone furnace 7 Fluidized bed combustion: Circulating Fluidized Bed and Bubbling Fluidized Bed 2 Gasification: Coal and biomass gasification 2 Steam Generators: High-pressure boilers, subcritical and supercritical boilers, Calculation of economizer, superheater, reheater, and air preheater 4 Draught systems: Forced Draught (FD), Induced Draught (ID), and balanced draught, calculation of fan power 2 Circulation: natural and forced, circulation ratio, performance rating of boilers 1 Flow Through Nozzles and Diffusers, shocks, super-saturation of steam through nozzle flow 4 Steam Turbines: Machines working on impulse and reaction principles, Turbine blading, velocity triangles, blade speed ratio, Velocity and pressure compounding, stage and overall efficiencies, degree of reaction 6						
Text Books, and/or reference material	Text Books: 1. Power Plant Engineering-P.K.Nag 2. Power Plant Technology-M.M.El.Wakil						
	Reference Books: 1. Power Plant Engineering-F.T.Morse 2. Steam Turbine Design and Practice-Karetan 3. Power Plant Engineering-Black and Veatch 4. A Course in Power Plant Engineering-S.Domkundwar,S.C.Arora.						

Department of Humanities and Social Sciences (offered for all)							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSC631	Economics and Management Accountancy	PCR	3	0	0	3	3
Pre-requisites							
Course Outcomes		- Learners will be able to review basic economic principles. - Learners will be introduced to the basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works. - Learners will gain a good knowledge of financial accounting, enabling them to prepare, analyse and interpret financial statements for taking informed decisions.					
Topics Covered		<u>PART1:Economics</u> GroupA: Microeconomics Unit 1: Economics: Basic Concepts, Unit 2: Theory of Consumer Behaviour, Unit 3: Theory of Production, Cost and Firms, Unit 4: Analyses of Market Structures: Perfect Competition Unit 5: Monopoly Market, Unit 6: General Equilibrium & Welfare GroupB: Macroeconomics Unit 1: Introduction to Macroeconomic Theory; Unit 2: National Income Accounting Unit 3: Determination of Equilibrium Level of Income; Unit 4: Money, Interest and Income; Unit 5: Inflation and Unemployment; Unit 6: Output, Price and Employment <u>PART2: Management Accountancy</u> Unit1: Introduction to Accounting: 3L Accounting Environment of Business; Objectives of Unit 1: Accounting; Accounting Equations for Financial Statements. Books of Accounting: Journal, Ledger, Cashbook. Unit2: Financial Statement Preparation and Analysis: 5L Preparation of Trial Balance, Trading, Profit & Loss, account and Balance Sheet. Case study discussion. Unit3: Financial Ratio Analysis: 4L Common Size Statements; Computation of Financial Ratios; Interpretation and analysis of Financial Ratios with the help of case studies.					
Text Books, and/or reference material		Text Books: Part1: GroupA: Microeconomics 1. Koutsoyiannis: Modern Microeconomics 2. Maddala and Miller: Microeconomics 3. Anindya Sen: Microeconomics: Theory and Applications 4. Pindyck & Rubinfeld: Microeconomics Part1: GroupB: Microeconomics 1. W.H. Branson: Macroeconomics – Theory and Policy (2nd ed) 2. N.G. Mankiw: Macroeconomics, Worth Publishers 3. Dornbusch and Fisher: Macroeconomic Theory 4. Soumyen Sikder: Principles of Macroeconomics PART2: Management Accountancy 1. Gupta, R.L. and Radhaswamy, M: Financial Accounting; S. Chand & Sons 2. Ashoke Banerjee: Financial Accounting; Excel Books 3. Maheshwari: Introduction to Accounting; Vikas Publishing 4. Shukla, MC, Grewal T S and Gupta, SC: Advanced Accounts; S. Chand & Co.					

