EXPLORE INNOVATE EXCEL

UG-Curriculum

(Structure and Course Contents)

With effect from July 2020 onwards

Mechanical Engineering
Punjab Engineering College
(Deemed to be University) Chandigarh

CREDITS BREAK-UP FOR B.TECH. PROGRAMME (2020-21 onwards)

CURRICULAR COMPONENTS	Credits
(A) Institute Core Courses (ICC) **a)** Basic Sciences (BSC) **b)** Engineering Sciences (ESC) **c)** General Science (GSN)	 16 17 04
Total	**37**
(B) Humanities, Communication and Management Elective Courses (HSSMEC)	**12**
(C) Department Core Courses (DCC) (including 3 credits of Minor Project)	**39**
(D) Departmental Elective Courses (DEC)	**20**
(E) Institute Open Elective Courses (GSE/ HSEC) **a)** Courses **b)** Project (Compulsory Major Project)- Inter disciplinary	 **24** **06**
Total	**30**
(F)Internship/ Course Work* (4 credits of Deptt. Elective + 4 credits of Open Elective+ 4 credits of Project Work) *** Optional**	**12**
(G) Non Academic Courses (CCA)	**10**
Grand Total (For those who **do not opt** for Honours)	**160**
(H) Honours	**16**
Grand Total (For those who **opt** for degree with Honours)	**160+ 16**

Note: Minor Specialization will be given to a student who earns 16 credits from the basket of Open Elective courses offered by any one department (outside the parent department). Major Specialization will be given to a student who earns 16 credits in any one domain of Department Elective courses offered by parent department. To get Honours, the student will have to complete additional 16 credits of discipline open Electives.

Semester wise UG Scheme to be implemented w.e.f. 2020-21 session

SEMESTER-I		
S.No.		**Credits**
1	Orientation (including Introduction to Discipline course-1 credit 14 hours)	2
2	BSC-I (Mathematics)	4
3	BSC-II/ BSC-IV (Physics/ Chemistry)	4
4	GSC-I & GSC-II/ ESC-I	4
5	HSM-I/ ESC-II	3
6	ESC-III/ ESC-IV	3/2
	TOTAL	**20/19**

SEMESTER-II		
S.No.		**Credits**
1	BSC-III (Mathematics)	4
2	BSC-IV/ BSC-II (Chemistry/ Physics)	4
3	ESC-I/ GSC-I & GSC-II	4
4	ESC-II/ HSM-I	3
5	ESC-IV/ ESC-III	2/3
6	ESC-V/ ESC-VI	2
	TOTAL	**19/20**

SEMESTER-III		
S.No.		**Credits**
1	ESC-VII/ HSM-II	3
2	Deptt Core Courses (DCC)	12
3	OE-I	4
4	Industrial Tour	2
	TOTAL	**21**

SEMESTER-IV		
S.No.		**Credits**
1	HSM-II/ ESC-VII	3
2	Deptt Core Courses (DCC)	12
3	OE-II	4
4	Proficiency-I	2
	TOTAL	**21**

SEMESTER-V		
S.No.		**Credits**
1	DEC-I	4
2	Deptt Core Courses (DCC)	12
3	DEC-II	4
4	Minor Project	3
	TOTAL	**23**

SEMESTER-VI		
S.No.		**Credits**
1	**Internship Training (Optional)**	12
	Students opting for course work will do Deptt. Elective (4 credits), Open Elective (4 credits) and Project Work (4 credits)	
	TOTAL	**12**

SEMESTER-VII		
S.No.		**Credits**
1	HSM-III	3
2	DEC-III	4
3	DEC-IV	4
4	OE-III	4
5	OE-IV	4
6	Major Project-I	2
	TOTAL	**21**

SEMESTER-VIII		
S.No.		**Credits**
1	HSM-IV	3
2	DEC-V	4
3	OE-V	4
4	OE-VI	4
5	Discipline	2
6	Proficiency-II	2
7	Major Project-II	4
	TOTAL	**23**

ABBREVIATIONS		
	Basic Science Course	BSC
	Engineering Science Course	ESC
	General Science Course	GSC
	Humanities, Social Sciences & Mgmt.	HSM

ABBREVIATIONS		
	Department Core Course	DCC
	Department Elective Course	DEC
	Open Elective Course	OE

Total Credits = 160 without Honours **Total Credits = 160 + 16 with Honours**

Note: Minor Specialization will be given to a student who earns 16 credits from the basket of Open Elective courses offered by any one department (outside the parent department). Major Specialization will be given to a student who earns 16 credits in any one domain of Department Elective courses offered by parent department. To get Honours, the student will have to complete additional 16 credits of discipline Electives.

ESC-I	Introduction to Computing
ESC-II	Engineering Drawing with CAD Software
ESC-III	Introduction to Mechatronics

ESC-IV	Introduction to Electronics & electrical Engineering
ESC-V	Introduction to Manufacturing
ESC-IV	Strength of Materials
ESC-VII	Artificial Intelligence

ESC-VII and HSM-II (in 3rd and 4th semesters) are common to all branches.

Teaching Scheme for B. Tech. Mechanical Engineering

(Courses/Credit Distribution) (2021-22) onward

FIRST YEAR

Semester I

Course Code	Subject	Credits	L	T	P	Category
OR1101	Orientation (1 Credit) + Introduction to Mechanical Engineering (1 Credit)	2				
MA1101	BSC-I Mathematics: Calculus & Ordinary DE	4	3	1	0	BSC
PY1101	BSC-II Physics (Mechanics & Optics	4	3	0	2	BSC
GS1201/ GS1101	GSC-I & GSC-II Intr. to Environmental Sc. I & II	4	3	0	2	ESC
HS1101	HSM-I Communication Skill & Ethics	3	2	0	2	HSM
ES1301	ESC-III Introduction to Mechatronics	3	2	0	2	ESC
	Total	**20**	**13**	**1**	**8**	

* L-T-P (Lecture-Tutorial-Practical)

Semester II

Course Code	Subject	Credits	L	T	P	Category
MA1201	BSC-III Linear Algebra, Vector Calculus & PDE	4	3	1	0	BSC
CH1201	BSC- IV Chemistry: Applied Chemistry II	4	3	0	2	BSC
ES1101	ESC-I Introduction to Computing	4	3	0	2	GSC
ES1201	ESC-II Engineering Drawing & CAD	4	2	0	2	ESC
ES1401	ESC-IV Introduction to EC & EE	2	2	0	0	ESC
ES1601	ESC-VI Strength of Materials	2	2	0	0	ESC
	Total	**19**	**15**	**1**	**6**	

SECOND YEAR

Semester III

Course Code	Subject	Credits	L	T	P	Category
HSM II	HSM II	3				HSM
ME1031	Elements of Manufacturing Process	3	2	0	2	DCC
ME1032	Elements of Thermodynamics	3	3	0	0	DCC
ME1033	Mechanics of Material	3	2	1/2	2/2	DCC
ME1034	Theory of Machine	3	2	1/2	2/2	DCC
	Open Elective Course-I	4				OE
	Industrial Tour	2				
	Total	**21**				

Semester IV

Course Code	Subject	Credits	L	T	P	Category
ME1041	Manufacturing Processes	3	2	0	2	DCC
ME1042	Applied Thermodynamics	3	2	1/2	2/2	DCC
ME1043	Refrigeration & Air Conditioning	3	2	1	0	DCC
ME1044	Mechanical Vibration	3	2	1/2	2/2	DCC
	Open Elective Course-II	4				OE
ES1701	ESC-VII Artificial Int. & Machine Learning	3				ESC
	Proficiency-I	2				
	Total	**21**				

THIRD YEAR

Semester V

Course Code	Subject	Credits	L	T	P	Category
ME1051	Production Engineering	3	2	1	0	DCC
ME1052	Production and Operation Management	3	3	0	0	DCC
ME1053	Heat and Mass Transfer	3	2	0	2	DCC
ME1054	Design of Mechanical System	3	3	0	0	DCC
	Department Elective Course I	4				DEC
	Department Elective Course-II	4				DEC
	Minor Project	3				DCC
	Total	**23**				

Semester VI

Course Code	Subject	Credits	L	T	P	Category
	Internship (Optional) *	12				DCC
	Students opting for course work will do Dept. Electives (4 Cr), Open elective (4 Cr), Project work (4 credits)					
	Total	**12**				

*Internship Seminar presentations may be held a week before the date of Registration in Semester-I of 4th Year

FOURTH YEAR

Semester VII

Course Code	Subject	Credits	L	T	P	Category
	HSM-III	3				HSM
	Department Elective Course-III	4				DEC
	Department Elective Course-IV	4				DEC
	Major Project-I	2				DCC
	Open Elective Course-III	4				OE
	Open Elective Course-IV	4				OE
	Total	**21**				

Semester VIII

Course Code	Subject	Credits	L	T	P	Category
	HSM-IV	3				HSM
	Department Elective Course-V	4				DEC
	Open Elective Course-V	4				OEC
	Open Elective Course-VI	4				OEC
	Discipline	2				
	Proficiency-II	2				
	Major Project-II	4				DCC
	Total	**23**				

Orientation Course (OR1101) of 2 credits includes Introduction to Discipline Engineering of 1 credit – 14 hours

Course Name	**:**	**Introduction to Aerospace Engineering**
Course Code	**:**	
Credits	**:**	**1**
Lectures	**:**	**14 hrs**

Total No. of Lectures – 14

Course Objectives:

1	To introduce various aspects of aerospace engineering
2	To make the students aware about challenges and opportunities in the field of aerospace engineering.

Lecture wise breakup	**No. of Lectures**

1	**Aerospace: History and future** History of aviation and space technology, Scope of Aerospace Engineering , Aerospace Industry, Current status and future of Aerospace Industry.	(2)
2	**Aspects of Aerospace Engineering** Anatomy of Aircraft and spacecraft, Classification of aircrafts and space crafts, Brief introduction to: Aircrafts instruments and systems, Aircraft structural components, Wind Tunnel: Utility	(4)
3	**Basic understanding of flight** Airfoils, lift, drag, Thrust, weight and moments, force diagram. Different phases of flight, VTOL and STOL.	(2)
4	**Aerospace Propulsion** Introduction to different aerospace propulsion systems: Piston engine, Turboprop, Turbojet, Turbofan, Ramjet, Scramjet, Pulsejet and Pulse detonation engine and Rocket propulsion.	(2)
5	**Satellites** Different Launch Vehicles, Accomplishment of ISRO	(2)
6	**Aircraft Regulating Bodies** Role of DGCA, AAI and MoCA, Introduction to airports.	(2)

Suggested Books:

S.No.	**Name of Books**	**Year of Publication**
1	Introduction to Flight by John D. Anderson Jr.,7th Edition, Mc Graw Hill Pvt. Ltd.	2011
2	Aircraft Basic Science by Ralph D. Bent & James L. Mackinley.	1993
3	Flight without formulae by A.C. Kermode, 5th Edition, Pearson publication,	1989

Course Outcomes:

1	The students will be able to realize interesting aspects of aerospace engineering
2	The students will be able to describe important basic concepts of aerospace engineering

Orientation Course (OR1101) of 2 credits includes Introduction to Discipline Engineering of 1 credit – 14 hours

Course Name	**:**	**Introduction to Civil Engineering**
Course Code	**:**	
Credits	**:**	**1**
L T P	**:**	**1 0 0**

Total No. of Lectures: 14

Course Objectives:
On completion of this course, the student shall be introduced to an overview of Civil Engineering profession and the ethical responsibilities of engineering practice.

Lecture wise breakup		**No. of Lectures**
1	**Structural Engineering:** Role of structural engineering in construction projects, Introduction of construction materials. General aspects of Structural Design.	3
2	**Hydraulics/Water Resources Engineering:** Flow in Pipes/Channel, Reservoirs/Dam, Application of Water Resources Engineering.	2
3	**Geotechnical Engineering:** Scope and Importance of Geotechnical Engineering, field/practical illustration for civil engineering applications e.g. subgrade, embankment, foundations, dams, canals, tunnels, landslide problem etc.	2
4	**Transportation Engineering:** Opportunities and challenges in Transportation Infrastructure, Construction Materials, Design objectives, Highways, Rail Network, Airports, Monorails, sustainability.	3
5	**Environmental Engineering:** Elements of water and wastewater Engineering, Air Pollution & Solid Waste Management technologies.	2
6	**Geomatics Engineering:** Importance of surveying in civil engineering projects, introduction of conventional techniques, advancement in surveying techniques (GIS/RS/ Photogrammetry/Drone)	2

Course Outcomes:
Upon completion of this course the student shall be able to 1. Make choice of career decisions 2. Apply concepts of ethics in professional practice

Suggested Books:		
S. No.	**Name of Books / Authors/ Publishers**	**Year of Publication/ Reprint**
1.	Penn M. R. and Parker P. J. "Introduction to Infrastructure: An Introduction to Civil and Environmental Engineering" John Wiley & Sons	2011
2.	Arora, M.K. and Badjatiya, R.C. “Geomatics Engg”, Nem Chand and Bros., Roorkee	2009
3.	Mckay W. B. “ Building Construction” Orient Longman	2003
4.	Schodek D. L. “Structures” Prentice Hall of India Pvt. Ltd.	2002

Orientation Course (OR1101) of 2 credits includes Introduction to Discipline Engineering of 1 credit – 14 hours

Course Name	**:**	**Introduction to Computer Science and Engineering**
Course Code	**:**	
Credits	**:**	**1**
L T P	**:**	**1 0 0**

Total No. of Lectures – 14

Course Objectives:

The students should know about various disciplines in Computer Science and Engineering and are aware of emerging trends of Computer Science and Engineering.

Lecture wise breakup		**No. of Lectures**
1	**COMPUTER HARDWARE** Basics of Number System, Evolution of Computer Hardware, Moore's Law.	**2**
2	**LOGIC DEVELOPMENT AND ALGORITHMS** Various techniques to solve a problem, Ways to specify an algorithm.	**2**
3	**VARIOUS DISCIPLINES OF COMPUTER SCIENCE AND ENGINEERING** Basics of Operating Systems, Artificial Intelligence, Computer Networks, Information Security, Software Engineering, Computer Vision.	**6**
4	Current and future trends and challenges in various fields of computing. Social, ethical and economic issues related to computing technology. Exploration of career and professional development opportunities.	**4**

Course Outcomes:

At the end of the course, students will have:	
1	Students get knowledge about various fields of Computer Science and Engineering.

Suggested books		**Year of Publication/ Reprint**
1	Computing Fundamentals, Peter Norton, 4th Ed., Tata McRaw Hill	Latest edition
2	Computer Science Handbook, Allen B. Tucker, CRC Press	Latest edition

Orientation Course (OR1101) of 2 credits includes Introduction to Discipline Engineering of 1 credit – 14 hours

Course Name	:	**Introduction to Electrical Engineering**
Course Code	:	
Credits	:	**1**
L T P	:	**1-0-0**

Course Objectives:
At the end of this course, the student should be able to acquire basic knowledge of fundamentals of Electrical Engineering along with energy resources, generation, transmission, distribution and utilization of electrical energy.

Total No. of Lectures - 14

Lecture wise breakup		**Number of Lectures**
1	**OVERVIEW OF ELECTRICAL ENGINEERING** General Introduction to the Field of Electrical Engineering and its Sub- disciplines,	1
2	**ENERGY RESOURCES** Conventional and Non-conventional Energy Resources; Availability of Resources; Principle of Energy Conversion and its Utilization; National and International Energy Trends; Global Warming and Greenhouse Effects.	1
3	**GENERATION** Generation of Electrical Power, Synchronous Generator; Generated Voltage Waveform, Voltage and Frequency Level.	2
4	**TRANSMISSION** Purpose of Transmitting Power, AC Transmission Voltage Levels; Transmission Lines, Transmission Substation; HVDC Transmission.	1
5	**DISTRIBUTION** Distribution Network and Substation; Single Line Diagram of Distribution Network; Overhead Lines and Underground Cables; Grounding and Earthing.	2
6	**ELECTRICAL MACHINES** Static and Rotating Machines, Classification, Working Principle and Applications.	2
7	**UTILIZATION** Types of Load- Heating, Motor, Traction, Lighting and Fans; Load Characteristics; Consumer Loads; Power Electronic Equipment.	1
8	**METERING** Active and Reactive Power, Apparent Power, Voltage, Current, Power and Energy Measurement.	2
9	**ELECTRICAL WIRING CONCEPTS** Residential Wiring Diagram, Symbols of Switches, Fuse, Rheostat, SPDT, DPDT, Contacts, Contactors, MCB, Safety and Protection.	1
10	**POWER QUALITY AND CONTROL** Nature of Non- linear Loads; Problems due to Non-sinusoidal Current; Use of Electronics, Microprocessor and Control Systems.	1

Course Outcomes: By the end of this course, the student will be able to:	
1	Understand the fundamentals of Electrical Engineering and become familiar with the field of Electrical Engineering and its various sub-disciplines.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Basic Electrical Engineering by D. P. Kothari, I.J Nagrath, McGraw Hill	2009
2	Beaty H.W., Fink D.G., "Standard Handbook for Electrical Engineers", McGraw Hill 15th Edition	2007

3	Singh, S.N., “Electric Power Generation, Transmission and Distribution”, Prentice Hall of India, 2nd Edition,	2010
4	Mullin Ray C., “Electrical Wiring Residential”, Delmar Publishers Inc., 11th edition,	1993
5	Electrical Engineering Fundamentals by Vincent Del Toro, PHI, 2nd Edition,	2003
6	Das Kamalesh, “Electrical Power Systems for Industrial Plants”, JAICO Publishing House,	2011
7	Jelley N., Andrews John, “ Energy Sciences – Principles, Technologies, and Impacts”, Oxford University Press,	2011

Orientation Course (OR1101) of 2 credits includes Introduction to Discipline Engineering of 1 credit – 14 hours

Course Name	**:**	**Introduction to Electronics & Communication Engineering**
Course Code	**:**	
Credits	**:**	**1**
LTP	**:**	**1-0-0**

Course Objective:
To familiarize the students with the evolution and basics of electronics and communication engineering. To introduce the various fields of electronics and communication engineering and their applications.

Total Number of Lecture:14

	Syllabus	**Number of Lecture**
1	**Introduction to Semiconductor Devices, Analog/Digital Electronics, Embedded Systems, VLSI design, Communication Systems (Analog and Digital), Microwave Engineering and Antennas, Wireless Communication, Optical Communication, Satellite Communication, and applications.**	14

Course Outcomes: By the end of the course the students will be able to

1. Describe the evolution of electronics and communication engineering.
2. Explain the various fields of electronics and communication engineering.
3. List the diverse applications of electronics and communication.

SuggestedBooks:

Sr. No.	**Name of Book/Authors/Publisher**	**Yearof Publication/ Reprint**
1	Electronics Devices & Circuit Theory, RL Boylestead& L Nashelsky (PHI)	2009
2	Digital principles & applications, Malvino Leach, TMH	2011
3	Electronic Communication Systems, R.Blake, Cengage Learning	2002
4	Embedded Systems, Raj Kamal, TMH.	
5	Microwave devices and Radar Engineering (3rd Edition) by Kulkarni, Umesh publications	2003
6	Electronic Communication Systems by G. Kennedy And B. Davis, Mc Graw Hill, 4th Edition	2006

Orientation Course (OR1101) of 2 credits includes Introduction to Discipline Engineering of 1 credit – 14 hours

Course Name	**:**	**Introduction to Mechanical Engineering**
Course Code	**:**	**OR1101**
Credits	**:**	**1**
L T P	**:**	**1-0-0**

Course Objectives:

1	To familiarize student with the basics of Mechanical Engineering.
2	To introduce basic machine elements.
3	To familiarize with basic manufacturing processes.
4	To familiarize with the sources of energy and power generation.
5	To familiarize with the thermal systems like heat engines, refrigeration and air conditionings.

Lecture wise break up		**No. of Lectures**
1	**INTRODUCTION:** History, Role, and Scope of Mechanical Engineer.	(1)
2	**MECHANICAL PROPERTIES OF MATERIALS** :Materials classification, Ferrous/non ferrous, Alloys e.g. Brass, mechanical properties, stress-strain curves	(1)
3	**MACHINE ELEMENTS**: Classification and types of Springs, Shaft, Bearing, Flywheel, Gears and their applications.	(1)
4	**METROLOGY AND MEASUREMENTS**: Limits, Fits,, Tolerances, Gauges:their classifications and applications.	(1)
5	**BASICS OF MANUFACTURING PROCESSES**: Machine Tools e.g. Lathe machine, work/tool holding devices vice, chuck, Classification and applications of machining, Welding, Casting, and Forming.	(2)
6	**BASICS OF POWER PLANT ENGINEERING**: Thermal /Nuclear/ Hydraulics their main Parts with schematic diagram. Power generation in India	(2)
7	**RENEWABLE ENERGY SOURCES** : Solar Energy and its application in deferent fields ,Wind, Bio Mass, Geothermal and Ocean energy	(2)
8	**REFRIGERATION & AIR-CONDITIONING SYSTEMS**: Working Of Window ,Split Air Conditioning Systems, Working Of Domestic Refrigerators	(1)
9	**INTERNAL COMBUSTION ENGINES**: Basics of two strokes, four strokes, Petrol & Diesel Engines. Their salient features, differences between two.	(2)
10	**LATEST DEVELOPMENTS IN MECHANICAL ENGINEERING**: Micro-fluidics, Electric vehicle, Hydrogen energy	(1)

Text Book:

1	An Introduction to Mechanical Engineering by Jonathan Wickert and Kemper Lewis, 3rd edition, Cengage Learning

Reference Books:

1	Materials and Processes in Manufacturing and Management-a new perspective, Mc Graw Hil,Inc.1994.
2	Power Plant Engineering by P. K. Nag. Pub: Tata Mc Graw Hill
3	Applied Thermodynamics by R. Yadav

Course Outcomes:

1	Student will be able to clear the basic concept of Mechanical Engineering.
2	Student will be able to realize the importance of thermal systems and manufacturing.
3	Student will be able to come up with the innovative conceptual idea about sources of energy.
4	Student will get at glance knowledge regarding overall aspects and trends in mechanical engineering.

Orientation Course (OR1101) of 2 credits includes Introduction to Discipline Engineering of 1 credit – 14 hours

Course Name	**:**	**Introduction to Metallurgical & Materials Engineering**
Course Code	**:**	
Credits	**:**	**1**
LTP	**:**	**1-0-0**

Course Objectives:

At the end of this course, student will be able to:

1. Understand and classify the sub branches and domains of Materials & Metallurgical Engineering stream.
2. The possible opportunities in the domains of Materials & Metallurgical Engineering.
3. Understand all basic principles involved in the theory of Elasticity and Plasticity.

Total No. of Lectures– 14

Lecture wise breakup		**Number of Lectures**
1	**History and Evolution** Definition, concept, scope and nature of materials and metallurgy industries associated to metallurgical engineering and allied fields, opportunities in metallurgical and materials engineering	2
2	**Basics of Material Development** Principles of production of ferrous and non-ferrous metals; overview of alloy making and Units involved in such process.	3
3	**Overview of Materials Processing Technologies** Principle and overview of heat treatment industry, metal casting units, material joining technology etc.	3
4	**Basics of Materials Selection** Basics and principles involved in material selection for special applications like high temperature exposure, nuclear reactor materials ;corrosion resistant materials etc	3
5	**Special and New Materials** Introduction to newer materials such as smart materials, biomaterials and their applications.	3

Course Outcomes:

Student will be able to:

1. The student will be able to understand and create the areas and domains in Metallurgical & Materials Engineering on the basis of his/her interest and opportunity available in present industrial scenario.
2. The student will be able to understand the basic principles of selection of materials and challenges to entrepreneurs in metallurgy

Suggested Books

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Introduction to Physical Metallurgy/ S.H.Avner/ McGrawHill/	2017
2	Materials Science and Engineering/ V.Raghavan/ PrenticeHall,NewDelhi	2015
3	Fundamentals of Materials Science and Engineering/WDCallisterJr./ JohnWileyandsons/ 9thEdition.	2014
4.	Principle of Blas Furnace (Iron making)/ AK Biswas/ Cootha	2003

Orientation Course (OR1101) of 2 credits includes Introduction to Discipline Engineering of 1 credit – 14 hours

Course Name	**:**	**Introduction to Production and Industrial Engineering**
Course Code	**:**	
Credits	**:**	**1-0-0**

Total no. of lectures: 14

Course Objectives:
To acquaint the students with evolution, scope and basics of Production and Industrial Engineering

	Syllabus	**Hrs**
(1)	HISTORY AND EVOLUTION: Definition, concept and scope of Production and Industrial Engineering, evolution of Production and Industrial Engineering.	2
(2)	Concept of: Digital and Smart Manufacturing, Industrial Internet of things and basic concepts of Industry 4.0	2
(3)	Concept of manufacturing systems, design of manufacturing systems, operations and management of manufacturing systems.	2
(4)	INTRODUCTION TO PRODUCTION ENGINEERING: Principles of good product design, tolerances and product life cycle, Machining, Metal casting, Metal forming, Joining and welding processes	2
(5)	INTRODUCTION TO INDUSTRIAL ENGINEERING: Product economy and production system, Concept of quality and cost, Logistics, Production planning and inventory control, Operations research, Quality control.	2
(6)	INTELLECTUALPROPERTY RIGHTS: Concept, scope and challenges	2
(7)	FUTURE TRENDS IN PRODUCTION AND INDUSTRIAL ENGINEERING: New developments, Applications and Case studies.	2

Course Outcomes:	
1	Students will be able to relate the evolution of Production & Industrial Engineering to societal and other needs.
2	Students will be able to identify the basic processes and applications of Production & Industrial Engineering.