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC6XX	Artificial Intelligence and Machine Learning	PCR	3	0	2	5	4
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
Basic Concepts of Probability and Statistics, Knowledge of Algorithm analysis		CE+EA					
Course Outcomes	• CO1: Identify problems where artificial intelligence (AI) techniques are applicable • CO2: Understand to apply search strategies to solve the problems. • CO3: Principal models used in machine learning and Apply them in machine learning to appropriate problems • CO4: Formulate valid solutions for problems involving uncertain inputs or outcomes by using decision making techniques. • CO5: Understanding different supervised and unsupervised learning methods.						
Topics Covered	Introduction to Artificial Intelligence (AI): What is Intelligence, Reasoning and Planning, Learning and Adaptation, and interaction with the real world, A brief history of AI, Application areas of AI, State of the art. (2) Problem solving by search: Problem types, Illustrative search problems; Search Space, Search tree; BFS, DFS, UCS; Local search; Hill climbing; Heuristics; A* search (6) Knowledge Representation: Propositional, predicate logic, first order logic, resolution and unification (5) Reasoning under Uncertainty: Conditional independence representation, exact inference through variable elimination, and approximate inference through sampling. (5) Introduction to Machine Learning: Basic concepts, bias-variance trade off, evaluation metrics etc. (2) Supervised Learning: Simple linear regression, multiple linear regression, logistic regression, support vector machine, decision trees, Introduction to artificial neural network. (14) Unsupervised Learning: Clustering algorithms, k-means/k-medoid, hierarchical clustering (6) Dimensionality reduction: Principal component analysis. (2) Sessional experiments: Study of PROLOG programming language to implement different search techniques, Implementation of different machine learning techniques (linear and logistic regression; Decision Trees; Support Vector Machine; artificial neural network; Clustering techniques) by programming in Python						
Text Books, and/or reference material	Text Books: 1. Artificial intelligence : A Modern Approach- Stuart Russell, Peter Norvig, Prentice Hall, Fourth edition, 2020 2. Tom M. Mitchell, “Machine Learning”, McGraw Hill Education, International Edition, 2010 Reference Books: 1. Elaine Rich, Kevin Knight and Shivashankar B Nair, “Artificial Intelligence”, Tata McGraw Hill, 3rd Edition 2017. 2. Ethem Alpaydin, “Introduction to Machine Learning”, Third Edition, , MIT Press, 2014						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES651	Power Generation Laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment(EA))					
Engineering Thermodynamics(MEC304), Heat and Mass Transfer(MEC403), IC Engine and Gas Turbine(MEC502)		CT+EA					
Course Outcomes	CO1: Experimentation of refrigerating systems CO2: Experimentation on steam generators CO3: Study of steam turbines CO4: Test of diesel engine CO5: Experimentation on steam nozzle						
Topics Covered	Refrigeration and air-conditioning: Specification, performance test and loading of refrigerators. Concept of air conditioning. Types of air conditioning systems and their application. Steam generators: Fundamental concept, types, application and performance data. Use of steam for power generation. Fundamental concept and function of Turbines. <i>Study of-</i> - Construction of fire tube and water tube boiler. - Starting and loading of fire tube boiler. - Construction of vapour compression refrigerator unit.						
	<i>Experiments on-</i> - Determination of dryness fraction of steam. - Efficiency test of a boiler. - Performance test of diesel engine using mechanical type dynamometer under variable speed conditions. - Determination of critical pressure ratio of a steam nozzle. - Effect of humidity and outside air temperature on cooling load of air conditioning machine. - Determination of output and back-work ratio of a gas turbine unit under variable load condition.						
Text Books, and/or reference material	Text Books: - Refrigeration and Air-conditioning--W.F. Stoecker, J.W. Jones - Refrigeration and Air-conditioning--C.P. Arora - Power Plant Engineering--P.K. Nag - Power Plant Engineering--F.T. Morse - Steam Turbine Design and Practice--Kaerton						
	Reference Books: - Jeffrey M Gordon, Kim Choon Ng, Cool Thermodynamics, Viva Books, 2008. - Refrigeration and Air-conditioning--R.C. Jordon, G.B. Priester - Modern Air-conditioning, Heating and Ventilation-- W. H. Carrier, R. E. Cherne						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core(PCR)/ Electives(PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial(T)	Practical (P)	Total Hours	
MES652	Machine Design Sessional	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment(EA))					
MEC401,MEC503		CT+EA					
Course Outcomes	CO1: Acquire basic idea about making the design and production drawing for simple and common mechanical assembly. CO2: To understand the method of implementation of engineering tolerances. CO3: To identify the importance of using the standards and use of catalogues in making the design.						
Topics Covered	Design and manufacturing Drawing of Screw Jack using CAD Design and manufacturing Drawing of gearbox using CAD Product Design related project.						
Text Books, and/or reference material	Text Books: 1. Design of Machine Elements–V.B.Bhandari 2. Design of Machine Elements–M.F.Spotts 3. Design Data Book–P.S.G.College of Technology, Coimbatore.						
	Reference Books: 1. Mechanical Engineering Design–J.E.Shigley 2. Fundamentals of Mechanical Design–R.M.Phelan						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES653	Manufacturing Laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Casting, Forming and Welding (MEC402)		CT+EA					
Course Outcomes	CO1:- Analyze the moldings and property used in foundry industry by different sand technique. CO2:- Apply the concept of machining in different machine tools like milling, radial drilling, grinding machine etc. CO3:- Demonstrate the different welding procedure to produce the joining effect. CO4:- Analyze the laser and hot embossing procedure for sample preparation. CO5:- Perform photo-chemical machining and contact angle goniometer experiment.						
Topics Covered	List of Experiments:- Foundry:- Experiment 1: To determine the amount of moisture content in sand sample used for casting using rapid moisture teller machine. Experiment 2: To determine the particle size and grain fineness number (GFN) of moldings and used in casting Experiment 3: To Study the sand properties and sand casting procedure for foundry industry. Machining:- Experiment 4: To perform grinding operation on specimen using surface grinding machine. Experiment 5: To perform drilling operation on sample using radial drilling machine. Experiment 6: To prepare specimen of face milling operation on MS plate in a Vertical Milling Machine Welding:- Experiment 7: To perform SAW welding on MS specimen for joint preparation. Experiment 8: To perform GTAW welding on MS specimen for joint preparation. Experiment 9: To perform GMAW welding on MS specimen for joint preparation. Advanced Manufacturing Techniques:- Experiment 10: To develop micro pattern using fiber laser engraving machine. Experiment 11: To study and perform the hot embossing process. Experiment 12: To study the wettability of a substrate using Contact Angle Goniometer. Experiment 13: Fabrication of micro-sized complex patterns by using Photo Chemical Machining (PCM)						
Text Books, and/or reference material	Text Books: 1. Manufacturing Processes for Engg. Materials—Kalpakjian 2. Production Technology (vol I & II)—R.K. Jain and S.C. Gupta 3. A Course in Workshop Technology (vol I & II)—B.S. Raghuvanshi						
	Reference Books: 1. Manufacturing Science—A. Ghosh, A.K. Mallik 2. Principles of Foundry Technology—P.L. Jain						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE610	Nonconventional Machining	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Casting, Forming and Welding (MEC402)		CT+EA					
Course Outcomes	CO1: Cutting edge technology for nonconventional/ precision machining. CO2: Emerging trend of metal removal process						
Topics Covered	Introduction 1 ECM: Working Principle; ECM Machine Tool; Process performances; Advantages, limitations and applications; ECG- Working Principles; ECG Machine Tool; Process performances; Advantages, limitations and applications; Electrochemical Debarring (ECDe), Shaped Tube Electrolytic Machining (STEM). 8 AJM, Water Jet Machining and Abrasive Water Jet Machining 8 USM: Working Principles, USM Machine Tool, Mechanics of cutting, Process capabilities, Advantages, limitations and applications. 4 FIB: Working Principles, Machine Tool, Mechanism of material removal and surface modification 4 EDM: Working Principles, EDM Machine Tool – Power Supply, Dielectric System, Electrodes, Servo-system, Pulse generating Circuits and analysis, Process Variables and Process Characteristics; Electrical Discharge Grinding. 4 Wire-cut EDM: Working Principles, EDM Machine Tool, Process Variables and Process Characteristics. 4 LBM: Production of LASERs, Working Principles of LBM, Types of LASERs, Process characteristics, Advantages, Limitations and Applications. 3 EBM: Production of Electron Beam, Working Principles of EBM, Focusing and control of electron beam, Process characteristics, Advantages, Limitations and Applications. 3 Chemical Machining, Microfabrication and Micromachining 3						
Text Books, and/or reference material	Text Books: 1. Non-conventional Machining Process: P.K. Mishra 2. Non-conventional Machining Process: V.K. Jain						
	Reference Books: 1. Manufacturing Science: Ghosh and Mallik 2. Modern Machining Processes: Pandey and Shan						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE611	Design and Optimization of Thermal Systems	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC304, MEC403, MEC502		CT+EA					
Course Outcomes	CO1: Latest methodologies for the design of thermal system CO2: Use of economics, system simulation and optimization method for thermal system CO3: Will learn exergy analysis and its application for thermal system CO4: Use of thermo-ecological parameters to assess various thermal system CO5: Modeling of energy system						
Topics Covered	<u>1. Introduction to Thermal System Design</u> Introduction, Life cycle design, Thermal system design aspects, Computer aided thermal system design <u>2. Thermodynamics, Modelling, and Design Analysis</u> Basic concepts and definition, Control volume aspects, Property relations, Reacting mixtures and combustion, Modelling and design of piping systems <u>3. Thermodynamic Modelling of Polygeneration System</u> Modelling of Power Generation, Modelling of Cogeneration, Modelling of Polygeneration <u>4. Exergy Analysis</u> Why exergy and energy analysis, Balances for mass, energy and entropy, Physical exergy, Chemical exergy, Exergy for systems and flows, Exergy balance, Reference environment, Applications <u>5. Applications with Thermodynamics and Heat and Fluid Flow</u> Heat transfer, Heat exchangers, Trade-off between thermal and fluid flow irreversibility, Application to power generation and refrigeration <u>6. Economic Analysis</u> Estimation of capital investment, Principles of economic evaluation, Cost of utility, Profitability evaluation <u>7. Thermoeconomic Analysis and Evaluation</u> Fundamental of thermoeconomics, Thermoeconomic variable for component, evaluation, Costing considerations <u>8. Problem Formulation and Method for Optimization</u> Introduction, Optimization method, Optimization of thermal systems, Practical aspects <u>9. Thermoeconomic Optimization</u> Introduction to optimization, Cost optimal exergetic efficiency, Optimization of heat exchanger networks, Enhanced system optimization <u>10. Exergy Method: Ecological Applications</u> Cumulative exergy consumption, Thermo-ecological cost, Applications						
Text Books, and/or reference material	Text Books: 1. Bejan A., Tsatsaronis G., Moran M.; Thermal design and optimization. Wiley. 2. Jaluria Y., Design and optimization of thermal system. CRC Press. 3. Szargut J., Exergy method: Technical and ecological applications. WIT Press. 4. Dincer I., Rosen MA., Exergy: Energy, environment and sustainable development. Elsevier.						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE612	Control Systems	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC302, MEC502		CT+EA					
Course Outcomes	CO1: Will get exposure to the block diagram based formulations, behavior of linear time continuous control systems. CO2: Ability to analyze the system performance and relative stability information. CO3: Understand the relevance of characteristic roots in the behavior of various dynamic systems. CO4: Ability to design simple controllers for analog systems. CO5: To study and analyze state space methods, controllability and observability of control systems.						
Topics Covered	Introduction to Control, Systems and Elements, Transducers, Feedbacks, Classification of systems						3
	Mathematical modelling, Block Diagram and Transfer Functions						4
	Analysis of Response of simple feedback control systems						5
	Structure of Control systems and Control Laws						4
	Root locus plot and analysis						5
	Stability analysis by frequency response methods – Nyquist and Bode diagrams						5
	State-space representations						5
	PID controllers – Analysis and design						5
	Digital Control Methods.						2
	Design of Control Systems in Matlab Simulink Environment.						2
Text Books, and/or reference material	Text Books: 1. Kuo, B. C., Automatic Control System, 3 rd Edition, Prentice Hall Inc., New Jersey, 1975. 2. Nise, N. N., Control Systems Engineering, 6 th Edition, John Wiley & Sons, Inc., USA, 2011.						
	Reference Books: 1. Raven, F. H., Automatic Control Engineering, McGraw Hill Book Company Private Ltd., USA, 1961.						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE613	Fundamentals of Combustion	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC304, MEC403, MEC405		CT+EA					
Course Outcomes	CO1: Understand Combustion Fundamentals CO2: Analyze Combustion Reactions CO3: Apply Thermodynamic and Chemical Kinetic Models CO4: Solve Energy and Mass Balance Problems in Combustion						
Topics Covered	Review of Thermodynamics: Combustion Terminology, Matter and its properties, Microscopic overview of thermodynamics, Conservation of mass and energy, First Law and Second Law of thermodynamics. 4 Stoichiometry and Thermochemistry of Reacting Systems: Overall reactions, Gas analysis, Global Conservation equations for reacting systems, Thermochemistry: Enthalpy of Formation, Application of Thermochemistry 6 Reaction Direction and Equilibrium: Chemical Equilibrium, Chemical Equilibrium Relations, Van't Hoff equation, Adiabatic flame temperature with Chemical Equilibrium 4 Fuels: Gaseous Fuels, Liquid Fuels, Solid Fuels, Other Fuels, Size Distribution of Solid and Liquid Fuels 4 Chemical Kinetics: Reaction rates, Elementary reactions and molecularity, Multiple Reaction Types, Chain Reaction and Reaction Mechanism, Global Mechanisms for Reactions, The Arrhenius Law, Global and Backward Reactions, The partial Equilibrium, Time Scale for Reactions, Solid-Gas Reactions 8 Mass Transfer: Heat Transfer and Fourier's law, Mass transfer and Fick's Law, Molecular Theory, Generalized form of Fourier's and Fick's Law 4 First Law Applications: Generalized relations in Molar Form, Closed system Combustion, Open system combustion: Plug Flow Reactor, Perfectly stirred reactor, Solid Carbon Combustion, Droplet Burning 7 Conservation Relations: Simple Diffusive Transport Constitutive Relations, Conservation Equations, Generalized Transport, Simplified Boundary-Layer-Type Problems, Shvab-Zeldovich Formulation, Turbulent Flows 5						
Text Books, and/or reference material	Text Books: 4. Combustion Science and Engineering – K. Annamalai and I. K. Puri 5. Fundamentals of Combustion Engineering – A. Mukhopadhyay and S. Sen						
	Reference Books: 3. An Introduction to Combustion – S. R. Turns						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE614	Modeling and Simulation of Dynamic Systems	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Engineering Mechanics, Strength of Material, Dynamics of Machine.		CT+EA					
Course Outcomes	CO1 By the end of the course students are able to know the fundamental of modeling and simulation and its usefulness. CO2 Overview of various modeling software and its usefulness in development of mathematical model. CO3 Modeling concept for electro-mechanical, mechatronic systems and feedback control. CO4 Interpretation of simulation results and diagnosis of systems.						
Topics Covered	Introduction to system modeling 6 Introduction to modeling with examples, introduction to simulation, MATLAB and Simulink, bond graph and Adams multi-body simulation tools. Modeling of dynamics systems 6						
	Introduction to dynamics systems with examples, bond graph modeling, causality, generation of system equations, Methods of drawing bond graph models of electrical and mechanical systems. Modeling of systems (fundamental model) 8 Fundamental models of mechanical, electrical, hydraulic, pneumatic and thermal systems, hydraulic and thermal system modeling, examples of fundamental systems such as two-tank system, thermal damping, compressor-reservoir system, etc. Modeling of systems (as a combination of subsystems) 10 Linear and nonlinear systems, modeling of systems: a combination of translational and rotational systems, hydro-mechanical systems and electro-mechanical systems, modeling of mechatronics systems and feedback control of mechanical systems. Simulation and its applications 10 Simulation using Simulink, bond graph and Adams, simulation of simple and compound pendulum, simulation of planar mechanisms, validation of simulation results with examples.						
Text Books, and/or reference material	Text Books: - Bond graph in modeling simulation and fault identification, Amalendu Mukherjee, Arun Kumar Samantaray, and Ranjit Karmakar, CRC Press. - MATLAB for mechanical engineers, Rao V. Dukkipati, Newage International.						
	Reference Books: - Measurements, Modelling and Simulation of Dynamic Systems, Edward Layer, Krzysztof Tomczyk, Springer-Verlag Berlin and Heidelberg GmbH & Co. KG. - Modelling and simulation Exploring Dynamic System Behavior, Louis G. Birta, Gilbert Arbez, Springer London Ltd						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE615	Non-Linear Vibration	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC301, MEC302, MEC504		CT+EA					
Course Outcomes	CO1: Understanding the various characteristics of nonlinear dynamic system. CO2: Development of solution procedures employing approximate methods. CO3: Develop the concept of stability and different methods for stability and bifurcation analysis. CO4: Analysis of nonlinear system employing numerical techniques and comparing the results with approximate methods.						
Topics Covered	Introduction: linear and nonlinear systems, conservative and non-conservative systems; potential well, Phase planes, types of forces and responses, fixed points, periodic, quasi-periodic and chaotic responses; Local and global stability; commonly observed nonlinear phenomena: multiple response, bifurcations, jump phenomena. 9 Analytical solution methods: Harmonic balance, perturbation techniques (Linstedt-Poincaré, method of Multiple Scales, Averaging method) 6 Stability and bifurcation analysis: static and dynamic bifurcation of fixed point and periodic response, different routes to chaotic response. 6 Numerical techniques: Time response, phase portrait, FFT, Poincaré maps, point attractors, limit cycles and their numerical computation, strange attractors and chaos; Lyapunov exponents and						
	their determination, basin of attraction: point to point mapping and cell to cell mapping, fractal dimension. 9 Applications: Single degree of freedom systems: Free vibration-Duffing's oscillator; primary-, secondary- and multiple- resonances; Forced oscillations: Van der Pol's oscillator; parametric excitation: Mathieu's and Hill's equations, Floquet theory; effects of damping and nonlinearity. Multi degree of freedom and continuous systems. 10						
Text Books, and/or reference material	Text Books: 1. Nayfeh, A.H., and Mook, D.T., Nonlinear Oscillations, Wiley-Interscience, 1979. 2. Hayashi, C. Nonlinear Oscillations in Physical Systems, McGraw-Hill, 1964. Reference Books: 1. Nonlinear Ordinary Differential Equations: An Introduction for Scientists and Engineers, D. Jordon and P. Smith, Oxford 2. Evan-Ivanowski, R.M., Resonance Oscillations in Mechanical Systems, Elsevier. 3. Nayfeh, A.H., and Balachandran, B., Applied Nonlinear Dynamics, Wiley. 4. Seydel, R., From Equilibrium to Chaos: Practical Bifurcation and Stability Analysis, Elsevier						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE616	Mechanics of Complex Fluids	PEL	3	0	0	3	3
Pre-requisites: MEC303, MEC304, MEC403, PHC01		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEE616		CT+EA					
Course Outcomes	CO1: To acquire an in-depth knowledge of various constitutive models in viscous flows CO2: To apply the constitutive models in momentum conservation laws CO3: To learn the various types of complex fluid types and their source of nonlinearity CO4: To undertake the solution process to simple flows of complex fluids CO5: To learn the concepts of rheometry and complex fluids in industrial settings						
Topics Covered	(1) Introduction to Complex Fluids with Applications. (3) Review of required mathematics: Linear algebra and partial-differential equations. (3) (2) Mass and Momentum Conservation Laws in Hydrodynamics. (4) The Cauchy Stress Tensor and the Navier–Stokes Equations. Examples of viscous flows. (8) (4) Material functions and Generalized Newtonian Fluids: Shear-Thinning and Shear-Thickening and Carreau–Yasuda Models. (7) Linear viscoelastic theory, Oldroyd’s theory and Ericksen-Leslie theory (for liquid crystals): (Properties of Viscoelastic Fluids: relaxation time, yield stress, normal stress differences, shear thinning properties). (6) Basic introduction to Differential Constitutive Equations, Integral Constitutive Equations, Continuum Mechanics, Stokes equations (Admissible constitutive forms, differential and integral constitutive equations). (7) Rheology of Suspensions (Colloidal fluids, Emulsions and Blends): Suspensions Viscosity, Suspension of particles and microorganisms (4) Rheometry and Application of complex fluids in industrial settings						
Text Books, and/or reference material	Text Books: 1. “Dynamics of Polymer Liquids: Vol. 1: Fluid Mechanics” by R.B. Bird, C. Armstrong, O. Hassager (Wiley), 2nd Edn., 1987. 2. “A Physical Introduction to Suspension Dynamics” by Guazzelli and Morris (Cambridge University Press), 2011. 3. “The Structure and Rheology of Complex Fluids” by R.G. Larson (Oxford), 1999.						
	Reference Books: 1. ”Microhydrodynamics” by S. Kim and S.J. Karrila (Dover Publications), 1991. 2. “Mathematical Modeling for Complex Fluids and Flows” by M. O. Deville and T. B. Gatski (Springer), 1 st Edition, 2012.						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
MEE620	Automobile Engineering	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Engineering Thermodynamics (MEC304), Heat and Mass Transfer (MEC403), IC Engine and Gas Turbine (MEC502)		CT+EA					
Course Outcomes	CO1: Classification and layouts of different vehicles CO2: Different types of Engines in use CO3: Different types of clutch, gearbox and transmission used CO4: Different types of brakes, drivelines and wheels and tyres.						
Topics Covered	Automotive engine: Construction, operation and service of automotive engine.						8
	Bearing, lubrication and cooling system.						6
	Fuel and exhaust, emission control.						10
	Starting and charging system. Contact point and electronic ignition system.						8
	Other accessories with electrical and electronic devices. Engine trouble diagnosis and tune up.						6
	Automotive power train: Transmission and transaxles, gear train, differentials and drive axles, drivelines and universal joints, clutches and brakes.						4
Text Books, and/or reference material	Suggested Text Books:						
	1. Automobile Engineering -- K. Singh						
	2. Automotive mechanics -- W. H. Crouse, D. L. Anglin						
Suggested Reference Books:	1. Automotive mechanics -- J. Heitner						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P) [#]	Total Hours	
MEE621	Gas Dynamics and Propulsion	PEL	3	0	0	3	3
Fluid Mechanics (MEC303) and Engineering Thermodynamics (MEC304)		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					
Course Outcomes	CO1: To learn compressible flows with constant entropy only, with friction only and with heat transfer only. CO2: To learn Normal shock, oblique Shock and Prandtl-Meyer Flow with real life applications. CO3: To learn Performance analysis of Air Breathing Engines (Ramjet, Turbojet (standard): Fan exhausted turbojet & Fan mixed turbojet and Turbo prop.) CO4: To learn Performance analysis of Non Air Breathing Engines (Solid Rocket Motors and Liquid Rocket Engines).						
Topics Covered	<u>Part-I: Gas Dynamics:</u> Review of basic compressible flow e.g. sonic velocity, wave propagation. Flow with Variable area duct without normal shock and with normal shock. Fanno flow and Rayleigh flow. Solution of problems using gas table. 7 Moving Normal shocks and Oblique shocks: Normal velocity superposition for moving Normal shock and tangential velocity superposition for oblique shock, oblique shock analysis for perfect gas, oblique shock table and charts. Problems. 7 Prandtl-Meyer flow: Isentropic turn (either around expansion or compression corner) from infinitesimal shocks, Mach waves, Prandtl-Meyer flow analysis, Prandtl-Meyer function, over expanded and under expanded nozzles, boundary conditions for flow direction and pressure, shock diamond, supersonic aerofoils, Working of supersonic wind tunnel. 4 Correlation of Fanno flow, Rayleigh flow, and a normal shock 2 <u>Part-II: JET PROPULSION</u> Air Breathing Engines: Derivation of generalized equation/expressions for thrust, propulsion efficiency, thermal efficiency and overall efficiency. Relation between them, TSFC (Thrust specific fuel consumption); stoichiometry, equivalence ratio, mass fraction, mole fraction, partial pressure, mass balance in chemical equations, heat of reaction, heat balance in constant volume and constant pressure processes, fuel air ratio, variation of temperature with F/O and its stoichiometric value. Condition for maximum efficiency. Performance analysis of the following: (a) Ramjet, (b) Turbojet (standard): Fan exhausted turbojet & Fan mixed turbojet (c) Turbo prop. Effect of after burner on all the above. Related problems 12 Non-air breathing engines: Performance of Rocket vehicle such as Thrust, specific Impulse (I_{sp}), vehicle acceleration, burning time. Type of chemical Rockets: Solid Rocket Motors and Liquid Rocket Engines. Elementary theory and performance						