REFERENCE BOOKS:

S. No.	**Title, Author, Edition and Publisher**	**Year / Reprint**
(1)	Manufacturing Engineering & Technology, Kalpakjian and Shmid (Pearson Publications), 7th Edition	2013
(2)	Materials and Processes In Manufacturing, DeGarmo, , John Wiley & Sons	2011
(3)	W.C. Introduction to Industrial and Systems Engineering, Turner, Prentice Hall,	1992
(4)	Introduction to Basic Manufacturing, CS Jawalkar, Narosa Publishers	2016

Course Name	**:**	**Calculus and Ordinary Differential Equations**
Course Code	**:**	**MA1101 (Common to all branches)**
Credits	**:**	**4**
L T P	**:**	**3-1-0**
Total No. of Lectures	**:**	**42**

Course Objectives:
At the end of the semester, the students should be able to

1	understand the behavior of infinite series and their use.
2	learn the concepts related to differential calculus of functions of several variables and their applications.
3	learn the concept and methods of evaluating multiple integrals and their applications to various problems.
4	learn the methods to solve ordinary differential equations of various types.

	Lecture wise breakup	**No. of Lectures**
1	**INFINITE SERIES** Infinite series and convergence, alternating series, power series and convergence. Taylor's and Maclaurin's Series. (Scope as in Chapter 8, Sections 8.1, 8.3 – 8.9 of Text Book1).	8
2	**DIFFERENTIAL CALCULUS** Limit, Continuity and Partial Derivatives; Euler's Theoem for Homogeneous functions; Differentiability, Linearization and Differentials; Chain rule; Extreme values and Saddle Points; Lagrange multipliers; Taylor's Formula**. (**Scope as in Chapter 12, Sections 12.1 – 12.6, 12.8 – 12.10 of Text Book 1).	12
3	**INTEGRAL CALCULUS** Cylinders and Quadric surfaces, Double integrals in Rectangular and Polar form, Triple integrals in Rectangular, Cylindrical and Spherical Coordinates, Substitutions in Multiple integrals. Applications to practical problems. (Scope as in Chapter10, Sections10.6 and 10.7 and Chapter 13, Sections 13.1, 13.3, 13.4,13.6 and 13.7 of Text Book 1).	10
4	**ORDINARY DIFFERENTIAL EQUATIONS** First order exact differential equations, Integrating factor, Orthogonal trajectories, Second and Higher order Linear Differential Equations with constant coefficients, Differential Operators, Methods of Variation of Parameters and Undetermined Coefficients, Euler Cauchy Equation, Wronskian. (Scope as in Chapter 1, Section 1.5, 1.8 Chapter 2, 2.1-2.4, 2.6, 2.9-2.10, 2.13- 2.15 of Text Book 2).	12

Course Outcomes:
At the end of the semester, the students are able to

1	test the behavior of infinite series.
2	Apply the concepts of differential calculus of functions of several variables.
3	evaluate multiple integrals and apply them to practical problems.
4	solve ordinary differential equations of various types

Text Books:

1	Calculus and Analytic Geometry, Thomas and Finney, 9th edition, Pearson Education Asia.	2006
2	Advanced Engineering Mathematics, Kreyszig, 8th edition, John Wiley and Sons.	2005

Reference Books:

1	Differential Equations, Frank Ayers, SI edition, Mc Graw Hill.	1972
2	Advanced Engineering Mathematics, Wylie and Barrett, 6th edition, Mc Graw Hill.	2003

Course Name	**:**	**Linear Algebra, Vector Calculus and Partial Differential Equations**
Course Code	**:**	**MA1201 (For Aero, ECE, Mech and student-specific for Civil)**
Credits	**:**	**4**
L T P	**:**	**3-1-0**
Total No. of Lectures	**:**	**42**

Course Objectives:

At the end of the semester, the students should be able to

1	learn the various concepts associated with real vector spaces and theory of matrices
2	learn the various concepts of vector calculus and their applications to problems.
3	formulate and solve linear and nonlinear partial differential equations and apply to engineering problems.

S.No	**Lecture wise breakup**	**No. of Lectures**
1	**ALGEBRA** Vector spaces over reals, Linear dependence, Basis, Dimension, Co-ordinates with respect to a basis, Change of basis, Subspace, Linear transformation $R^n \rightarrow R^m$, Range space and Rank, Null space and Nullity, Rank and Nullity relation, Matrix representation of a linear transformation, Similar matrices, Invertible linear transformation, Eigenvalues and eigenvectors, Cayley Hamilton theorem, Diagonalization of a matrix.	16
2	**VECTOR CALCULUS** Gradient, Divergence and Curl – their physical interpretation, Line, Surface and Volume integrals, Green's theorem in the plane, Stoke's theorem, Divergence theorem, Applications to Science and Engineering.	14
3	**PARTIAL DIFFERENTIAL EQUATIONS** Formation and solution of first order partial differential equations, Linear equations of higher order with constant coefficients, Applications to Engineering problems**.**	12

Course Outcomes:

At the end of the semester, the students are able to

1	solve the various problems related to real vector spaces and theory of matrices
2	apply various concepts of vector calculus to problems.
3	formulate and solve linear and nonlinear partial differential equations and apply to engineering problems.

Text Books:

1	Introductory Linear Algebra with Applications, Kolman, B. and Hill,D.R.,7th editiom, Pearson Education	2001
2	E. Kreyszig, Advanced Engineering Mathematics, Eighth Edition, John Wiley.	2005

Reference Books:

1	Elements of Partial differential equations, Sneddon, Mc Graw Hill.	1957
2	Advanced Engineering Mathematics, Wylie and Barrett, 6th edition, Mc Graw Hill.	2003

Course Name	**:**	**Probability and Statistics**
Course Code	**:**	**MA1301 (For CSE, Electrical, Metta, Prod and student-specific for Civil)**
Credits	**:**	**4**
L T P	**:**	**3-1-0**
Total No. of Lectures	**:**	**42**

Course Objectives:
At the end of the semester, the students should be able to

1	understand the concepts of random variable and probability distribution.
2	learn the concepts of some theoretical probability distributions .
3	understand the concept of sampling distribution and be able to construct and interpret confidence interval estimates for the mean , proportion , difference of mean and proportion
4	learn to use various tests of hypotheses

	Lecture wise breakup	**No. of Lectures**
1	**RANDOM VARIABLES** Random variables, Discrete, Continuous and Joint Probability distributions, Marginal and Conditional distributions, Independent random variables, Expectation, Variance and Covariance, Means and variances of linear combinations of random variables, Chebyshev's inequality	10
2	**PROBABILITY DISTRIBUTIONS** Binomial, Poisson, Uniform and Normal distributions, Normal and Poisson approximations to Binomial, Moments, Moment generating function.	10
3	**SAMPLING DISTRIBUTIONS** Population, Sample, Sampling distributions, Central limit theorem, Distribution of sample mean, Difference of means, Proportions and difference of proportions, Chi-square distribution, Student's t-distribution.	7
4	**ESTIMATION** Estimation of parameters, Point estimate, Confidence interval for mean, difference of means and proportions.	6
5	**TESTS OF HYPOTHESES** Hypothesis, Test statistic, Critical region, Significance level, Single Sample and Two Samples Tests for mean and proportion.	9

Course Outcomes:
At the end of the semester, the students are able to

1	understand the concepts of random variable and probability distribution.
2	apply the concepts of some theoretical probability distributions .
3	use the concept of sampling distribution and apply tests of significance to practical problems of engineering

4	apply various tests of hypotheses

Text Books:

1	Probability and statistics for Engineers and Scientists, Walpole, Myers, Myers and Ye, 7th edition, Pearson Education	2006

Reference Books:

1	Miller and Freund's: Prabability and Statistics for Engineers, Richard A. Johnson, C.B. Gupta, Pearson Education.	2006
2	John E. Freund's: Mathematical statistics with Application, Miller and Miller, Pearson Education.	2004

Course Name	**:**	**Mechanics and Optics**
Course Code	**:**	**PY1101 (For Mechanical, Production, Civil and Aero)**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
1. To inculcate the application of mechanics concepts in engineering.
2. To familiarize students with statics, kinematics and kinetics of rigid body.
3. To familiarize the students withlasers,optical fibers, ultrasonics and their applications.
4. To make the students able to understand the basic concepts ofnanotechnology and its applications.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**STATICS:** Free body diagrams, analysis of system of forces, Equation of equilibrium in space and its applications, Center of gravity, Centroid, mass, area and Polar moment of inertia of simple and compound bodies	6
2	**DYNAMICS:** Kinematics of a Particle, Introduction, Motion of a projectile. Kinetics of a particle: Force and acceleration, Work and energy, Impulse and momentum.	4
3	**PLANAR KINEMATICS OF A RIGID BODY:** Rigid-Body motion,Translation, Rotation about a fixed axis, Absolutegeneral Plane Motion analysis. Relative-MotionAnalysis: Velocity, Instantaneous center of zero velocity, Acceleration, Relative-Motion analysis using Rotating axes.	4
4	**PLANAR KINETICS OF A RIGID BODY:** Momentof Inertia. Planar Kinetic equations ofmotion. Equations of motion: Translation, Rotation about a fixed axisand General Plane motion. Kinetic Energy, Work of a Force, Work of a Couple, Principle of Work and Energy, Conservation of Energy, Linear and Angular Momentum, Principle of Impulse and Momentum, Conservation of Momentum, Eccentric Impact.	12
5	**LASERS, OPTICAL FIBRES ANDULTRASONICS:** Basics of Interference, Diffraction and Polarization, Laser and its characteristics, He-Ne laser, ruby laser, semiconductor lasers, Applications of Lasers, Optical fibres; Numerical aperture, Classification of optical fibres, fibre Losses, fibre manufacturing, Applications of optical fibres. Production of ultrasonics, detection and uses of ultrasonic, reverberation.	12
6	**NANOTECHNOLOGY:** Introduction, Length Scale, Size dependence, Synthesis of Nanoparticles: Mechanical Method,Sol-gel Technique, Physical Vapour Deposition, Chemical Vapour Deposition, Applications of Nanotechnology	4

List of Experiments		**No.of Turns**
1	Familiarization of students with basic instruments Vernier Calipers, Screw Gauge and Spectrometer.	1
2	To find the wavelength of sodium light using Fresnel's biprism.	1
3	(i) To determine the wavelength of He-Ne laser using transmissiongrating. (ii) To determine the slit width using the diffraction pattern.	1
4	To determine the wave length of sodium light by Newton's rings method.	1
5	To determine the wave length of sodium light using a diffraction grating.	1
6	To find the specific rotation of sugar solution using a Bi-quartz Polarimeter.	
7	(i)To determine the angle of acceptance and numerical aperture of given fibre optical cable. (ii) To determine the losses in optical fibre in dB due to micro bending of fibre.	1
8	To determine the Moment of Inertia of a Flywheel.	1
9	To determine the range of projectile as a function of angle of inclination and initial velocity.	1
10	To determine the velocity of ultrasonic waves in a given liquid.	1
11	To determine the restoring force per unit extension of a spiral spring by a statistical and dynamic method and also to determine the mass of the spring.	1
12	To measure the centripetal force, F_c, and compare to $F_c = mv^2/r = m\omega^2 r$.	1
13	To study conservation of energy and momentum in collision.	1

Course Outcomes: By the end of the course	
1	Students will be able to understand and applythe concepts of mechanics, types of motions and characteristics of a rigid body.
2	Students will develop capability to tackle the numerical problems in general and in the various areas covered in the course.
3	Students will learn about lasers and fibre optics, which have important applications for societal needs.

Suggested Books:	
Sr. No.	**Name of Book/ Authors/ Publisher/Edition**
1	Engineering Mechanics, Statics and Dynamics, R.C. Hibbeler, Pearson (12th Edition).
2	Dynamics, Merriam and Kraige, Wiley and Sons (5th Edition).
3	Dynamics F.P. Beer et al., McGraw Hill (8th Edition).
4	Optics, Ajoy Ghatak, McGraw-Hill (3rd Edition).

Course Name	**:**	**Electromagnetic Theory and Quantum Physics**
Course Code	**:**	**PY1201 (For CSE, ECE, Electrical)**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

1. To familiarize the students with the concepts of electrostatics and boundary value problems.
2. To make the students able to understand the magnetostatics and their boundary value problems.
3. To make the students able to understand and apply the concepts of electromagnetic wave propagation.
4. To familiarize the students with the concepts and principles of Quantum Mechanics.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**VECTORS, FIELDS AND ELECTROSTATICS:** Cartesian coordinate System, Cylindrical and Spherical coordinate Systems, Gradient, Divergence of a Vector and Divergence Theorem, Curl of a vector and Stoke's theorem, Gauss's law & its applications, Maxwell's 1st eqn. (Electrostatics), Electric Energy and potential, Potential gradient, the dipole fields, Energy density in an electrostatic field. Current and current density, Continuity of current, Metallic conductors, Dielectric materials, Electrostatic boundary-value problems, Laplace's and Poisson's equations.	12
2	**MAGNETOSTATICS:** Biot-Savart's law, Ampere's circuital law, Magnetic flux and magnetic flux density, Scalar and vector magnetic potentials. Magnetic dipole, Force due to Magnetic field on a differential current element, force between two differential current elements, Force and torque on a closed circuit, magnetic materials, Magnetic boundary conditions, Inductors and inductances,	10
3	**MAXWELL'S EQUATIONS AND ELECTROMAGNETIC WAVE PROPAGATION:** Faraday's law, Displacement current, Maxwell's equations in point form, Maxwell's equations in integral form, EM waves in general, EM wave propagation in Lossy Dielectrics, Wave propagation in lossless dielectrics, Plane waves in free space, Plane waves in Good conductors, Power & Poynting Vector, Reflection of a plane wave at normal incidence.	10
4	**QUANTUM PHYSICS:** Need of Quantum theory, Photoelectric effect, The Compton effect; matter waves, group and phase velocities; Uncertainty principle and its application; time independent and time dependent Schrödinger wave equation; Eigen values and Eigen functions, Born's interpretation and normalization of wave function, applications of Schrödinger wave equation for particle in one dimensional infinite potential well. Introduction to nanoscience	10

List of Experiments:		**Number of Turns**
1	Familiarization of students with basic instruments Vernier Calipers, Screw Gauge and Spectrometer.	1
2	To study dielectric constant and Curie temperature of Ferroelectric ceramic BaTiO3.	1
3	To study the ratio of electron charge to mass ratio in uniform magnetic field.	1
4	To determine coercivity of magnetic material using hysteresis loop tracer.	1
5	To study the Hall effect and to determine Hall Voltage (V_H) and Hall coefficient (R_H)	1
6	To determine the energy band gap of semiconductor (Ge) using Four Probe Method.	1
7	To design a method to draw equipotential lines with various geometries of electrodes kept at different potentials.	1
8	To study the variation of magnetic field with distance along the axis of current carrying circular coil using Stewart and Gee's apparatus.	1
9	To plot I-V Characteristics of Solar cell.	1
10	To determine magnetic susceptibility of paramagnetic sample using Quink's tube method.	1
11	To determine the flashing and Quenching Potential of neon/Argon and also to find the capacitance of unknown capacitor.	1

Course Outcomes:By the end of the course	
1	Students will be equipped with the tools of electromagnetic theory.
2	Students will be able to solve numerical problems based on electrostatics, magnetostatics, electromagnetic wave propagation.
3	Students will be able tounderstand and apply the basic concepts of Quantum Mechanics.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Yearof Publication/ Reprint**
1	Engineering Electromagnetics, William H Hyat, Jr., and John A. Buck, Tata McGraw Hill	2013 / 5th edition
2	Elements of Engineering Electromagnetics, Matthew N.O. Sadiku, Oxford University Press	2012 / 4th edition
3	Concepts of Modern Physics, Arthur Beiser, McGraw Hill Education (India) Pvt. Ltd., New Delhi.	2013
4	Modern Physics, J. Bernstein, P.M. Fishbane and S.G. Gasiorowicz, Pearson, Education India Pvt. Ltd., New Delhi	2009

Course Name	**:**	**Condensed Matter Physics**
Course Code	**:**	**PY1301 (For Metallurgical Engineering)**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:	
1	To familiarize the students with basic concepts of the condensed phase of matter especially solids.
2	Tomake the students able to understand the crystal structure, lattice vibrations, electronic properties, dielectric and the magnetic properties etc. in relation to engineering applications.
3	To familiarize students with the concept of Density Functional Theory.
4	To make the students able to understand the basics concepts of superconductivity, nanoscience and theirapplications.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Basic concept of electrons and phonons:** Space lattice, crystal structures (cubic and hexagonal cells). Lattice vibrations: Introduction of Phonons, Vibrations of one dimensional monoatomic and diatomic lattices, Momentum of Phonons.	(5)
2	**Basic of Free Electron Theory**; Classical and Quantum Theory of free electrons,Fermi-Dirac Distribution Function, Density of States, Motion in magnetic field (Hall effect), Electron in a Periodic Potential (Kronig Penney Model), Energy versus wave vector, Energy bands in solids.	(10)
3	**Basic of electronic interactions, Dynamics and Responses:** Electron dynamics in crystals, Schrodinger Equation, Born Oppenheimer Approximation, HartreeFock Approximation, Hohenberg and Kohn formulation of DFT, Kohn Sham formulation of DFT, Applications of Density Functional Theory.	(7)
4	**Dielectrics and Magnetism:** Fundamental of dielectrics, active and passive dielectrics, various polarization mechanisms, Frequency and temperature dependence on polarization of dielectrics, Internal field, Dielectric Loss Tangent, Dielectric Breakdown. Fundamentals of Magnetism, Classification of magnetic materials, ferromagnetic domains, hysteresis, antiferromagnetism.	(8)
5	**Optical Phenomena and Superconductivity**: Basic concept, Electronic transitions and optical properties of metals and non-metals, Optical phenomena: luminescence, lasers, thermal emission, photo-conductivity (only Definitions). Superconductivity: Introduction, Effect of Magnetic field, Effect of current, Type1 and Type II superconductors, Thermal properties, Isotope effect, London Equations, Qualitative idea of BCS theory, Applications of superconductivity.	(8)
6	**Nanoscience:** Introduction, Length Scale, Size dependence of properties: Surface energy, Electronic structure, Reactivity, Optical Properties, Melting Point, Nanoclusters, Nanocomposite, Fullerenes, Carbon Nanotubes and Graphene.	(4)

S.No.	**List of Experiments**	**Number of Turns**
1	Familiarization of basic instruments Vernier Calipers, Screw Gauge and Spectrometer.	1
2	To study dielectric constant and Curie temperature of Ferroelectric ceramic BaTiO3.	1
3	To study the ratio of electron charge to mass ratio in uniform magnetic field.	1
4	To determine coercivity of magnetic material using hysteresis loop tracer.	1
5	To study the Hall effect and to determine Hall Voltage (V_H) and Hall coefficient (R_H)	1
6	To determine the energy band gap of semiconductor (Ge) using Four Probe Method.	1
7	To study the variation of magnetic field with distance along the axis of current carrying circular coil using Stewart and Gee's apparatus.	1

8	To Plot I-V Characteristics of Solar cell.	1
9	(i) To determine the wavelength of He-Ne laser using transmission grating. (ii) To determine the slit width using the diffraction pattern.	1
10	To determine magnetic susceptibility of paramagnetic sample using Quink's tube method.	1
11	To determine the flashing and Quenching Potential of neon/Argon and also to find the capacitance of unknown capacitor.	1

Course Outcomes: By the end of the course	
1	Students will be able to understand the physics behind structural properties of the solids.
2	Students will be able to develop their capability to tackle problems in general and in various areas covered in the condensed matter physics.
3	Students will be aware of latest developments in certain areas of condensed matter physics, which have important applications for societal needs.

Suggested Books:	
Sr. No	**Name of Book/ Authors/ Publisher**
1	Introduction to Solid State Physics, Charles Kittel, Wiley India Pvt. Ltd., New Delhi (8^{th} Edition)
2	Solid State Physics, S.O. Pillai, New Age International, Pvt. Ltd., New Delhi (5^{th} Edition)
3	Solid State Physics, M. A. Wahab, Narosa Publishing House, Pvt. Ltd. New Delhi (3^{rd} Edition).
4.	Fundamentals of Condensed Matter Physics, Marvin L. Cohen and Steven G. Louie, Cambridge University Press (June 2017).
5.	Solid State Physics R.K. Puri, V.K. Babbar, S. Chand & Company, Pvt. Ltd. New Delhi (3^{rd} Edition).
6.	Density Functional Theory: A Practical Introduction, David S. Sholl Janice A. Steckel, John Wiley &Sons, Inc., Hoboken, New Jersey.

Course Name	**:**	**Applied Chemistry I**
Course Code	**:**	**CH1101 (For Electrical, ECE and CSE)**
Credits	**:**	**4**
L T P	**:**	**3 -0-2**

Total No. of Lecture-42

Objective: To teach the fundamentals and application of chemical sciences essential for the development of electrical and electronic materials and technologies. Students will be learning various analytical techniques for the characterizations of electronic organic/inorganic materials.

Lecture wise breakup	***No. of Lectures = 42***

1	**Fundamentals for Applied Chemistry** Molecular orbital theory, Jahn-Teller Effect in Crystal Field Theory, Solid state chemistry: Crystal defects and line imperfections, Reaction mechanism in organic chemistry: Principles and methods of determination, Chemical Kinetics: Langmuir–Hinselwood Mechanism, acid-base equilibria in non aqueous media, Introduction to Computational chemistry and open source softwares	**(10)**
3	**Polymeric Materials** Mechanism and methods of polymerization, structure-activity relationship, Conducting Polymers: types (n- or p- doping) and applications, Polymeric fibre materials	**(6)**
4	**Energy Storage and Sensing Devices:** Fundamentals of Electrochemistry, types of electrodes, Reference electrodes, Ion-selective electrodes, Fuel cells, Batteries (Lithium-ion Batteries and EV Batteries), Renewable energy (Artificial photosynthesis), Solar cells, Sensors for IoT	**(8)**
5	**Spectroscopic Methods for structural Analysis:** Principle and applications (UV, IR, NMR, SEM and TEM)	**(9)**
6	**Chemistry of Electronic and Electrical Materials** Semi-conductor and super conducting Materials, Carbon materials, Optical Materials (OLED), 2D Materials, Magnetic materials.	**(9)**

Practicals	
Sr. No.	**Name of Experiment**
1.	Synthesis of metal-complex and determination of melting point
2.	Implementation of IR technique for the analysis of metal-complex synthesized
3.	Preparation of Metal-oxide by sol gel and hydrothermal method
4.	Characterization of metal–oxide using SEM technique by structural determination
5	Synthesis of an organic compound and chemicals analysis.
6	Structural analysis of organic compound by NMR technique.
7	Synthesis of polymer material and its analysis.
8	Application of UV spectroscopy for polymer functional group analysis
9	Investigation of redox chemistry of an inorganic material by Cyclic Voltammeter.
10	Application of open source software for chemical analysis and drug design.

Outcomes: 1. To be able to apply the fundamentals of chemistry towards developing new Technologies based on new materials.

2. To attain the essential analytical skills and designing of materials for electrical and electronic applications.

3. Application of softwares as important tools in technological applications.

Books:

1. Concise Inorganic Chemistry, by J. D. Lee, 5th Edition, 2003 (Chapman & Hall).
2. Organic Chemistry by S. M. Mukherji, and S. P. Singh, 2017 (Newagepublishers).
3. Principles of Physical Chemistry by Puri, Sharma and Pathania, 2008 (W.H. Freeman & Co).
4. Atkin's Physical Chemistry by Peter Atkins, Julio de Paula, 7th Edition (Oxford University Press).
5. Principle of Polymerization by G. Odian, 4th Edition, (John Wiley & Sons, Inc.).
6. D. S. Pavia, G.M. Lasmpman and G.S. Kriz: Introduction to Spectroscopy, 4th Edition, (Thomson learning, Indian Edition).
7. Computational chemistry: Introduction to theory and applications of molecular and quantum mechanics: Lewars Errol G. (Springer)
8. NPTEL web lectures: Chemistry of Materials, Engineering Chemistry I & III.

Course Name	**:**	**Applied Chemistry II**
Course Code	**:**	**CH1201 (For Mech., Prod., Metta, Aero. And Civil)**
Credits	**:**	**4**
L T P	**:**	**3 -0-2**

Total No. of Lecture-42

Objective: To teach the fundamentals and application of chemical sciences essential for the development of engineering materials and processing technologies. Students will be learning various analytical techniques for the characterizations of composites and hybrid materials.