	characteristics of both types of chemical rockets. Related problems.	10
Text Books, and/or reference material	Text Books: 1. Fundamentals of gas dynamics - R.D. Zucker & Oscar Biblarz. 2. Mechanics and thermodynamics of propulsion: P.G. Hill & C.R. Peterson. Reference Books: 1. The Dynamics and Thermodynamics of Compressible Fluid Flow by A.H. Shapiro. 2. Aircraft Propulsion: V. Babu	

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE622	Mechanics of Composites and Functionally Graded Materials	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and End Assessment (EA))					
Solid Mechanics		CA+ EA					
Course Outcomes	CO1: Learn about composite materials and their applications from large to small scales.CO2: Understand general Hooke's law for composite materials and compute its engineering constants.CO3: Build up the ability to calculate micromechanical parameters for lamina level analysis.CO4: Builds up the ability to calculate macromechanical parameters for laminate level analysis.CO5: Basic understanding about functionally graded materials and its high temperature applications.						
Topics Covered	Introduction to Composite Materials						05
	Lectures Definition, Classifications, Various reinforcement and matrix materials, Mechanical behavior, Manufacturing process and applications, and Basic terminologies.						
	Macromechanical Analysis of Lamina						15
	Lectures Hook's law anisotropic, orthotropic, transversely isotropic and isotropic material. Stress-strain relation and Engineering constants for this material. Stress and strain transformation.						
	Micromechanical Analysis of Lamina						05
	Lectures Volume and mass fraction, Density and void content. Evaluation of Elastic moduli, Ultimate strength of unidirectional lamina.						
	Macromechanical Analysis of Laminate						10
	Lectures Macromechanical behavior of lamina, Classical lamination theory, Laminate stiffness of a few cases, Stress-strain variation in a laminate. Special cases of laminates, symmetric, cross-ply, angle ply, and antisymmetric laminates.						
	Failure Criterion of Composites						03
Lectures Failure criteria and failure modes.							
Introduction to FGMs						04	
Lectures Historical perspective and importance, Graded microstructures, Types, and Applications. Modeling and Design: Rules of mixtures, Variational, Micromechanical, Empirical, Mori-Tanaka approaches, Thermophysical and mechanical properties, and material gradation laws.							

Text Books, and/or reference material	TextBooks: 1. Mechanics of Composite Materials by Robert M. Jones, Taylor & Francis, USA. 2. Mechanics of Composite Materials by Autar K. Kaw, CRC Press, Boca Raton. 3. Functionally Graded Materials by R. M. Mahamood and E. T. Akinlabi, Springer.
	ReferenceBooks: 1. Engineering Mechanics of Composite Materials by Isaac M. Daniel and Ori Ishai, Oxford University Press, New York. 2. Advances in Functionally Graded Materials and Structures by F. Ebrahimi (Editor), ExLi4EvA.