Lecture wise breakup	***No. of Lectures = 42***

1	**Fundamentals for Applied Chemistry** Molecular orbital theory, Jahn-Teller Effect in Crystal Field Theory, Solid state chemistry: Crystal defects and line imperfections , Reaction mechanism in organic chemistry: Principles and methods of determination, Chemical Kinetics: Langmuir –Hinselwood Mechanism, Acid -base equilibria in non aqueous media	**(8)**
2	**Polymer Chemistry** Mechanism and methods of polymerization, Structure-Activity relationship, High performance polymers and applications, Natural and synthetic fibres, biodegradable polymers	**(5)**
3	**Fuels and Catalysis** Petroleum processing**,** Solid and liquid Fuels for Propellents, Chemistry of combustion and equations, Catalytic convertors	**(5)**
4	**Electrochemistry and Corrosion:** Introduction to Electrochemistry, Fuel cells, Batteries (Lithium-ion Batteries and EV Batteries), Corrosion control and protective coatings	**(7)**
5	**Spectroscopic Methods for strucutral analysis:** Principle and Applications (UV, IR, NMR, AAS/ICP-AES, SEM, TEM, XRD)	**(10)**
6	**Chemistry of Metal based and Composite Materials** Ceramic and Cement Materials, Metals and Alloys ,Phase change materials, Bio-inspired materials, Composite materials, Smart materials	**(7)**

Practicals	
Sr. No.	**Name of Experiment**
1.	Synthesis of metal-complex and determination of melting point
2.	Implementation of IR technique for the analysis of metal-complex synthesized
3.	Preparation of Metal-oxide by sol gel and hydrothermal method
4.	Characterization of metal–oxide using SEM technique by structural determination
5	Synthesis of an organic compound and chemicals analysis.
6	Structural analysis of organic compound by NMR technique.
7	Synthesis of polymer material and its analysis.
8	Application of UV spectroscopy for polymer functional group analysis
9	Investigation of redox chemistry of an inorganic material by Cyclic Voltammeter.
10	Application of open source software for chemical analysis and drug design.

Outcomes:

1. To be able to apply the fundamentals of chemistry towards emerging materials to benefit the societal needs.
2. To attain the essential analytical skills and designing of materials for various applications.
3. To be able to identify the chemical compositions required for designing of high performance materials.

Books:

1. Concise Inorganic Chemistry, by J. D. Lee, 5th Edition, 2003 (Chapman & Hall).
2. Organic Chemistry by S. M. Mukherji, and S. P. Singh, 2017 (Newagepublishers).
3. Principles of Physical Chemistry by Puri, Sharma and Pathania, 2008 (W.H. Freeman & Co).
4. Atkin's Physical Chemistry by Peter Atkins, Julio de Paula, 7th Edition (Oxford University Press).
5. Principle of Polymerization by G. Odian, 4th Edition, (John Wiley & Sons, Inc.).
6. D. S. Pavia, G.M. Lasmpman and G.S. Kriz: Introduction to Spectroscopy, 4th Edition, (Thomson learning, Indian Edition).
7. NPTEL web lectures: Chemistry of Materials, Engineering Chemistry I & III.

Course Name	**:**	**Introduction to Environmental Sciences-I**
Course Code	**:**	**GS 1101 (Common to all branches)**
Credits	**:**	**2**
L T P	**:**	**2 0 0**

Total No. of Lectures – 28

Course Objectives:
1. This course aims to acquaint students with the basics of Environmental Sciences.
2. To make them understand the importance of Environmental Sciences.

Lectures with breakup **No. of Lectures**

S. No.	**Unit wise breakup**	**No. of Lectures**
1	Introduction to environmental studies: Multidisciplinary nature of environmental studies; Scope and importance; Concept of sustainability and sustainable development.	4
2	Ecosystems: What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession. Case studies of the following ecosystems :a)Forest ecosystem b) Grassland ecosystem c)Desert ecosystem d)Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)	8
3	Natural Resources: Renewable and Non-Renewable Resources: Land resources and Landuse change; Land degradation, soil erosion and desertification. Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations. Water: Use and over--exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter--state).Energy resources: Renewable and non-renewable energy sources, use of alternate energy sources, growing energy needs, case studies.	8
4	Environmental Pollution: Environmental pollution: types, causes, effects and controls; Air, water, soil and noise pollution. Nuclear hazards and human health risks. Solid waste management: Control measures of urban and industrial waste. Pollution case studies.	8

Course Outcomes:
1. Students will be able to relate the importance of Environmental Sciences for sustainable development of society
2. Students will be able to understand the problems and remedies of Environmental Sciences

Text Books:

1	Environmental Science Ceonage Learning Publications, Miller G.T. and Spool Mar
2	Environmental Studies, Tata Mcgraw Hill Pub., Banny Joseph
3	Text book of Environmental Studies for U.G. Courses - University Press – ErachBharucna
4	Environmental Studies – from criteria to cure, Oxford Univ. Press, R. Raogopalan

SUGGESTED BOOKS:

S. No.	**Name of Book/Authors/Publishers**	**Year of Publications/Reprints**
1.	"Building Construction Punmia B.C, Punmia Arun Jain & Ashok Jain, Laxmi Publication (P) Ltd.	2012
2.	"Estimation and costing in Civil Engineering'', B.N Dutta, UBS publisher distributors.	2014
3.	"Engineering Materials", S.C. Rangwala, Charotar Publishing House.	2016
4.	"Building Construction", P.C. Varghese, PHI learning Pvt Ltd.	2014
5.	"Building Construction", Mckay W. Barry, Pearson Publication.	2013

Course Name	**:**	**Introduction to Environmental Science-II (GSC-II)**
Course Code	**:**	**GS1201 (Common to all branches)**
Credits	**:**	**2**
L T P	**:**	**1 0 2**

Total No. of Lectures: 14

Course Objectives: This course aims to attract the attention of students towards understanding the chemistry of pollutants, their analysis and disposal along with introduction to green chemistry for Environment friendly processes and products.

	Contents	Lectures
1.	**Air Pollution:** Introduction, Air pollutants, Photochemical reactions in the atmosphere, Photochemical smog, Health effects and the usual ways to control air pollution	3
2.	**Water Pollution:** Types of Pollution, Contaminants and their sources, measurements and its control	3
3.	**Soil Pollution:** Inorganic and organic contaminants, Pesticides and herbicides, health effects and remedial measures, metal toxicology	3
4.	**Green chemistry for clean Technology:** Goals, Principles and applications	2
5.	**E-waste Management:** Introduction, Environmental impact/ health effects of e-waste exposure, Methods to dispose e-waste	3

Course Outcomes:

1. Students will be able to identify the source of contaminants in Water, Soil and Air and develop the strategies to minimize the levels of pollution
2. Students will understand the applications of green chemistry in mitigating the environmental pollution
3. Hands on training through lab experiments for chemical analysis of various pollutants.

Books:

1. Chemistry for Environmental Engineering and Science, Fifth Edition by Sawyer, McCarty and Parkin (Publisher: McGraw-Hill Education, 2003)
2. Environmental Chemistry, Seventh Edition by A.K. De (Publisher: New Age International (P) Limited, 2017)
3. Environmental Chemistry: Pollution and Remedial Perspectives by A.V. Salker (Publisher: Alpha Science International Limited, 2017)

Practicals	
Sr. No.	**Name of Experiment**
1.	Determination of total dissolved solid (TDS) by conductivity measurement
2.	Measurement of acid-base equilibria by pH meter in water/soil sample.
3.	Measurement of dissolved oxygen in given waste water sample
4.	Determination of organic pollutants (pesticides) in water/soil sample by extraction and IR analysis
5	Measurement of alkalinity and hardness in a given sample of water
6	Measurement of biological oxygen demand (BOD) in given sample of water
7	Measurement of chemical oxygen demand (COD) in given sample of water
8	Measurement of oil and greases in waste water by gravimetric analysis
9	Detection of heavy metal by complexation and UV-Visible spectrophotometer
10	Removal of toxic metals by chemical adsorption method

Course Name	**:**	**Introduction to Computing**
Course Code	**:**	**ES1101 (Common to all branches)**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objective:
To develop logical skills so that students should be able to solve basic programming problems. To use programming knowledge to develop small projects including basic GUI design

Total No. of Lectures: 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION TO PROGRAMMING** Evolution of languages: Machine languages, Assembly languages, High-level languages. Software requirements for programming: System softwares like operating system, compiler, linker, loader; Application softwares like editor. Flowcharts. Algorithm, specification of algorithm. Industrial uses of programming in various domains	**3**
2	**DATA TYPES and OPERATORS AND EXPRESSION** Storing integers, numbers with decimals, characters and strings, typecasting. User input and output, use of command line arguments Operators:arithmetic operators, relational operators, logical operators, bitwise operators, miscellaneous operators. Expressions and their evaluation. Precedence and associativity rules.	**7**
3	**ITERABLE CONTAINERS and STATEMENTS** List, set, tuple and dictionaries; range function; difference between various iterable containers Decision making statements: if, if-else, nested if and if-else. Control statements: for & while loops, nested loops; Role of statements like break, continue	**7**
4	**FUNCTIONS and CLASSES** Advantage of modularizing program into functions, function definition and functioninvocation. Function arguments: default, keyword and positional arguments. Scope and lifetime of a variable. Recurrence relations and Recursion Advantage of using classes, defining class data members & functions and accessing using objects. Constructors and destructors in a class, parameterized constructors	**8**
5	**GUI design** Introduction to tkinter library, use of TK &mainloop methods, use of widgets like Button, Canvas, Checkbutton, Entry, Frame, MenuButton, Listbox, Menu, Scrollbar, Text, Message, Pack, Grid, place etc. for GUI design	**5**
6	**SORTING AND SEARCHING** Searching: Linear search, binary search and hash search. Sorting: Insertion sort, selection sort, bubble sort, quick sort, merge sort, heap sort, and Bucket sort. Time and space complexity of algorithms, comparing algorithms	**9**
7	**Problem Solving** Real-world programming problems	**3**

Total no. of turns: 14

List of Experiments:	
1	Implement programs to input/output various data types
2	Implement programs to use command line arguments
3	Implement programs making use of various operators
4	Implement programs making use of conditional statements and loops
5	Implement programs making use of iterable containers
6	Implement programs making use of functions and recursion
7	Implement programs performing file operations

8	Implement various searching and sorting algorithms
9	Project work including GUI design using tkinter

Course Outcomes: At the end of the course, students will be able to:	
1	Develop understanding ofthe fundamental concepts essential for programming.
2	Make efficient use of iterables, function and classes to programming problems
3	Develop simple GUI applications
4	**Learn to compare algorithms and improve efficiency of algorithms**

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Think Python, How to Think Like a Computer Scientist, Version 2.0.17 Allen Downey Green Tea Press Needham, Massachusetts	2012
2	Python Programming: An Introduction to Computer Science by John M. Zelle, Franklin, Beedle& Associates Inc	2015
3	Core python programming, Dr. R. Nageswara Rao, 2nd edition, Dreamtech press	2018

Course Name	**Engineering Drawing with CAD Software**
Course Code	**ES1201 (Common to all branches)**
Credits	**3**
L TP	**2-0-2**
Total No. Lectures	**28**

Course Objectives:

At the end of this course, the student should be able to understand the basic concepts of Engineering Drawing. The student should be able to visualize and draw the two- and three-dimensional objects. The student should also be able to understand the features associated with operations of the computer-aided design (CAD) software.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	Introduction to Engineering Graphics, Concept of points and lines, System of Projections, Orthographic projections, Dimensioning.	4
2	Introduction to different types of CAD Softwares e.g. SolidWorks/AutoCAD/ CATIA etc., 2D-Sketching, Sketching Entities & Relation, 3D-Sketching, Editing and its Features, Dimensions, Sketch Tools, File handling	7
3	Projections of planes / lamina on reference planes, classification of primary and secondary planes, use of auxiliary planes, Exercises using CAD software	5
4	Classification of solids, Projections of solids on the basis of positions of the axis of various solids on reference planes and Sectioning of solids, Exercises using CAD software	6
5	Introduction to Perspective projection, isometric views, Isometric lines & Axes, conversion of orthographic views to isometric views and vice-versa, Exercises using CAD software	6

List of Experiments:		**Number of Turns**
Exercises to be done using CAD software		
1	2D & 3D Sketching using various sketching tools.	2
2	Projection of planes.	2
3	Developments of 3D-parts.	2
4	Projection of solids.	2
5	Projection of Sectioning of solids.	2
6	Isometric and orthographic views.	2
7	Generating drawings of 3D-parts.	2

Sr. No.	**Course outcome** By the end of this course, the students will be able to:	Knowledge Level (Blooms Level)
1	Understand the basic concepts of Engineering Graphics, drawing standards, conventions and symbols that are in common usage.	**L2**
2	Apply the concepts of engineering drawing to create orthographic projections of points, lines, planes, solids with conventional and CAD software.	**L3 & L6**
3	Visualize the actual objects and convert them in to readable drawings with conventional and CAD software.	**L6**
4	Create new designs/engineering models with conventional and CAD software.	**L6**

CO-PO & PSO Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**

CO1	2	2	2	2	-	-	-	-	-	-	-	1	2	1
CO2	3	2	3	3	3	-	-	-	1	-	-	1	3	2
CO3	3	2	3	3	3	-	-	-	1	-	-	1	3	2
CO4	3	2	3	3	3	-	-	-	1	-	-	1	3	2

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Engineering Drawing, P. S. Gill, S.K. Kataria& Sons.	2012
2	Engineering Drawing, D.A. Jolhe, Tata McGraw Hill	2010
3	Engineering Graphics with SOLIDWORKS, David C. Plan chard, SDC Publications	2020

Course Name	**:**	**Introduction to Mechatronics**
Course Code	**:**	**ES 1301 (Common to all branches)**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Course Objectives:

The objective of the course content is to:
CO1: Impart knowledge and information about product design.
CO2: Development and control of intelligent systems for all aspects of life.