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE623	Finite Element Methods	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and End Assessment (EA))					
Solid Mechanics		CA+ EA					
Course Outcomes	CO1: Implement the knowledge of theories of elasticity, weighted residual methods and energy methods for FE formulation. CO2: FE formulation, solution and analysis of one dimensional static problems CO3: FE formulation, solution and analysis of two dimensional static problems CO4: FE formulation, solution and analysis of one dimensional free vibration problems CO5: FE analysis of one dimensional problems using software package, and by computer programming						
Topics Covered	1. Stresses and Equations of Equilibrium, Stress-strain relations, Strain-displacement relations, Plane stress, Plane strain and axisymmetric problems. Potential energy, principle of minimum potential energy, Rayleigh-Ritz Method. 6 2. Weighted residual methods, Weak form, Solution using weak form, Rayleigh-Ritz method. Steps in FE analysis, Elemental level equation, Assembly, Boundary conditions, solution, postprocessing. 5 3. Natural coordinates, Shape functions, Lagrange and Serendipity Elements, Numerical Integration, Derivation of elemental level equation for one dimensional bar using Galerkin's method and principle of minimum potential energy methods. Plane truss Problems, One dimensional thermal stress problems. One dimensional conduction-convection heat transfer problems. Torsion of circular shaft. 12 4. Finite element analysis of 2-D problems. Plane stress, Plane strain and axisymmetric problems. 4 5. Finite Element Analysis of beams using CBT and TBT. 6 6. Free vibration analysis of bar, beams and shaft using Finite Element Methods. 4 7. Discussion on FE based package and computer programming for FE analysis. 5						
Text Books, and/or reference material	Text Books: 1. Textbook of Finite Element Analysis by P. Sesu (PHI) 2. Introduction to Finite Elements in Engineering by T. R. Chandrupatla, A. D. Belegundu (Prentice- Hall) 3. An Introduction to the Finite Element Method by J. N. Reddy (Tata McGraw Hill) Reference Books: 1. Finite Element Procedures by K. J. Bathe (Prentice Hall) 2. Finite Element analysis Theory and Programming by C. S. Krishnamoorthy (Tata McGraw Hill) 3. Concepts and applications of finite element analysis by R. D. Cook, D. S. Malkus etc. (Wiley)						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE624	Additive Manufacturing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Manufacturing Technology, Machining and Machine Tools (MEC501)		CT+EA					
Course Outcomes	CO1: Able to understand the principles of different additive manufacturing processes CO2: Able to learn software's for additive manufacturing CO3: Able to expose materials for Additive Manufacturing and its selection CO4: Able to know areas of usage, possibilities and limitations of the additive manufacturing technologies						
Topics Covered	Introduction to Additive Manufacturing (AM), Overview, History, Need, Classification, Additive Manufacturing Technology in product development 2 CAD & Reverse Engineering, CAD model preparation – Part Orientation and support generation, Model Slicing, Tool path Generation, Software's for Additive Manufacturing Technology, Model Reconstruction – Data Processing for Additive Manufacturing Technology, Reverse engineering 6 Materials for Additive Manufacturing Technology 4 Different AM processes and relevant process physics, AM process chain 8 Sheet Lamination Processes 1 Photo-polymerization Processes 2 Extrusion-Based Systems 1 Powder Bed Fusion Processes 3 Binder jetting 1 Material jetting 2 Directed Energy Deposition Processes 3 Micro & Nano additive manufacturing processes 4 Design for Additive Manufacturing 3 Application of Additive Manufacturing 2						
Text Books, and/or reference material	Text Books: 1. Ian Gibson, David W. Rosen and Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing, Springer. 2. C.K. Chua, K.F. Leong and C.S. Lim, 3D Printing and Additive Manufacturing: Principles and Applications, World Scientific.						
	Reference Books: 1. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers.						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE625	Mechanics of Forming and Press Working	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Casting Forming and Welding (MEC402)		CT+EA					
Course Outcomes	CO1: Specialized techniques in forming practiced in industry. CO2: Detailed and in-depth analysis of the forming processes						

Topics Covered	Module1: Stress-strain relationship: true stress true strain, elasticity, anelasticity, plasticity,workhardening,workdoneorstrainenergy.ComplexStressSystem,conceptofabsolute maximum shearing stress in a plane-stress system, three dimensional stresssystem andMohr'scirclefor the generalstateof stress(3-D). Plastic Deformation and Yield Criteria: maximum normal stress theory (Rankine'sTheory),Tresca'smaximumshearstresstheory,VonMises'maximumdistortionenergy theory, relation between tensile yield stress and shear yield stress, yieldingunderplanestrainGraphicalrepresentationofTresca'sandVonMises'theory. Forging: processes and its classification- drop forging and press forging, open die,impression die, closed die and precision forging processes. Grain flowin a forgedproduct. Forging die materials, lubrication, forging defects, forgeability of metals, die-manufacturingmethods.Analysisofforgingload:Lowfrictionorslidingfrictioncondition (as in cold forming); high friction condition; and, combined slipping andstickingfrictioncondition. Rolling:striprolling-recrystallizationandprocessdetails,conditionsforbiting,roleoffriction in rolling. Rolling mills, ring rolling, gear and thread rolling, various rolledsections,defectsinrolledproducts.Determinationofrollpressure:pressuredistribution in rolling, determination of neutral point, front tension and back tension,force and power calculation. Roll deflections and roll flattening, spreading, methods ofreductionof rollingforce,rollmaterials, various rolled sections. Drawing: drawing terms and their definitions, circular drawing die, drawing of wireand rod (homogeneous deformation), maximum possible reduction in a single pass,analysis of strip drawing, calculation of force and power, analysis of wire and roddrawing,calculationof force andpower. Extrusion:processes-directandindirectextrusion,impactandhydrostaticextrusion, metalextrusionpractice,metalflowduringextrusion. Module2: Sheetmetalforming:characteristics;parametersaffectingsheetmetalformingprocess such as, yield point elongation, anisotropy, grain size, residual stresses, springback,wrinkling, coated sheet. 1 Shearing, punching and blanking: punch force; shearing operations like, die cutting,fineblanking,slitting,steelrules,nibbling;Shearingdies:Punchanddieshapes,compound dies,progressivedies, transferdies,toolanddiematerials. 5 Bending of sheets and plates: minimum bend radius, factors affecting bendability,springback,compensationforspringback,commonbendingoperations. 3 Deep drawing: Characteristics of deep drawing, formability of sheet metal, designconsiderations Miscellaneous forming processes: stretch forming, bulging, hydroforming, variousspinningoperations. 3 High energy rate forming: Explosive forming, electrohydraulic forming, magneticpulseforming, superplasticformingetc. 3						
Text Books, and/or referencematerial	TextBooks: 1. ManufacturingProcessesforEngg.Materials-Kalpakjian 2. ProductionTechnology(volI&II)—R.K.JainandS.C.Gupta 3. ManufacturingProcesses:H.S.Shan,Vol.1 4. AtextbookofProductionEngineering–P.C.Sharma						
	ReferenceBooks: 1)ManufacturingScience--A.Ghosh,A.K.Mallik						
DepartmentofMechanicalEngineering							
Course Code	Title of thecourse	Program Core(PCR)/ Electives (PEL)	TotalNumber ofcontacthours				Credit
			Lecture(L)	Tutorial(T)	Practical (P)	Total Hours	
MEE626	Advanced WeldingTechnology	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Casting, Forming and Welding (MEC402)	CT+EA
Course Outcomes	• CO1 : To get the knowledge about newly developed welding process and its parameters • CO2: To learn various nonconventional welding methods • CO3: To learn various application fields of various welding processes
Topics Covered	Welding : Definition, requirements, Conditions for ideal weld, Classification of welding processes (1) Arc Welding : Arc Initiation, Arc Physics, Arc Maintenance, Power Sources, Power Factor, Duty Cycle, SMAW, GMAW, GTAW, SAW, ESW, EGW, PAW, AHW (10) Electrodes : Electrode Classification, Electrode Nomenclature, Electrode composition, Basicity Index, Role of different elements, Coating Factor, Selection of electrodes (3) Weld design and associated symbols, Numerical problems in welding (5) Shielding Gases: Types, roles, features, Selection (1) Weld Metallurgy: Zones in a weld, HAZ and its calculation, Weld Decay, Weld Distortion, Residual Stresses – their causes, identification and remedy (3) Solid State welding Processes – Forge Welding, Cold Welding, Friction Welding, Friction Stir Welding (6) Thermo-Chemical Welding Processes – Thermit welding, etc (3) Radiant Energy welding Processes – Electron Beam Welding, Laser Beam Welding, Ultrasonic Welding (2) Welding at Micro and Nano Scale (2)
Text Books, and/or reference material	Text Books: 1) Richard L. Little, Welding and Welding Technology, Tata McGraw Hill, 2004 2) J.F. Lancaster, Metallurgy of welding, Allen & Unwin, London, 1980 Reference Books: 1) V. Tsegelsky, The Electric Welder, Mir Publishers, Moscow, 1968

Course Code	Titleofthecourse	Program Core(PCR)/ Electives(PEL)	TotalNumber ofcontacthours				Credit
			Lecture (L)	Tutorial(T)	Practical (P)	Total Hours	
MEE627	Computer AidedDesign	PEL	3	0	0	3	3
Pre-requisites		CourseAssessmentmethods					
Machine Design, EngineeringMathematics		Continuous(CT)+MidTerm(MT)+EndTermassessment(EA)					
CourseOut comes	CO1:AbletounderstandscopeandapplicationofCAD/CAMtoolsinindustry CO2: Able to learn geometric modelling and computer graphics concept in CAD toolsCO3:AbletounderstandthedifferentdesignanalysisandoptimizationtoolsinCAD.						

Topics Covered	Introduction: Current trends in Design & Manufacturing, Fundamental concept of CAD-CAM-CAE, Product Life-cycle, Overview of CAD-CAM system. (2) Computer Graphics: Fundamentals of Geometric transformations, Graphics standards, CAD-CAM Data Exchange. (5) Geometric Modeling: Types and Mathematical representation of curves, surface and solids, Solid modeling & concepts of B-rep and CSG representation scheme, Geometric Modeling Using Point Clouds: Reverse Engineering and its Applications, Computer aided design for additive manufacturing (10) Computer aided Mechanism and Machine element design, Modeling and simulation (5) Fundamentals of Finite Element Modeling (FEM) (10) Design optimization tools. (8) Virtual Prototyping & Rapid Prototyping: Introduction to Virtual Prototyping and its applications in Mechanical Engineering. (2)
Text Books, and/or reference material	Text Books: 1. CAD/CAM: Theory & Practice by I. Zeid 2. CAD/CAM by P. N. Rao 3. Principles of Computer-Aided Design and Manufacturing by Farid Amirouche 4. Computer Graphics by Roy A. Plastock Reference Books: 1. Mastering CAD/CAM by I. Zeid 2. Finite Element Method by J. N. Reddy

SEVENTH SEMESTER

Department of Management Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSC731	PRINCIPLES OF MANAGEMENT	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and End Assessment (EA))					
		CA+EA					
Course Outcomes	- CO1: To make budding engineers aware of various management functions required for any organization - CO2: To impart knowledge on various tools and techniques applied by the executives of an organization - CO3: To make potential engineers aware of managerial function so that it would help for their professional career - CO4: To impart knowledge on organizational activities operational and strategic both in nature - CO5: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science, Quantitative Techniques and Decision Science						
Topics Covered	UNIT I: Management Functions and Business Environment: Business environment – macro, Business environment – micro; Porter’s five forces, Management functions – overview, Different levels and roles of management, Planning – Steps, Planning and environmental analysis with SWOT, Application of BCG matrix in organization (12) UNIT II: Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis (6) UNIT III: Creating and delivering superior customer value: Basic understanding of marketing, Consumer behavior – fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. (8) UNIT IV: Behavioral management of individual: Motivation, Leadership, Perception, Learning. (8) UNIT V: Professional ethics: Introduction to Professional ethics, Morals, values and Ethics, Ethics in Business. (2)						
Text Books, and/or reference material	Text Books: - Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India - Management Principles, Processes and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education - Organizational Behavior, 13th edition, Stephen P Robbins, Pearson Prentice hall India - Operations Management, 7th edition (Quality control, Forecasting), Buffa & Sarin, Willey - A.C. Fernando: Business Ethics & Corporate Governance, Pearson Education 2nd edition						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC701	Industrial Engineering and Engineering Measurement	PCR	3	1	0	3	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic knowledge of Engineering Mechanics		CT+EA					
Course Outcomes	CO1: Knowledge on the structures of Engineering Organization in general. CO2: Planning of manufacturing and production line. CO3: Ability for material management. CO4: Indian standards of measurement. CO5: Techniques of engineering measurements with its application.						
Topics Covered	Organization Structure: Classical principles, Different types of organization structure- Line, Staff, Line and staff, Committee organization, Case study. 3 Plant Location: Factors affecting plant location, Plant location theories- material index theory, location factor theory, Dimensional decision making model, Force analogy method, Specific site selection. 4 Plant layout: Different types of layout, Various flow patterns, Factory building construction, Travel chart. 2 Job evaluation, Merit rating and Wage incentive schemes: Methods of job evaluation- Ranking method, Classification method, Point method, Factor comparison method. Merit rating- Point rating scale, Employee comparison system. Different wage incentive schemes. 4 Work study: Operation process chart, Flow process chart, Flow diagram, String diagram, Multiple activity chart- Man-machine chart, Man-machine-helper chart, Left hand-right hand chart, Motion study, SIMO study, Cycle graph and chronocycle graph, Performance rating, Stopwatch time study. 4 Operations Research : Fundamentals, Graphical Method, Simplex Method, 4 Network Techniques : Fundamentals, Utility, Gant Chart 2 Program Evaluation and Review technique 3 Critical Path Method 3 Generalised measurement systems- Calibration, Sensitivity, Damping, Characteristics of first order and second order systems, Dynamic response, Harmonic analysis. 5 Standards of linear measurements, Interferometric measurements. 2						
	Limit, Fit and Tolerances: Basis of a limit system, Unilateral and Bilateral systems. 2 Indian limit system IS 919:1993; Types of fits and selection of fits, IS 2709:1982 3 Dimension chain and Dimensional analysis, Design and use of limit gauges. 2 Error of flatness and straightness: Concept of mean true plane, Measurement of flatness error using Beam Comparator, Autocollimator and Precision Block Level. 3 meters for measuring 2-component and 3-component machining forces. 2 Surface roughness measurement. 3						

Text Books, and/or reference material	TextBooks: 1. Industrial Engineering and Management--Dr. Ravishankar 2. Industrial Engineering and Production Management--M. Mahajan 3. A Textbook of Engineering Metrology--I. C. Gupta 4. Engineering Dimensional Metrology--L. Miller						
	ReferenceBooks: 1. Management in Industry--C. S. George 2. Engineering Tolerances--H. W. Conway						
Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES751	Machine Dynamics Laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Theory of Machines and Mechanisms (MEC302)		CT+EA					
Course Outcomes	CO1 Analyse the gyroscopic effect on mechanical systems CO2 Minimise unbalance of rotating and reciprocating machines CO3 Introduction of single and two body lumped mass system with compliant elements and its application in design of mechanical systems.						
	Software Related: 1. Demonstration of Software(s) for dynamic analysis of mechanism Hardware Related: Data Acquisition Card Experimental setup for demonstration 1. Estimation of centrifugal force in different types of governors. 2. Synthesis of cam profile. 3. Kinematic analysis of epicyclic gear trains; estimation of holding torque. 4. Estimation of gyroscopic torque. 5. Balancing of rotating machine. 6. Free and forced vibration of SDOF system. 7. Determination of critical speed of shaft 8. Journal Bearing apparatus To study the pressure profile of lubricating oil at various conditions of load and speed. 9. Coriolis Component of acceleration To find out the Coriolis acceleration of component and the speed rating at different water flow rate.						
Text Books, and/or reference material	TextBooks: 1. Theory of Machines and Mechanisms, Uicker J. J., Pennock G 2. Theory of Mechanisms and Machines, Ghosh A., Mallik A. K. 3. Mechanism and Machine Theory, J. S. Rao and R. V. Dukkipati,						
	ReferenceBooks: 1. Dynamics of machinery: Holowenko, Alfred R						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core(PCR) / Electives(PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial(T)	Practical (P)	Total Hours	
MES752	Engineering Measurement Laboratory	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods(Continuous(CT) and End Assessment(EA))					
Industrial Engineering and Engineering Measurement		CA+ EA					
Course Outcomes	1) Learn how to use basic mechanical measuring instruments. 2) To apply the technique of engineering measurements. 3) To recognize and employ the precaution and care for precision engineering measurement. 4) Interpret the experimental results. 5) To prepare the report in engineering measurement.						
Topics Covered	Experiments 1. Measurement of a stepped shaft. 2. Measurement of chordal gear tooth thickness. 3. Measurement of a plug screw gauge. 4. Measurement of angle of an angle plate gauge by sine-bar method. 5. Measurement of angles of a single point cutting tool. 6. Measurement of Young's modulus and Poisson's ratio of a given material using strain gauges. 7. Measurement of bore diameter. 8. Measurement of surface roughness and establishing the relationship between feed and surface roughness for a turned cylindrical specimen 9. Measurement of an external taper gauge. 10. Measurement of modulus of resilience and modulus of toughness from stress-strain curve using planimeter						
Text Books, and/or reference material	Text Books: 1. A Textbook of Engineering Metrology--I.C. Gupta 2. Engineering Dimensional Metrology--L. Miller						
	Reference Books:						

Course Code	Title of the course	Program Core (PCR)/Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE710	Machine Tool Engineering and Automation	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC501		CT+EA					
Course Outcomes	CO1: In depth study of mechanical machine tools construction and design. CO2: Introduction to machine tools automation.						
Topics Covered	General principles of Machine Tool design, Machine Tool drives and mechanisms. 2 Design of speed and feed gear box, Optimum design principles for using double bound gears. 12 Design of Machine Tool structures: beds, slides and guides, selection of bearing for machine tools. 3 Hydrostatic and Hydrodynamic lubrication in Machine Tool slide ways and Guides, Stick-slip motion in Machine Tool slide ways. 3 Machine tool rigidity, system compliance and process capability of machine tools. 4 Machine tool inspection, testing and maintenance. 2 Overview on Automation: Definition, application, advantages and disadvantages. Types of automation: fixed automation (automatic machines, transfer devices and semi-automatics), Programmable automation (NC, CNC and machining centres, DNC, adaptive control machines, Industrial robots, CAD/CAM, CIM) and flexible automation (FMS). 5 CNC Hardware: Constructional features, operational characteristics of CNC machine tools, Machine tool drives, sensing devices, open and closed loop control 3 CNC machining, part programming, NC tool path generation. 8						
Text Books, and/or reference material	Text Books: 1. Principles of Machine Tools – Sen and Bhattacharya 2. Computer Controlled of Manufacturing Systems – Y. Koren						
	Reference Books: 1. Machine Tool Engineering – N.K. Mehta 2. Numerical Control and Computer Aided Manufacturing – Kundra, Rao and Tiwari						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE711	Fracture Mechanics	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and End Assessment (EA))					
Strength of Material Theory of Elasticity and Plasticity		CA+ EA					
Course Outcomes	CO1: Extend basic concept of strength of material, and theory of elasticity for fracture mechanics and fatigue characteristic to understand, assess and overcome failure. CO2: Provide basic understanding between structural design with strength of materials approach and fracture mechanics approach, various historical structures fail. CO3: Evaluate SIFs for different modes of fracture under various loading conditions. CO4: Apply fracture mechanics parameters in failure analysis. CO5: Apply advance knowledge for solving complex fracture and fatigue problems.						
Topics Covered	Introduction to Fracture 10 Lectures Historical background of fracture mechanics and fatigue failure, Ductile and brittle fractures, Modes of fracture, Introduction to Griffith's energy balance, Energy release rate, Irwin-Orowan theory of almost brittle materials, R-curves, Critical energy release rate. Linear Elastic Fracture Mechanics 26 Lectures Stress intensity factors, Irwin's SIFs, Westergaard's and William's stress functions, Relationship between K and G, Critical SIFs, SIF of complex cases, Fracture toughness, Crack-tip plasticity, Effects of length and thickness on fracture toughness, Plastic zone shape for plane stress and plane strain condition, Experimental methods of determining SIFs, Mixed mode fracture mechanics. Introduction to Fatigue 06 Lectures Fatigue loading, High and low cycle fatigue, Mechanism of fatigue crack initiation and propagation, Factors influencing fatigue strength, Fatigue design philosophies (life prediction, prevention of fatigue failures, fail-safe design criteria), Fatigue crack growth.						
Text Books, and/or reference material	Text Books: 4. Elements of Fracture Mechanics by Prashant Kumar, McGraw Hill Education. 5. Fracture Mechanics Fundamentals and Applications by T.L. Anderson, Taylor & Francis. 6. Fundamentals of Fracture Mechanics by T. Kundu, CRC Press. 7. Fatigue of Materials and Structures – Fundamentals by C. Bathias, A. Pineau, (Eds.), John Wiley & Sons. Reference Books: 3. The Stress Analysis of Cracks Handbook by H. Tada, P.C. Paris and G.R. Irwin, Del Research Corporation. 4. Fracture Mechanics: An Introduction by E.E. Gdoutos, Springer. 5. Fracture Mechanics Fundamentals and Applications by S.K. Maiti, Cambridge University Press. 6. Fatigue of Structures and Materials by J. Schijve, Springer.						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE712	Micro and Nano Manufacturing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Casting, Forming and Welding (MEC402), Machining and Machine Tools (MEC501)		CT+EA					
Course Outcomes	CO1: To understand the need for micro and nano scale fabrication CO2: To get acquainted with different micro and nano scale fabrication techniques and their characterization CO3 : To be able to select a suitable micro or nano scale fabrication process based upon the requirement CO4: To compare and understand the differences between macro and nano scale fabrication processes						
Topics Covered	Need for Micro and Nano Scale Manufacturing Processes : Examples of micro and nano scale parts being used in various applications, How the performances of micro/nano scale components are better AFM, STM, SEM, TEM, XRD, 2						
	Photo Lithography: Historical perspective, Overview, Electromagnetic Spectrum Clean Room – Classes, Features Photoresist: Positive and Negative Photoresists; Glass Transition Temperature, Photoresist deposition: Spin coating, Spray coating, Electro-deposition; Baking, Masks, Exposure: Contact Printing, Projection Printing, Proximity Printing, Development, Critical Dimension, Overall Resolution, Line Width Metrology, Resist Profiles, Photolithography Resolution Enhancement Technology: through Improved Resist Performance, through Improved Mask Technology, through Improved Exposure Technology Reducing the minimum feature dimension in photolithography Examples 10 Dry Etching Definitions, Plasma, Physics of plasma, Sputtering or Ion Etching, Ion Beam Milling, Plasma Etching, Deep Reactive Ion Etching (DRIE), ICP, Examples 3 Wet Etching Chemical Milling, Photochemical Milling, Wet Isotropic and Anisotropic Etching, Etch Stop Techniques, 3 Moore's Law, Need for pushing the feature sizes to lower levels, Next Generation Lithographic Techniques : EUV , XRL, LIGA, EBL : EBL Resists, electron emission, Ion Beam Lithography, Nano Imprint Lithography, Lithographic techniques still in research and developmental state Examples 10 Physical Vapor Deposition: Thermal evaporation, Sputtering – DC and RF Sputtering, Pulsed Laser Deposition – Laser sputtering, Aerosol Deposition Examples 4 Chemical Vapor Deposition: Overview, description, PVD vs CVD, APCVD, LPCVD, PECVD, ALD, Examples 2 Micro and Nano Scale Joining Techniques. 2						
Text Books, and/or reference material	Text Books: - Fundamental of Microfabrication and Nanotechnology Volume 2, by Prof Marc J Madou, CRC Press, Taylor and Francis Group - Micro and Nano manufacturing, Mark J Jackson, Springerlink - Micro and Nano manufacturing Volume 2, Mark J Jackson, Springerlink						