Lecture wise breakup		**No. of Lectures**
1	**Understanding Mechatronics** Mechatronics System, Evolution, Definitions of Mechatronics, Key Elements of Mechatronics, Mechatronics for all Civil, Metallurgical, Aerospace, Chemical, Architecture, Medical, Robotics, Defense, Agriculture, etc., Role of Mechanical, Electrical, Electronics, Computer Engineers in Intelligent Product and Process Design, Development and Control, Bio-mechatronics.	02
2	**Systems and Machines :** System, Classification of System, Mechanistic System Classification Based on Input Energy, Mathematical Model and Function, Machine, Parts of Machine, Concepts of Machine, Classification of Machines based on Function and Size.	02
	System Intelligence: Properties of Intelligent System, System Intelligence Levels, Human Intelligence System, Future Generation System Intelligence Level, Expressing System Intelligence.	02
3	**Sensor and Transducer :** Sensors in Mechatronics System, Difference between Sensors and Transducers, Classification of Sensors, Based on Sensor Output Signal, Sensor Input Physical Parameters, Sensor Accuracy (Smart/Intelligent Sensor), Performance Terminology, Static Characteristics, Dynamic Characteristics.	03
4	**Signal Conditioning Devices :** Signal Conditioning Processes,Application of Signal Conditioning Devices in Mechatronics based on Their Characteristics such as Diode, Transistor, SCR, DIAC, TRIAC, Op-Amps, Signal Filtering, Circuit Protection, Signal Conversion, ADC and DAC, Logic Gates, Flip-Flops, Register, Counters.	05
5	**Actuators:** Actuators, Types of Actuators, Mechanical Actuation System (i.e. Linear-rotary, Rotary-linear Mechanism, Gear, Bearing, Pulleyetc.). Electrical Actuation System (DC, AC, Stepper Motors), Pneumatic and Hydraulic Actuation System.	05
6	**Controllers :** Microprocessor, Microcontroller, PLC Controller& Their Architectures, Principles and Working Software Programs (Assembly/High Level),Interfacing Aspects, Application Examples.	05
7	**Robotics and Automation:** Evolution of Robots, Definitions, Types of Motions, Function, Governing Laws, Classification, Features and Components of Robots, System Automation .	04
	Total No. of Lectures	28

LIST OF EXPERIMENTS		
	Number of Turns	
1	**Experiment on Sensors & Transducers (Mechatronics Lab)**	
(i)	To study the characteristics of LVDT using linear displacement trainer Kit & compare with ideal characteristics.	01
(ii)	To measure the strain of the metal strip using strain gauge trainer kit & compare with ideal characteristics.	01
(iii)	To measure the angular displacement of resistive & capacitive transducer using angular displacement trainer kit & compare with ideal characteristics.	01
(iv)	To obtain the characteristics of RTD, Thermistor, thermocouple with hot and cold junction thermal trainer kit & compare with ideal characteristics.	01
2.	**Experiments on Signal Conditioning**.	
(a)	Experiments on Analog Devices	

(i)	PN Junction Diode	01
(ii)	Zener Diode	01
(iii)	Half wave rectifier	01
(iv)	Full wave rectifier	01
(b)	**Experiments on Digital devices**	
(i)	Logic Gates (AND, OR, NAND, NOR etc)	01
(ii)	Flip Flop (RS Flip Flop), D Flip Flop.	01
3	**Experiments on Controller**	01
(i)	Study of microprocessors, microcontroller, programmable logic controller (PLC)	
(ii)	PLC interfacing of I/O and I/O addressing.	01
(iii)	To perform any basic sequence programming using PLC.	01
4.	**Experiments on Actuators**	01
(i)	Study of mechanical, electrical, hydraulic/pneumatic actuators.	

Course Outcomes:

	By the end of this course, the student will be able: CO1: To understand components of mechatronic system, CO2: To design product and systems theoretically as well as practically with intelligence.

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Mechatronics First edition by Tilak Thakur, published by Oxford University Press	2016
2	Mechatronics, Fourth edition, by W Bolton. ISBN 978-81-317-3253-3	2013
3	Dan Necsulescu Mechatronics published by Pearson Education (Singapore) Pvt. Ltd., Indian Branch, 482 FIE, Patparganj, Delhi India.	2001
4	Book by H M T Limited, Mechatronics Tata McGraw Hill Publishing Company Limited, New Delhi.	1988
5	Mechatronics Principles, Concepts & Applications by Nitaigour P Mahalik published by TMH	2003

Course Name	**:**	**Introduction To Electronics & Electrical Engineering**
Course Code	**:**	**ES1401 (Common to all branches)**
Credits	**:**	**2**
LTP	**:**	**2-0-0**

Course Objective:
To introduce to the students, the fundamental concepts of electronic devices, circuits and electrical systems for engineering applications.

Total Number of Lecture:28

	Lecture wise breakup	**Number of Lecture**
1	**Semiconductor Device sand applications**: Familiarizations with active and passive components Physics of p-n junction diode, BJT, JFET and MOSFET, diode as Rectifier, clippers and clampers, Transistor as an amplifier, Introduction to Audio amplifiers, Functional operation of OpAmp, concept of Oscillators, filters and their types	7
2	**Digital Electronics**: Introduction to logic gates, combinational circuits: adder, subtractor, multiplexer, demultiplexer, sequential circuit: flipflops, counters, registers, Analog to digital conversion, Digital to analog conversion and applications	5
3	**Communication Systems:** Various frequency bands used for communication, Block diagram of Analog and Digital communication, need of modulation, Analog modulation techniques (Amplitude and frequency), Digital modulation techniques (ASK, FSK, PSK,)	3
4	**Fundamentals of Electrical Engineering:** Introduction to circuit laws, Network theorems, Amplitude, Phase, Phase difference, RMS value and Average value of a AC signal, Active and Reactive Power, single phase and 3 phase systems,star delta connection, construction, working principle and speed control of AC and DC machines, Transformer: construction, working principle and applications	8
5	**Measurements:** Principle of measurement, voltage, current, power and energy measurement, analog and digital measurement system	5

Course Outcomes: By the end of the course the students will be able to

1. Express the understanding of semiconductor devices (p-n Diode, BJT, MOSFET etc), and their applications.
2. Describe the functional operation of various analog and digital electronic circuits.
3. Solve basic electronic circuits using circuit laws and network theorems.
4. Describe the basic principle and working of fundamental electrical systems, ac dc motors and transformer etc.
5. Explain the basic principle of measuring electrical quantity such as voltage, current, power and energy.

SuggestedBooks:

Sr. No	**NameofBook/Authors/Publisher**	**Year of Publication/ Reprint**
1	Electronics Devices & Circuit Theory, RLBoylestead & LNashelsky(PHI)	2009
2	CircuitsandNetworks:AnalysisandSynthesis,SudhakarandShyamMohan,TMH	2009
3	ElectronicCommunicationSystemsbyG.Kennedy,McGrawHill,4thEdition	2008
4.	Digital Principles And Applications, Seventh Edition, A. Malvino and D. Leach	2011
5.	Alexander, Charles K., and Sadiku, Matthew N. O., Fundamentals of Electric Circuits, 5th Ed, McGraw Hill	2013
6.	A K.Sawhney-A course in Electrical and Electronic Measurements and Instrumentation	Latest Edition

Course Name	**:**	**Introduction to Manufacturing**
Course Code	**:**	**ES1501 (For Aero, CSE, ECE and Electrical)**
Credits	**:**	**2**
LTP	**:**	**2-0-0**

Total no. of lectures: 28

Course Objectives:
To equip the students with basic understanding and learning of its concepts for conventional and advanced manufacturing processes along-with their applications.

	Syllabus	**Hrs**
(1)	Concept of Manufacturability, Classification of Manufacturing processes -Introduction to Primary Manufacturing processes: Types and applications -Introduction to Secondaryand Tertiary Manufacturing processes: Types and applications.	6
(2)	Concept of Smart, Digital and Sustainable manufacturing processes with applications. Concepts of Industry 4.0 its relevance and Industrial Internet of Things (IIOT).	6
(3)	Introduction to Advanced Manufacturing practices: Classification, Principles and Applications of Electric Discharge Machining (EDM), Laser Beam Machining (LBM), Abrasive Flow Machining (AFM), Chemical and Electro Chemical Machining (ECM), Ultrasonic Machining and Welding etc.	6
(4)	Computer Integrated Manufacturing: Concept of CAD/ CAM. a) Concept of Additive and Subtractive manufacturing processes: Rapid Prototyping & Rapid Manufacturing, Principles, Major technologies used and its applications. b) CNC machines, concepts, uses and applications. c) Industrial Robots, types and applications.	6
(5)	Case studies and practical examples on: a) Manufacturing of small precision parts. b) Manufacturing of ICs & PCB. c) Manufacturing of keyboards and hardware.	4

Course Outcomes:	
1	Students would be able to classify and choose manufacturing processes for typical applications.
2	Understand the process, steps and applications of Rapid Prototyping
3	Understand the principles and applications of CNC and Robots in manufacturing.

REFERENCE BOOKS:

S. No.	**Title, author and Publisher**	**Publication year / Reprint**
(1)	Manufacturing Engineering & Technology, Kalpakjian and Shmid (Pearson Publications)	2013
(2)	Advanced Manufacturing Processes, VK Jain, Allied Publishers	2014
(3)	Introduction to Basic Manufacturing, CS Jawalkar, Narosa Publishers	2016

Course Name	**Strength of Materials**
Course Code	**ES1601 (For Civil, Mechanical, Metta and Production)**
Credits	**2**
L T P	**2-0-0**
Total No. Lectures	**28**

Course Objectives:
At the end of this course, the student should be able to understand the basic concept regarding the strength of material. The course will prepare the students to apply these concepts to engineering and applied sciences problems.

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Equations of static equilibrium, Concept of various forces/loads, stresses and strains developed due to these forces/loads, Uniaxial tensile test, Stress-strain diagrams for various types of ferrous and non-ferrous materials, isotropic and anisotropic materials, Compression test, impact test, fatigue test, hardness test, torsion and bending test as per ASTM standards	**3**
2	**SIMPLE STRESS & STRAIN:** Hooke's law, stress and elongation produced in various types of bars due to its own weight and applied axial force, Poisson's ratio, relationship between elastic constants, stresses and elongationproduced in simple & composite bars due to axial, thermal and combined loading.	**5**
3	**2-D STATE OF STRESS ANALYSIS:** Generalized 2-D state of stress accompanied by shear stress, stresses on an arbitrary plane under this state of stress, sign conventions, complementary shear stress, principal stresses and principal planes, Different stresses determination through Mohr's stress circle approach in 2-D state of stress.	**5**
4	**SHEAR FORCE AND BENDING MOMENT IN BEAMS:** Classification of beams, supports and loads, Shear force (SF) &Bending moment (BM) in beams, sign conventions, Relation between rate of loading (w) with SFand BM. SF and BM diagrams of cantilevers, simply sported beams with or without overhang under different types of loading e.g. concentrate loads, uniformly distributed load, uniformly varying load, moment or its combinations, the point of contra-flexure	**5**
5	**BENDING & SHEAR STRESSES IN BEAMS**: Theory of pure bending, position of neutral axis, Bending equation, practical application of bending equation, review of moment of area concepts, variationof bending stress in various cross-sectional beams, shear stresses in beams, variation of shear stresses for different cross-sectional beams	**5**
6	**TORSION OF CIRCULAR SHAFTS:** Torsional equation of circular shafts, shear stress distribution, torsional rigidity, power transmitted by the shaft, comparisons of hollow & solid circular shafts, analysis of shafts in series and parallel mode	**5**

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the concept of stresses & strains, various types of materials, its properties & testing processes as per ASTM standards	**L2**
2	Understand and evaluate simple and complex stresses for various machine elements.	**L2 & L5**
3	Evaluate various beams on the basis of shear force and bending moment under different loading conditions.	**L5**
4	Analyze beams due to shear and bending stresses.	**L4**
5	Understand the torsional stresses in circular shaft and apply the concept for design of various shafts in power transmission.	**L2, L3 &L6**

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO3	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO5	3	3	3	3	-	-	-	-	-	-	-	1	3	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Strength of Material - G. H. Ryder (MacMillan)	1969
2	An Introduction to the Mechanics of Solids – Crandall & Dahl (Mc-Graw Hill)	2012
3	Engg. Mechanics of Solids - E. P. Popav (Pearson Education)	2003
4	Strength of Material: D S Bedi, Fifth Ed.	2010
5	Strength of Material by R K Rajput, Fifth Ed.	2012

Course Name	**:**	**Communication Skills & Ethics**
Course Code	**:**	**HS1101 (Common to all branches)**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Course Objectives :

1. Thecourseaimstoenhancecommunicationskillsandcriticalthinkingskillsofthestudentsto further develop their personality so as to be more effective in personal and professional life.
2. The course further aims to provide basic knowledge in ethics, values, norms and standards to establish their importance in life and to enable students to self-assess and enhance their personality.