ReferenceBooks:

Micro/Nano Manufacturing, Hans Nørgaard Hansen and Guido Tosello,
MDPI Publishing (for application examples)

Department of Mechanical Engineering

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Contact Hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE713	Aerospace Engineering	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CA), Mid-term (MT) and End-term assessment (ET))					
MEC303, MEC403		CA+ MT+ EA					
Course Outcomes							
- CO1: Understanding fluid flow principles and Aerospace design basics. - CO2: Relate the lift and drag force associated with airfoil shapes. - CO3: Analyze how an aircraft is able to lift off the ground and get into the air before you use up all the runway lengths - CO4: Understanding the concept of control when hit by gust of wind that momentarily pitches the airplane up - CO5: Examine the models of a wide variety of propulsion systems.							
Chap No.	Course Content						
1	Basic Aerodynamics 7 Continuity Equation, Incompressible and Compressible Flow, Momentum Equation, Discussion of Compressibility, Introduction to Viscous Flow, Results for a Laminar Boundary Layer, Results for a Turbulent Boundary Layer, Flow Separation.						
2	Airfoils and Wings 12 Introduction, Brief History of Aviation, Aircraft Component Nomenclature- Wings, Fuselage, Empennage, Flight Control Surfaces, High Lift Devices, Airfoil Nomenclature, Lift, Drag, and Moment Coefficients, Infinite versus Finite Wings, Pressure Coefficient, Obtaining Lift Coefficient from C_p , Compressibility Correction for Lift Coefficient, Critical Mach Number and Critical Pressure Coefficient, Drag-Divergence Mach Number, Wave Drag (At Supersonic Speeds), Swept Wings, Aerodynamics of Airfoils, How Lift is Produced—Some Alternative Explanations.						
3	Principles of Stability and Control 7 <i>Static Stability, Dynamic Stability, Control, Absolute Angle of Attack, Neutral Point, Criteria for Longitudinal Static Stability, Contribution of the Wing to M_{cg}, Contribution of the Tail to M_{cg}, Neutral Point, Static Margin, Concept of Static Longitudinal Control, Calculation of Elevator Angle to Trim, Stick-Fixed Versus Stick-Free Static Stability.</i>						
4	Elements of Airplane Performance 7 Introduction: The Drag Polar, Equations of Motion, Thrust Required for Level, Unaccelerated Flight, Power Available and Maximum Velocity, Altitude Effects on Power Required and Available, Rate of Climb, Gliding Flight, Absolute and Service Ceilings, Time to Climb, Range and Endurance: Propeller-Driven Airplane, Range and Endurance: Jet Airplane, Takeoff Performance, Landing Performance						
5	Propulsion 7 Introduction, Propeller, Reciprocating Engine, Jet Propulsion—The Thrust Equation, Turbojet Engine-Thrust Buildup for a Turbojet Engine, Turbofan Engine, Ramjet Engine, Scramjet Engine, Rocket Engine, Rocket Propellants, Engine Efficiency- Propulsive Efficiency, Electric Propulsion						
Text Book: 1. Introduction to Flight: J.D. Anderson, Jr., McGraw-Hill International Editions.							

ReferenceBooks:

1. Introduction to Aerospace Engineering with a Flight Test Perspective: Stephen Corda, John Wiley&Sons.
2. MechanicsofFlight: WarrenF.Phillips. JohnWileyandSons, Inc
3. Miele, A., FlightMechanicsTheoryofFlightPaths, Vol.I, Addison-Wesley, Reading, MA.
4. AircraftDesign: AConceptualApproach, D.Raymer(4thEd.), AIAAPress, 2006.
5. ElementsofGasDynamics: LeipmannandRoshko, JohnWileyandSons.
6. TheDynamicsandThermodynamicsofCompressibleFlows: A.HShapiro, JohnWileyandSons.

Department of Mechanical Engineering							
			Total Number of contact hours				Credit
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE714	Advanced Mechanical Vibration	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC404		CT+EA					
Course Outcomes	CO1: Understanding the fundamental material for a modern treatment of vibrations. CO2: Application of Lagrange equations for lumped and continuous systems CO3: Understanding fundamentals of beam theory; extensional, torsional, and flexural vibrations of beams. CO4: Understanding Self-excited vibration, nonlinear vibration etc.						
Topics Covered	Review of relevant mathematics: linear algebra						3
	Generalized co-ordinates, Lagrange's equations						3
	Single-DOF and multi-DOF vibration						7
	Vibration Absorber						2
	Torsional vibration						4
	Periodic excitation and Fourier series, impulse and step response						5
	Vibration in continuous systems						4
	Self-excited vibration, Criterion of stability; Effect of friction						5
	Introduction to nonlinear vibration						7
Text Books, and/or reference material	Text Books: 1. Mechanical Vibrations, S.S.Rao, Pearson Education Inc. (4th Ed.), 2007. 2. Fundamentals of Vibrations Leonard Meirovitch, Mc-Graw Hill Inc., 2001 3. Vibration and Control, D.J. Inman, John Wiley & Sons Inc, 2002						
	Reference Books: 1. Mechanical Vibrations, S. Tamadonni & Graham S. Kelly, Schaum's Outline Series, Mc-Graw Hill Inc, 1998. 2. Vibration Condition Monitoring of Machines, J.S. Rao, Tata Mc-Graw Hill, 2006.						

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Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
MEE715	SOLAR ENERGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment(EA))					
MEC304, MEC403, MEC502		CT+EA					
Course Outcomes	CO1: Acquire knowledge of solar radiation principles concerning solar energy estimation CO2: Estimate the available solar energy in a particular site. CO3: Suggest a suitable conversion mechanism for generating power or thermal application from solar energy CO4: Design a Solar Thermal/PV system for any requirement						
Topics Covered	Solar Radiation and Measurements:						
	Solar energy option-an overview, Fundamentals of solar radiation, Basic Earth-sun-angles, Solar time and equation of time, Empirical equations for predicting the availability of solar radiation, Computation of radiation on a surface, measurements of solar radiation-Pyranometer, Pyrheliometer, sunshine recorder. <i>Liquid Flat Plate Collectors:</i> Liquid flat plate collector design, Efficiency of flat plate collectors and performance analysis, Flat plate solar air heaters, Other types of solar air heaters, some novel designs, Performance analysis, and testing procedures. <i>Solar Concentric Collectors:</i> Cylindrical parabolic collectors, Performance analysis of cylindrical parabolic collectors, Compound parabolic concentrating collectors, Performance analysis of compound parabolic concentrating collectors, Paraboloid dish collectors. <i>Solar Thermal Energy Storage system:</i> Need for thermal energy storage, size and duration of storage, sensible heat storage, latent heat storage, PCM, and Thermochemical energy storage. <i>Solar Thermal Applications:</i> Solar space heating, active systems, passive system-Trombe wall, Solar refrigeration and air conditioning, Solar cookers, Solar desalination, Solar dryers, Solar ponds and their thermal performance, Solar energy for industrial process heat <i>Solar Thermo-Mechanical Power Generation:</i> Principles of solar engines, limitation of solar mechanical power conversion, Types of solar power plants, Solar chimney, Parabolic through power plants, Central receiver power plants. Solar furnaces. <i>Solar Photovoltaic Systems:</i> Conversion of solar energy into electricity, photovoltaic effects, photovoltaic cell and its working principle, different types of solar cells, series and parallel connections, photovoltaic applications, battery chargers, domestic lighting, street lighting and water pumping.						
Text Books, and/or reference material	Suggested Text Books: 1. Sukhatme S. P., “Solar Energy: Principles of Thermal Collection and Storage,” 3rd Ed., Tata McGraw-Hill Publishing Company Ltd. 2. H. P. Garg and J. Prakash, Solar Energy: fundamentals and applications, 1st Ed., Tata McGraw-Hill Publishing Company Ltd. Suggested Reference Books: 1. Solar energy Process –Duffie and Beckman, John Wiley						

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Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE720	Advanced Machining and Surface Engineering	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC501		CT+EA					
Course Outcomes	CO1: To understand theory of machining, orthogonal cutting CO2: To understand oblique cutting mechanics as applied to drilling and milling CO3: To study other important aspects in machining related to cutting tools CO4: To understand the surface modification processes and technology						
Topics Covered	Module 1: Theory of Machining (27 hours) Introduction: Characteristics and development of tool materials, cutting tool inserts and its geometry, cutting fluids 5 Mechanics of Metal Cutting, Shear angle relationships and Lee and Shaffer's Theory, Work hardening and Chip breakers. 5 Stress distribution on rake face of the tool 1 Thermal aspects of machining. 2 Mechanisms of tool wear, Surface Finish and Effects of cutting parameters and tool geometry on tool life. 4 Economics of machining. 1 Drilling: Geometry of drilling tools and mechanics of drilling. 3 Milling: Geometry of milling tools and mechanics of plain milling 6 Module 2: Surface Engineering (15 hours) Surface structure and Properties, 2 Surface texture and roughness 2 Tribology: Friction, wear and lubrication, 5 Surface treatments, Coating and Cladding 6						
Text Books, and/or reference material	Text Books: 1. Machining and Machine Tools - A.B. Chattopadhyay 2. Theory of metal cutting - G. Koppuswamy 3. Manufacturing Processes - Kalpakjian and Schmid 4. A text book of Production Engineering - P.C. Sharma						
	Reference Books: 1. Manufacturing Science - A. Ghosh, A.K. Mallik						

Course Code	Title of the course	Program Core (PCR) /Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
MEE721	Microfluidics	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment(EA))					
MEC303, MEC304, MEC403,PHC01,CYC01, BTC01		CT+EA					
Course Outcomes	CO1: To learn the fundamentals of micro channel flows with heat transfer and the impact of flow Reynolds number hydrodynamic on flow characteristics. CO2: To learn Surface Tension Driven Flows with real life applications. CO3: To learn the diverse flow actuation techniques using Electrohydrodynamics CO4: To acquaint with various Microfabrication Techniques CO5: To learn the basics of Nanofluidics and Molecular Dynamics Simulations						
Topics Covered	Introduction to Microfluidics: Origin, Definition, Benefits, Challenges, Commercial activities, Physics of miniaturization, scaling laws, Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations. Microfluidics- Some Application Examples: Drug delivery, Diagnostics, Bio-sensing. 1 Equations of Conservation: Momentum conservation (Navier Stokes Equation), Energy Equation, Species Conservation Equation 5 Pressure-driven Microflows: Exact solutions, Couette flow, Poiseuille flow 5 Some Examples of Unsteady Flows: Hydraulic resistance and Circuit analysis, Straight channel of different cross-sections, Channels in series and parallel. Stokes Drag on a Sphere: Stokes drag on a sphere, Time-dependent flows, Two-phase flows. 5 Lubrication Theory 2 Boundary Condition in Fluid Mechanics- Slip or No-slip: Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Re flows, Entrance effects 2 Surface Tension Driven Flows: Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary length and capillary rise, Interfacial boundary conditions, Marangoni effect 6 Thin Film Dynamics 4 Introduction to Micro-fabrication: Materials, Clean room, Silicon crystallography, Miller indices. Oxidation, photolithography-mask, spin coating, exposure and development, Etching, Bulk and Surface micromachining, Wafer bonding. Polymer micro fabrication, PMMA/COC/PDMS substrates, micromolding, hot embossing, fluidic interconnections 1 Electrokinetics: Electrohydrodynamics fundamentals. Electro-osmosis, Debye layer, Thin EDL limit, Ideal electro-osmotic flow, Ideal EOF with back pressure, Cascade electro-osmotic micropump, EOF of power-law fluids. Electrophoresis of particles, Electrophoretic mobility, Electrophoretic velocity dependence on particle size. Dielectrophoresis, Induced polarization and DEP, Point dipole in a dielectric fluid, DEP force on a dielectric sphere, DEP particle trapping, AC DEP force on a dielectric sphere. Electro-capillary effects, Continuous electro-wetting, Direct electro-wetting, Electro-wetting on a dielectric. 6 Dispersion, Introduction to Nanofluidics, Introduction to Molecular Dynamics Simulations, Biomicrofluidics, Nanofluidic Energy Conversion. 4						
Text Books, and/or reference material	Text Books: 1) Microfluidics-Stéphane Colin, Wiley-ISTE, 2010. 2) Micro- and Nanoscale Fluid Mechanics, Transport in Microfluidic Devices by Brian Kirby, Cambridge University Press, 2010.						

ReferenceBooks:

- 1) Theoretical Microfluidics-Henrik Bruus, Oxford University Press, 1st Ed., 2007.
- 2) Fundamentals and Applications of Microfluidics: Nam-Trung Nguyen and Steven T. Wereley, Artech House, Boston, 3rd Ed., 2018.

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Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE722	Refrigeration and Air Conditioning	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and End Assessment (EA))					
Fluid Mechanics (MEC303), Engineering Thermodynamics (MEC304), Heat and Mass Transfer (MEC403)		CA+ MT+ EA					
Course Outcomes	CO1: Understand the principles and applications of various refrigeration cycles. CO2: Knowledge of different refrigerants and its properties. CO3: Ability to understand the fundamentals of psychrometric, and psychrometric processes. CO4: Analyze air-conditioning system using the principles of psychrometric. CO5: To gain knowledge about components of cooling load, and its estimation.						
Topics Covered	History and Methods of Refrigeration, Refrigeration and Second Law of Thermodynamics, Units of Refrigeration, Reversed Carnot Cycle. Its Practical Limitations, Bell-Coleman Air Cycle, Standard Vapour Compression Refrigeration System and Its Performance Analysis. Effect of Evaporator and Condensing Pressure. Modifications, Its Effects, Actual Vapour Compression Refrigeration Systems, Second Law Efficiency of Vapour Compression Cycle, Multistage Vapour Compression System, Cascade Refrigeration System. Cryogenics: Introduction and application of cryogenics. [12]						
	Desirable Properties of Refrigerants, Designation of Refrigerants, Secondary Refrigerant, Thermodynamics analysis of vapour absorption System, Comparison between vapour absorption and vapour compression system, Aqua-Ammonia and Lithium Bromide absorption system. [6]						
	Psychrometric properties, Psychrometers, Preparation of psychrometric charts, Enthalpy deviation, Psychrometric Processes - Mixing process, Sensible heating, Sensible cooling, Humidification, Dehumidification, Cooling and Dehumidification, Heating and humidification, Bypass factor, Apparatus dew point, Sensible heat factor, Air washer, Adiabatic humidification, Efficiency of humidification, Summer and Winter air conditioning system. [10]						
	Factors affecting comfort air conditioning, Air conditioning system, Classification of air conditioning systems, Central air conditioning systems, Room sensible heat factor, Non-conventional refrigeration systems: Vortex and pulse tube refrigeration systems; Thermoelectric refrigeration systems. [8]						
	Components of a cooling load, Heat gain from solar radiation, Metabolic rate, Heating load calculations, Ducts, Pressure drop in ducts, Energy efficiency and Sustainable technologies: Energy efficiency, Green buildings etc., Artificial intelligence models for refrigeration, air conditioning and heat pump systems. [8]						

TextBooks and/orreference material	TextBooks: 1) RefrigerationandAirConditioningbyC.P.Arora,TataMcGraw-Hill. 2) RefrigerationandAirConditioningbyManoharPrasad,NewAgeInternationalPublishers. 3) RefrigerationandAirConditioningbyR.K.RajputKastonPublication.
	ReferenceBooks: 1) Refrigeration and Air Conditioning by W.F. Stoecker and J. W. Jones, Tata McGraw-Hill. 2) AroraS.C.andDomkundwarS.,“ACourseinRefrigerationandAirConditioning”,Dhanpat Rai&Sons, 2006. 3) AnanthanarayananP.N.,“BasicRefrigerationandAirConditioning”,TataMcGraw-Hill,2005. 4) ASHRAEHandbook.
	DataBooks: 1)Refrigerant and Psychrometric Properties - Tables and Charts [SI Units], M. L.Mathur,andF. S.Mehta, JainBrothers,2020 (RevisedEdition).

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE723	Computational Fluid Dynamics and Heat Transfer	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Fluid Mechanics (MEC303), Engineering Thermodynamics (MEC304)		CT+EA					
Course Outcomes	CO1: To learn to model a physical Fluid Mechanical and Heat Transfer problem (both Laminar & Turbulent Flow) mathematically in terms of PDEs.						
	CO3: To learn discretization of the PDEs using Finite Difference and Finite Volume Methods						
Course Outcomes	CO3: To learn R-K4 method to solve ODEs and Techniques to solve PDEs.						
	CO4: To learn to solve simple Heat transfer Problems and Viscous Incompressible Fluid Flow problems using MATLAB coding and checking the same by simulation using ANSYS-Fluent software.						
Topics Covered	Conservation equations of fluid flow and heat transfer: Mass, momentum (NS-equation), energy conservation equation and equation of state, Stream function- Vorticity method and Laminar Boundary layer equations for Viscous and Thermal Boundary layer. Classification of PDEs: Elliptical, Parabolic and Hyperbolic PDEs, Initial and Boundary value problems, some examples. Numerical methods: (1) Jacobi Iteration, (2) Point Gauss Siedel iteration (3), Line Gauss Siedel iteration (4) Point Successive over/under relaxation method and (5) TDMA using Thomas Algorithm. 9 Turbulence modeling: (1) RANS equations with (a) Mixing length model, (b) The $k-\epsilon$ model and (c) $k-\omega$ model. (2) Large eddy Simulation (Concept only) and (3) Direct Numerical Simulation, DNS (Issues and concepts). 5 Discretization techniques of PDEs: Finite Difference Methods: Central, Forward and Backward Differencing for both uniform and non-uniform grids. Numerical errors and accuracy; Consistency, Convergence and Stability of finite difference scheme. Grid generation, Discretization and solution using Matlab coding of both Steady and Unsteady Diffusion problems and Convection-Diffusion problems. Finite volume Method: Conservativeness, Boundedness and Transportiveness, Central difference						

	cingschemes,Upwind differencingschemes,Hybrid differencingschemes and Power law schemes, Quadratic Upstream Interpolation for Convective Kinetics (QUICK). 14
	Numerical methods for Viscous Incompressible Fluid Flow: Runge-Kutta methods and its application to solve Viscous Boundary layer equations (Blasius equation for flat plate) and Thermal boundary layer equations. Stream function-Vorticity method, MAC algorithm, SIMPLE, SIMPLER, SIMPLEC and PISO to solve Viscous incompressible fluid flow. 14
Text Books, and/or reference material	Text Books: 1. Pradip Neogy, S. K. Chakraborty and M. K. Laha: Introduction to Computational Fluid Dynamics; 2. H. K. Versteeg, and W. Malalasekera : An Introduction to Computational Fluid Dynamics: The Finite Volume Method. 3. P. S. Ghoshdastidar: Computational Fluid Dynamics and Heat Transfer. Reference Books: 1. Tannehill, J. C., Anderson, D. A. and Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer, McGraw Hill, 2002. 2. Patankar, S. V., Numerical Heat Transfer and Fluid Flow, Ane Books-New Delhi, 1980. 3. Blazek, J., Computational Fluid Dynamics: Principles and Applications, 2nd Edition, Elsevier Science & Technology, 2006. 3. Chung, T. J., Computational Fluid Dynamics, Cambridge University Press, 2003.

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE724	Theory of Plates	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Engineering Mechanics, Strength of Materials		CT+EA					
Course Outcomes	CO1: Concept of various plate theory CO2: Derivation of governing equation using virtual displacement theory CO3: Analysis of plates						
Topics Covered	Stress strain relations, strain displacement relation, equations of equilibrium, virtual work principle, Classical plate theory, FSDT, HSDT.						8
	Pure bending and cylindrical bending of isotropic rectangular plates, Navier and Levy solution of rectangular plates.						8
	Bending of circular plates.						6
	Bending analysis of laminated composite plates.						8
	Approximate solution methods for plate problems.						6
	Dynamics of Plates.						6
Text Books, and/or reference material	Text Books: 1. Theory of plates By K. Chandrashekara (Universities Press) 2. Theory and analysis of elastic plates and shells By J. N. Reddy (CRC Press) 3. Theory of plates and shells By S. P. Timoshenko and S. W. Krieger (Tata Mcgraw-Hill)						

ReferenceBooks:

- 1.Theory and analysis of plates classical and numerical methods By R. Szilard(PrenticeHall)

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE725	Energy Conversion Systems	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 601 (Power Plant Engineering)		CT+EA					
Course Outcomes	CO1: Acquire an idea about different energy conversion technologies CO2: To learn the energy efficient, economically viable, and environmental friendly power generation technologies CO3: To learn about different conventional and non-conventional power generation systems. CO4: Introduced to different direct energy conversion systems						
Topics Covered	Global and Indian Energy Scenario						3
	Advanced Coal Technologies						6
	Advanced Power generation Cycles-Supercritical Power plant, Cogeneration, Combined cycle power plants						7
	Fluidized bed combustion						5
	Gasification, Integrated Gasification Combined Cycle (IGCC)						6
	Direct Energy Conversion: Fuel Cells: Proton Exchange Membrane (PEM) Fuel cells, Solid Oxide Fuel Cells (SOFC), Magneto-Hydro-Dynamic (MHD) Systems						7
	Biomass based energy conversion						3
	Nuclear Power generation						5
Text Books, and/or reference material	Text Books: 1. Principles of Energy Conversion-Archie W. Culp 2. Power Plant Engineering-P.K. Nag						
	Reference Books: 1. Fluidized Bed Technology-J.R. Howard 2. PEM Fuel Cells: Theory and Practice-Franco Barbir						