Total No. of Lectures – 28

Lecture-wise Breakup		**No. of Lectures**
1	**Introduction to Communication Process** Scope, Significance, Types, Levels and Tools of Effective Communication. Verbal, Vocal and Non-Verbal Skills	**(1)**
2	**Critical Thinking Skills** Developing Thinking Skills-Descriptive, Referential, Inferential, Discursive, Analytical, Evaluative, Creative and Lateral Using Texts and Various Media Forms:(Books, Newspaper Articles, Films, Social Visuals)	**(4)**
3	**Speaking Skills** Developing Speaking Skills PACESS-Governed (PACESS-Purpose, Audience, Content, Expression, Structure, Style) for Communication at Various Levels: Interpersonal, Group, Organization and Society	**(3)**
4	**Advanced Technical Writing** Job Application, E-mail, PACESS-Governed Short Essay, Memo, Notice, Agenda, Minutes, IMRD-BasedReport.	**(4)**
5	**Job Preparation** Sensitization to Building Portfolio, Resume, Interview Skills	**(2)**
6	**Introduction to Ethics** Concept, Nature, Scope, Functions and Factors influencing Ethics, Psycho-Social Theories of Moral Development – Kohlberg and Carol Gilligan, Broader Ethical Issues in Society (Research Based)	**(5)**
7	**Ethics and Business** Concept and Objectives of Business Ethics, Factors influencing Business Ethics, 3 C's of Business Ethics, Ethical Dilemmas in Business (Role- Play)	**(3)**
8	**Self-Awareness & Self-Development** Concept of Self Awareness, Self- Esteem, Self-Assessment – SWOT Analysis, Concept of Self-Development, Social Intelligence, Emotional Intelligence, Time and Stress Management, Positive Human Qualities (Empathy, Gratitude, Compassion, Forgiveness and Motivation), Personality Development Models – Johari Window, Myers Briggs Type Indicator Leadership Development	**(6)**

Total No. of Practical Sessions: 14

Practical Session Wise Breakup		No. of Practical Sessions
1	**Organizational Communication** Verbal, Vocal and Non-Verbal Communication at Various Levels, Self- Introduction, Speech, JAM	**(2)**
2	**Applying Critical Thinking Skills** Reading Comprehension, Book Review, Film Review, Social Visuals Interpretation and Critical Analysis .	**(4)**
3	**Speaking Techniques at Different Forums** Group Discussions, Making and Presenting Power Point Presentations	**(4)**
4	**Practice on Technical Writing** Job Application, Email, Memo, Notice, Agenda, Minutes, Report, Short Essay	**(3)**
5	**Towards Job Preparation** Sensitization to Building Portfolio, Resume, Interview	**(1)**

Course Outcomes:	
1	The students will gain greater proficiency in English language and its technical aspects for its effective use in personal and professional life.
2	Thestudentswillachievegreaterrefinementofpersonalitythroughawarenessandacquisition of forms and techniques of communication skills.
3	The students will be able to distinguish between right and wrong in both personal and professional life.

Suggested Books& E-Material		
S.No.	***Name of Book/ Authors/ Publisher***	***Year of Publication/ Reprint***
1	TechnicalCommunication: Principles and Practices, III Edition,Meenakshi Raman and Sangeeta Sharma, OUP, NewDelhi (with E-Material)	2017
2	English for Writing Research Papers, Adrian Wallwork, Springer, London, New York	2011
3	Business Ethics – Text and Cases", Murthy C.S.V., 1st Edition, Pubs: Himalaya Publishing House.	2014
4	"Issues and Ethics in the Helping Professions", Corey G., Corey M.S. and CallananP., 8th Edition, Pubs: Brooks/Cole, Cengage Learning.	2010

	Reference Books and E-Materials	
1	Business Communication III Edition, RK Madhukar, Vikas Publication House Pvt. Ltd, Noida	2018
2	Body Language, Allan Pease, Sudha Publications Pvt Ltd., New Delhi	2004
3	Techniques of Writing Business Letter, Memos & Reports, Courtland L Bovee, Jaico Publishing House, Mumbai	2005
4	Bridging the Soft Skills Gap, Bruce Tulgan, Wiley, New Delhi	2005
5	A Guide to Gracious Living Etiquette & Life Skills, Jyoti Singh, Mohindra Publishing House	2017

6	TED Talks Videos on Ted.com (Not their Regional versions)	
7	"The Curse of Self: Self-awareness, Egotism and the Quality of Human Life", Leary M.R., 1st Edition, Pubs: Oxford University Press.	2007
8	Business Ethics", Hartman L.P. and Chatterjee A., 3rd Edition, Pubs: Tata McGraw Hill.	2006
9	Positive Human Qualities (web)	https://positivepsychology.com/
10	Theory of Moral Development (web)	https://www.verywellmind.com/kohlbergs-theory-of-moral-development-2795071

List of Undergraduate Courses for Batch 2020-21 Onwards

No.	Course Name	Course Code	Credits	L-T-P
Departmental Core Courses				
1.	Elements of Manufacturing Processes (3rd Sem)	ME1031	3	2-0-2
2.	Elements of Thermodynamics (3rd Sem)	ME1032	3	3-0-0
3.	Mechanics of Materials (3rd Sem)	ME1033	3	2-1/2-2/2
4.	Theory of Machines (3rd Sem)	ME1034	3	2-1/2-2/2
5.	Manufacturing Processes (4th Sem)	ME1041	3	2-0-2
6.	Applied Thermodynamics (4th Sem)	ME1042	3	2-1/2-2/2
7.	Refrigeration and Air Conditioning (4th Sem)	ME1043	3	2-1-0
8.	Mechanical Vibrations (4th Sem)	ME1044	3	2-1/2-2/2
9.	Production Engineering (5th Sem)	ME1051	3	2-1-0
10.	Production and Operations Management (5th Sem)	ME1052	3	3-0-0
11.	Heat and Mass Transfer (5th Sem)	ME1053	3	2-0-2
12.	Design of Mechanical Systems (5th Sem)	ME1054	3	3-0-0
Departmental Electives **1.** This basket is for department students as their Department Elective Courses with 2000 series number. **2.** This basket is also for department students for their Major Specialization in a specific field with 4000 series number. **3.** For Major Specialization in Mechanical Engineering, student has to opt **minimum three stream specific** department elective courses **out of required four courses.** **4.** The courses with * shall also be offered as Honours and Open Elective Courses with 3000 and 6000 series respectively.				
Department Electives for all Streams				
1.	Finite Element Method in Engineering	ME2001/ME4001	4	3-0-2
2.	Measurement and Metrology* (DEC & OE)	ME2002/ ME3001/ME4002/ME6001	4	3-0-2
3.	Automotive Engineering* (DEC & OE)	ME2003/ ME3002/ME4003/ME6002	4	3-0-2
4.	Optimization Techniques in Engineering* (DEC & OE)	ME2004/ ME3003/ME4004/ME6003	4	3-1-0
Design Stream				
5.	Mechanisms and Machines	ME2005/ME4005	4	3-1-0
6.	Vibration and Noise Control	ME2006/ME4006	4	3-1-0
7.	Computer Aided Design	ME2007/ME4007	4	3-0-2
8.	Fracture Mechanics and Fatigue	ME2008/ME4008	4	3-1-0
9.	Experimental Stress Analysis	ME2009/ME4009	4	3-1/2-2/2
10.	Mechanics of Composites Materials	ME2010/ME4010	4	3-1-0
11.	Vehicle Dynamics	ME2011/ME4011	4	3-0-2
12.	Kinematic and Dynamics of Robots	ME2012/ME4012	4	3-0-2
13.	Work Station Design and Neuro-Ergonomics	ME2013/ME4013	4	3-1-0
Manufacturing Stream				
14.	Computer Aided Manufacturing	ME2014/ME4014	4	3-0-2
15.	Precision Engineering	ME2015/ME4015	4	3-0-2
16.	Advanced Manufacturing Techniques	ME2016/ME4016	4	3-1-0
17.	Production Planning and Control	ME2017/ME4017	4	3-1-0
18.	Surface Engineering	ME2018/ME4018	4	3-0-2
19.	Engineering Metallurgy	ME2019/ME4019	4	3-0-2
20.	Product Design and Development	ME2020/ME4020	4	3-1-0
21.	Composite Materials	ME2021/ME4021	4	3-0-2

Thermal Stream				
22.	Fluid Mechanics	ME2022/ME4022	4	3-1/2-2/2
23.	Internal Combustion Engines	ME2023/ME4023	4	3-1-0
24.	Computational Fluid Dynamics	ME2024/ME4024	4	3-0-2
25.	Hydraulic Machines	ME2025/ME4025	4	3-1/2-2/2
26.	Convective Heat and Mass Transfer	ME2026/ME4026	4	3-1-0
27.	Two Phase Flow Heat Transfer	ME2027/ME4027	4	3-1-0
28.	Automotive Combustion and Emissions	ME2028/ME4028	4	3-1-0
29.	Thermal System Modelling and Simulations	ME2029/ME4029	4	3-1/2-2/2
30.	Design of Thermal Systems	ME2030/ME4030	4	3-1-0
31.	Micro-Nano Scale Heat Transfer	ME2031/ME4031	4	3-1-0
32.	Power Plant Engineering* (DEC & OE)	ME2032/ ME3004/ME4032/ME6004	4	3-1-0
Open Electives **1.** This basket list is for other department's students as Open Elective Courses with 6000 series number. **2.** This basket list is also for department students as their Department Elective Courses with 2000 series number. **3.** This basket list is also for department's students as Honors Courses with 3000 series number.				
1.	Measurement and Metrology*	ME2002/ ME3001/ME4002/ME6001	4	3-0-2
2.	Automotive Engineering*	ME2003/ ME3002/ME4003/ME6002	4	3-0-2
3.	Optimization Techniques in Engineering*	ME2004/ ME3003/ME4004/ME6003	4	3-1-0
4.	Power Plant Engineering*	ME2032/ ME3004/ME4032/ME6004	4	3-1-0
5.	MEMS and Micro System Design	ME2033/ME3005/ME6005	4	3-1-0
6.	Principles of Product Design	ME2034/ME3006/ME6006	4	3-1-0
7.	System Dynamics and Control	ME2035/ME3007/ME6007	4	3-1/2-2/2
8.	Smart Materials and Structures	ME2036/ME3008/ME6008	4	3-1-0
9.	Tribology & Lubrication	ME2037/ME3009/ME6009	4	3-1-0
10.	Modeling and Simulation	ME2038/ME3010/ME6010	4	3-1-0
11.	Hydraulic and Pneumatic Control Design	ME2039/ME3011/ME6011	4	3-1-0
12.	Non-Conventional Energy Resources	ME2040/ME3012/ME6012	4	3-1-0
13.	Advanced Unconventional Energy Resources	ME2041/ME3013/ME6013	4	3-1-0
14.	Experimental Methods for Engineers	ME2042/ME3014/ME6014	4	3-1/2-2/2
15.	Thermal Management of Engineering Systems	ME2043/ME3015/ME6015	4	3-1-0
16.	Solar Thermal Energy	ME2044/ME3016/ME6016	4	3-1-0
17.	Numerical Analysis Techniques	ME2045/ME3017/ME6017	4	3-1-0
18.	Thermal Management of Buildings	ME2046/ME3018/ME6018	4	3-0-2
19.	Thermal Energy Storage Technologies	ME2047/ME3019/ME6019	4	3-1-0
20.	Industrial Engineering and Management	ME2048/ME3020/ME6020	4	3-1-0
21.	Reliability and Maintenance Engineering	ME2049/ME3021/ME6021	4	3-1-0
22.	Operation Research and Simulation Techniques	ME2050/ME3022/ME6022	4	3-1-0
23.	Total Quality Management	ME2051/ME3023/ME6023	4	3-0-2
24.	Micro and Nano Manufacturing	ME2052/ME3024/ME6024	4	3-0-2
25.	Industrial Automation	ME2053/ME3025/ME6025	4	3-0-2
26.	Computer Integrated Design and Manufacturing	ME2054/ME3026/ME6026	4	3-1-0

* These courses shall also be floated as department as well as open elective.