DepartmentofMechanicalEngineering							
CourseCode	Titleofthecourse	Program Core(PCR)/ Electives(PEL)	TotalNumber ofcontacthours				Credit
			Lecture (L)	Tutorial(T)	Practical (P)	Total Hours	
MEE726	Advanced Robotics	PEL	3	0	0	3	3
Pre-requisites		CourseAssessmentmethods					
KnowledgeonMechanisms		Continuous(CT)+MidTerm(MT)+EndTermassessment(EA)					
CourseOut comes	CO1Understandtheprinciplesofdifferentroboticmechanisms,sensors,actuatorsCO2 Analyse the serial robotic manipulators for position, velocity and accelerationCO3Analyse thedynamicsofserial roboticmanipulators CO4Analysethekinematicsofparallelmanipulator CO5Applyanalyticalformulationformodellingofleggedrobots						
TopicsCo	Reviewofbasics ofRobotics(2)						

vered	Mathematical representation of industrial robots : Denavit-Hartenberg convention (2) Kinematic analysis of serial robotic manipulators: Forward kinematics, Inverse kinematics, velocity and acceleration analysis (8) Introduction to Dynamics of Serial Manipulators: Newton-Euler formulation, Lagrange-Euler formulation (5) Trajectory Planning of Manipulator: Joint space scheme, Cartesian space scheme (4) Introduction to parallel manipulators (1) Kinematics of parallel manipulators (5) Modelling and analysis of legged robots (4) Robot Sensors: Contact type, non-contact type, internal sensor, External sensor, Range sensor, Proximity sensor, touch sensor, Force and torque sensor, Encoders, robot vision etc (5) Robot actuators (1) Position and force control of manipulators (3) Robot Operating System (ROS) and Artificial Intelligence (AI) in robotics (2)
Text Books, and/or reference material	Text Books: 1. Ghosal, A., Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2nd reprint, 2008. 2. Saha, S.K., Introduction to Robotics, TMH Publishing Company Ltd., New Delhi, 2008. 3. Pratihari, D.K., Fundamentals of Robotics, Narosa Publishing House, India, 2017 Reference Books: 1. Spong, M.W., Hutchinson, S., and Vidyasagar, M., Robot Modeling and Control, Wiley India, New Delhi, 2006. 2. Fu, K., Gonzalez, R. and Lee, C.S.G., Robotics: Control, Sensing, Vision and Intelligence, McGraw-Hill, 1987.

Open Elective Subject offered by Mechanical Engineering Department

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEO741	Product Development and Value Engineering	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	• CO1: Understand the process of product design and development. • CO2: Identify the ergonomics between human and machines. • CO3: Analyze the concept of value engineering for product orientation. • CO4: Select the process for introduction of product for human interface.						
Topics Covered	1. Product Development: [15] Product design, Types of design, Phases in product design, Reason for product development, Factors affecting product development, Characteristics of successful product development, Challenges of product development, Product classifications, Product development processes, Concept development, Brainstorming, Product development plan, Identifying customers need, Deciding product specifications, defect investigation, selection of materials, important engineering materials, new materials, process selection criteria and process design. 2. Ergonomics: [12] Scope and objective of ergonomic, Human physical characteristics, application of human factor in engineering, Human machine systems. 3. Value engineering [15] Introduction of value engineering, cost reduction technique, Value engineering program, Advantages and applications, problem recognition, role of creativity, Value engineering job plan:- orientation phase, information phase, Function phase, Evaluation function, Investigation phase, project selection and value standard. Fast diagram and lifecycle cost:- Use of fast diagram, types of fast diagram, technically oriented fast diagram, lifecycle cost						
Text Books, and/or reference material	Text Books: • Product Design and Development: Karl T. Ulrich and Steven D. Eppinger • Human Factors in Ergonomics and Design: Sanders & McCormick						
	Reference Books: • Product design and manufacturing, A. C. Chitale and R C Gupta, Prentice Hall New Delhi • Value Engineering: A systematic approach by Arthur E Mudge – McGraw Hill						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEO742	Energy Management and Auditing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and End Assessment (EA))					
Nil		CT+EA					
Course Outcomes	CO1: To acquire the knowledge about energy conservation. CO2: Knowledge of energy conversion efficiency. CO3: Ability to evaluate the performance of pumps, fans, blowers, and industrial boilers etc. CO4: To gain knowledge about the energy conservation opportunities in various industrial processes. CO5: Students will be able to become energy manager and energy auditor in different industries.						
Topics Covered	Introduction: Importance of energy management, Role, Responsibilities and Duties of Energy manager and Energy Auditor, Energy Conservation Act and Calculation of energy consumption, Fundamental calculation in Mechanical, Thermal & Electrical system, Thermal energy basis, Measurement and instruments used in energy audit, Performance parameters for energy audit, Bureau of Energy Efficiency (BEE), Plant Energy Performance (PEP). (10) Material and Energy Balance, Energy analysis, Sankey diagram, Financial Management and analysis techniques, Project Management, Time-dependent energy analysis, Energy conversion efficiency, Capacity Factor (CF), Renewable energy sources, Non-renewable energy sources, and Conversion efficiency. (8) Mechanical and Thermal system: Gross Calorific Value (GCV) and Net Calorific Value (NCV), Combustion, Boiler efficiency testing, excess air control, steam distribution and use of steam traps, condensate recovery, flash steam utilization, Furnace efficiency, thermal insulation, Cogeneration, Waste heat recovery, Energy conservation in pumps, fan and blower, Compressed air systems, Refrigeration and air conditioning systems. (10) Electrical System: Power factor, energy efficient motors, lighting levels, Illuminance, Energy Conservation in cooling tower, Waste heat recovery, Trigeneration, Energy conservation building code. (5) Energy Auditing: Introduction, Importance of energy audit, uses of energy audit, Basic terms of energy audit, Types of energy audit, Procedure for carrying energy audit, Instruments used for energy audit. (9)						
Text Books, and/or reference material	Text Books: 1. Energy Management and Conservation Handbook, Frank Kreith and D. Yogi Goswami; CRC Press, Taylor & Francis Group. 2. Handbook of Energy Efficiency and Renewable Energy; Frank Kreith and D. Yogi Goswami; CRC Press, Taylor & Francis Group. 3. Guide to Energy Management, Seventh Edition, Barney L. Capehart, Wayne C. Turner, William J. Kennedy; CRC Press, Taylor & Francis Group. 4. Handbook of Energy Audits, Ninth Edition, Albert Thumann, Terry Niehus, and William J. Younger; CRC Press, Taylor & Francis Group. Reference Books: 1. Introduction to Power Plant Engineering - P K Nag 2. Energy Management in Buildings Using Photovoltaics, Elena V. M. Papadopoulou; Springer						

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Course Code	Title of the course	Program Core (PCR)/ Elective (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEO743	Dynamical Systems Theory	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MAC02		CT+EA					
Course Outcomes	CO1: Understand the dynamical behaviour of nonlinear systems. CO2: Explain different dynamical states and transition (Bifurcation) between them						
	CO3: Evaluate Stability of different dynamical states. CO4: Analyze different chaotic systems and their universality						
Topics Covered	Dynamics in State Space (in 2 and 3 dimension): State Space, 1st order differential equation, no-intersection theorem, dissipative systems and attractors, 1D state space, Taylor series linearization near fixed points, 2D State space, Dynamics and complex characteristics values, Dissipation and divergence theorem, Jacobian Matrix, Limit cycles, Poincare section, Stability of limit cycles, Bifurcation Theory. 14 Three Dimensional State space: 3 Dimensional dynamical Systems, Fixed points in 3D, Limit cycles and Poincare Sections, Quasi-periodic behaviour, Route to chaos: Period-doubling route to chaos, Quasi-periodicity route to chaos, Intermittency route to chaos, Chaotic Transients and Homoclinic Orbits, Lyapunov exponents. 12 Chaotic systems: A nonlinear Electrical System, Population Growth Model, Lorenz Model: a model of convecting fluid, Determinism, Unpredictability and Divergence of trajectories. 8 Universality of Chaos: Feigenbaum Numbers, Convergence criterion of real systems, Self-Similarity, Other universal features. 4 Iterated Map: Poincare section and Iterated Map, Bifurcation in Iterated Map, Tent Map, Shift map and Symbolic Dynamics, 2D Iterated Map 4						
Text Books, and/or reference material	Text Books: 6. Chaos and Nonlinear Dynamics – Robert C. Hilborn 7. Nonlinear Dynamics and Chaos – Steven H. Strogatz						
	Reference Books: 4. Dynamics for Engineers- Soumitro Banerjee						

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Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XEO744	Design Thinking, Innovation and Entrepreneurship	Open elective	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	• CO1: To get the knowledge about product design and consumer thinking. • CO2: Develop creative problem-solving skills and the ability to generate innovative solutions. • CO3: To learn about innovation and its types. • CO4: To learn various aspects of entrepreneurship and its successful examples.						
Topics Covered	Design Thinking: What is thinking? What is design thinking, Historical perspective, Importance of design thinking, User Centered Design (4) Design Thinking Process: Five stages - Empathize, Define, Ideate, Prototype, Test, Tools and Techniques for Each Stage, Defining problem statements, Double diamond approach, Applications (4) Critical thinking for problem solving: Requirement, History, Fallacy, Standards of Critical Thinking, Problem solving through critical thinking (5) Innovation: What is Innovation, Invention vs Innovation, Examples, Evolution of products through innovation – case studies, Types of innovation – Based on idea, Based on outcome, Problem solving through innovation – Case studies and discussion (11) Entrepreneurship: Definition, examples, Need, Product Development and Market Fit, Product Management Life cycle, Technology Readiness Level, Manufacturing Readiness Level, Investment Readiness Level, Business Plan Development (8) Market Research – Identifying market, Segmenting the market, Building a marketing plan (2) Business planning: Finances, Operations, Marketing (2)						
Text Books, and/or reference material	Text Books: • "Design Thinking for Entrepreneurs and Small Businesses" by Beverly Rudkin Ingle • "Change by Design" by Tim Brown • "Creative Confidence" by Tom Kelley and David Kelley • "Innovation and Entrepreneurship: Practice and Principles" by Peter F. Drucker • "Blue Ocean Strategy: How to Create Uncontested Market Space and Make the Competition Irrelevant" by W. Chan Kim and Renée Mauborgne • "Disruptive Innovation: The Christensen Collection (The Innovator's Dilemma, The Innovator's Solution, The Innovator's DNA, Harvard Business Review Articles)" by Clayton M. Christensen						