Minor Specialization in Mechanical Engineering - Course Basket (Student is required to opt minimum one course each from below mentioned groups)				
S. No.	**Course Name**	**Course Code**	**Credit**	**L T P**
	GROUP A			
1	Manufacturing Technology-I	ME5001	4	3-0-2
2	Manufacturing Technology-II	ME5002	4	3-1-0
	GROUP B			
3	Fundamentals of Thermo-Fluidics	ME5003	4	3-1/2-2/2
4	Fundamentals of Heat Transfer	ME5004	4	3-0-2
	GROUP C			
5	Strength of Materials and Concepts of Design	ME5005	4	3-1/2-2/2
6	Kinematics and Dynamics of Machines	ME5006	4	3-1/2-2/2

Departmental Core Courses

Course Name	**:**	**ELEMENTS OF MANUFACTURING PROCESSES**
Course Code	**:**	**ME1031**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Course Objectives:

1. To familiarize the students with the basic tools and equipment's used in manufacturing.
2. To introduce the practical knowledge on different aspects of manufacturing processes.
3. To familiarize with basic manufacturing processes, techniques, use of machine tool etc.
4. To familiarize with the production of basic raw materials and secondary processes like joining, forming, and assembly.

Total No. of Lectures – 28

Lecture wise breakup		**No. of Lectures**
1	**MANUFACTURING**: Definition, Classification, Concept of product design and development, Plant and shop layout, Manufacturing activities inside and outside the factory, Industrial safety, Selection of raw materials, Storing, Process planning.	4
2	**FOUNDRY:** *Raw materials*: fuels, fluxes, refractory and related materials, patterns, mould, core; *Furnaces*: Cupola, induction and resistance heating furnaces, core furnace, open hearth furnace, pit furnace, Sand casting, Mechanics of solidifications; *Design:* Gating system, runner and riser; Pouring time calculation, Degassing, Fettling; *Special Castings*: Centrifugal, carbon dioxide, plaster, shell and permanent moulding, precision casting, investment casting, die casting, Continuous casting;*Casting of composites:* Casting Al/SiC, Al/ZrO2, Al/Al2O3 and hybrid MMCs, properties and applications. *Casting defects:* Causes and their remedial actions.	8
3	**METAL FORMING**: Classification, hot and cold working processes, Types: coining, embossing, punching, blanking, rolling, forging, fullering, edging extrusion, drawing, *Special forming processes:* rotary swaging, ring rolling, gear forming, tandem rolling, thread rolling, bearing cup, spline shaft rolling, electro, hydraulic, magneto-electro and hybrid forming; *Forming defects*: Causes and remedial actions.	5
4	**WELDING:** Definition, classification, mechanism of welding, weldability. *Arc welding*: principle, types, Carbon, submerged, electro-slag, MIG, TIG and plasma arc welding. *Electrodes:* Types, classification and codification, selection and specific applications. *Resistance welding*: Principle, types, Spot-welding machines. *Solid state welding*: Cold, diffusion, ultrasonic, explosive, friction and forge welding. *Thermochemical welding:* Principle, types, applications. *Gas welding*: Types, different zone and temperature of flames, applications. Oxy-flame cutting: Principle, types, applications. *Brazing and soldering*: Principle, types, materials, application in macro and micro domain, *Welding defects*: Causes and remedial actions.	7
5	**HEAT TREATMENT:** Definition, classification, annealing, normalizing, hardening and tempering; Iron-carbon and TTT diagram, *Surface hardening processes*: carburizing, nitiriding, cyaniding and flame hardening, heat treatment processes for non-ferrous metals.	4

List of Experiments:	
1	Carpentry section: (i) half lap T & L-joint, (ii) pattern of hexagonal nut.
2	Fitting section: (i) leveling & surface marking, (ii) square hole making.
3	Foundry section: (i) mould making, (ii) casting hexagonal nut.
4	Smithy section: (i) round bar to cube, (ii) round bar to V-block.

5	Welding section: (i) arc welding: V, L,T joints, (ii) spot welding on sheet metal.
6	Machine section: (i) turning & tapering, (ii) thread cutting.
7	Assembly and electrical basic connection: (i) study automobile engine, (ii) wiring & electrical connection.
8	Sheet metal & Electroplating: (i) bending & joining, (ii) buffing and electroplating on sheet metal

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the concept of manufacturing, product design, selection of raw materials, storing and process planning.	**L2**
2	Plan and apply the different manufacturing processes to fabricate the ferrous, nonferrous and composite materials.	**L3**
3	Analyse the possible defects of manufacturing processes and ability to rectify the defects.	**L4**
4	Ability to select and apply the suitable manufacturing processes to make desire feature of products.	**L3**
5	Estimation pouring and solidification time of metal casting	**L5**
6	Design and adapt different gating system, runner and riser to cast product/parts for different industry.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	3	3	-	1	-	-	-	-	-	1	2	2	1
CO2	3	2	3	1	2	-	-	-	-	-	2	1	3	2
CO3	1	3	1	3	1	-	-	-	-	-	2	2	3	1
CO4	3	3	1	1	2	-	-	-	-	-	2	2	3	2
CO5	3	1	1	3	2	-	-	-	-	-	1	1	3	1
CO6	2	2	3	3	3	-	-	-	-	-	1	1	3	2

Suggested Books		
Sr. No.	**Name of the Book/ Authors/Publisher**	**Year of Publication/ Reprint**
1	Manufacturing Engineering and Technology; Serope Kalpakjian and Steven R. Schmid, 4th ed., Pearson.	2007
2	Principles of Manufacturing Materials and Processes; Campbell-Tata McGraw Hill.	1999
3.	Fundamentals of Modern Manufacturing, Mikell P. Groover, 5th ed., Wiley	2013
4.	Material and Processes in Manufacturing, E.P. Degarmo, Ronald A. Kohser, and J. T. Black; Prentice Hall of India	2008
5.	Manufacturing Processes, P.C. Sharma, S. Chand Publication.	2008

Course Name	**:**	**ELEMENTS OF THERMODYNAMICS**
Course Code	**:**	**ME1032**
Credits	**:**	**3**
L T P	**:**	**3-0-0**

Course Objectives:	
1	Understand the importance of thermodynamics.
2	Basic understanding of various types of thermodynamic systems.
3	Understand the basic principles of thermodynamics systems.

4	Understand the various types of boilers.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**BASIC CONCEPTS:** Introduction of thermodynamics, Concept of Continuum, ThermodynamicSystem,SurroundingandBoundary,ThermodynamicEquilibrium,State, Path, Process, cycle, Quasi-static Process, Reversible and Irreversible Process, Working Substance, Thermodynamic Properties, Zeroth Law of Thermodynamics, Temperature Scales, Concept of Heat and work in Thermodynamics.	05
2	**FIRST LAW OF THERMODYNAMICS:** Joule's Paddle Wheel Experiment, Mechanical Equivalent of Heat, First Law thermodynamics for closed and open systems, Different forms of stored Energy, Enthalpy, Energy of an isolated System, Perpetual Motion Machine of First kind. Flow Process, Control Volume, work and Energy Equations, Throttling Process, Non-Flow work, Limitation of First Law.	07
3	**SECOND LAW OF THERMODYNAMICS:** Second Law of thermodynamics, Heat and Work, Thermal Reservoir, Planck and Clausius statements, Energy Analysis of Heat Engine, Refrigerator and Heat Pump, Reversibility and Irreversibility, Carnot Theorem and cycle, Efficiency of the Reversible Heat Engine, Equality of Ideal Gas Temperature and Kelvin Temperature.	05
4	**ENTROPY**: Clausius Theorem, Clausius Inequality and concept of Entropy, Entropy: Principle, application, Irreversible Process, Transfer with Heat Flow, generation in closed and open System, Thermodynamics Equations relating properties of System, Reversible Adiabatic work in a Steady flow System, Entropy and disorder.	05
5	**AVAILABLE ENERGY AND AVAILABILITY**: Available Energy referred to a cycle, Quality of work, Maximum work in Reversible Process, Useful work, Dead State, Availability, Second Law Efficiency.	04
6	**GASPOWERCYCLES**: Air Standard efficiency, Mean Effective Pressure, Otto, Diesel, Dual, Brayton, Stirling and Ericson Cycle, Comparison of cycles. Equation of state of a gas, Properties of Mixture of gases, Internal Energy, Enthalpy, Entropy and Specific heat of gas & mixtures.	04
7	**PROPERTIES OF PURE SUBSTANCES**: *P-v*, *T-s*, *h-s*, diagram for a Pure Substance, Properties of Pure substance with special reference to water, Steam and its formation, Wet Dry, Saturated and Superheated Steam, sensible, Latent heat, Dryness fraction and its determination, Separating and Throttling calorimeter Enthalpy, Entropy and Internal Energy of Steam, Use of Steam Table and Mollier Diagram, Basic Thermodynamic Processes of Steam in Closed and Open System and their representation on P-V and H-S chart.	05
8	**INTRODUCTION TO STEAM GENERATORS/BOILERS:** Classification of boilers, fire tube boilers, water tube boilers, comparison between water tube and fire tube boilers, guidelines for the choice of a new boiler, essentials of a good boiler, boiler mountings and accessories.	03
9	**VAPOUR POWER CYCLE:** Carnot and Rankine Steam Power Cycle, Actual Vapour cycle Processes, Comparison of Carnot and Rankine cycle, Mean Temperature of Heat Addition, Reheat Cycle, Ideal Regenerative Cycle Reheat Regenerative Cycle, Feed Water Heater, Characteristics of an Ideal working fluid in Vapor Power cycle.	04

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand various laws of thermodynamics and their application to various systems.	**L2**
2	Apply the basics of thermodynamics in various engineering applications.	**L3**
3	Analyze the performance of vapor and gas power cycles, phase-change processes, and other thermodynamics processes.	**L4**

4	Examine the close and open thermodynamic systems, and find the optimized solution(s).	**L5**
5	Analyze and effectively utilize the thermal appliances in day-to-day life.	**L4**

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	1	-	-	-	-	-	-	-	1	1	1
CO2	2	1	1	1	-	-	-	-	-	-	-	-	2	1
CO3	3	2	2	2	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO5	2	2	2	2	-	-	-	-	-	-	-	3	2	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Engineering Thermodynamics, Gordon Rogers & Yon Machew, Pearson	2006
2	Thermodynamics, Yunus Cengel and Mike Boles, 9th ed., McGraw Hill	2019
3	Thermodynamics, C. P. Arora, McGraw Hill	2017
4	Engineering Thermodynamics, P.K. Nag, McGraw Hill	2005
5	Thermodynamics, D.S. Kumar, S.K. Kataria & Sons	2013

Course Name	**:**	**MECHANICS OF MATERIALS**
Course Code	**:**	**ME1033**
Credits	**:**	**3**
L T P	**:**	**2-1/2-2/2**

Course Objectives: In this course, the student should be able to
1. Understand the advance topics of strength of materials and apply these to engineering problems.
2. Develop the basic skills and knowledge required to analyze stress, strain and failure in deformable solids.

Total No. of Lectures – 28

Lecture wise breakup		**No. of Lectures**
1	**COLUMN AND STRUTS**: Definitions, Euler's theory of columns buckling, Euler's equation for various end restraints, Rankine and other empirical formulae.	4
2	**SPRING:** Close and open coiled helical springs under axial load and axial moment, leaf springs, flat spiral spring.	4
3	**DEFLECTION OF BEAMS**: Relationship between bending moment, slope and deflection, moment area method, method of integration, Macaulay's method, Use of these methods to determine slope and deflection for statically determinate and statically indeterminate beams under various loading conditions.	5
4	**THEORIES OF FAILURES**:Different theories of failures including Mohr's & Octahedral theories and their comparisons; Graphical representation and yield locus of these theories of failures for 2-D state of stress.	5
5	**STRAIN ENERGY:** Strain Energy of various types of loads under different loading conditions, total strain energy for a 3-D state of stress, strain energy of dilation and distortion for a 3-D state of stress, deflection of beams via strain energy approach, Castigliano's theorem, Maxwell's reciprocal theorem of deflection and their applications.	5
6	**THIN AND THICK SHELLS:** Thin cylinders and sphere, thick cylinders and sphere,	5

	comparison of thin and thick shell theories, compound cylinders, hub-shrunk on solid shaft.	

List of Experiments:		**No. of Hours**
1	To perform Tensile Test on a given material and to determine its various mechanical properties under tensile loading.	2
2	To perform Compressive and shear test on a given material and to determine its various mechanical properties under compression loading.	2
3	To perform Torsion test on a given material and to determine various mechanical properties under torsional load.	2
4	To perform Column test of a given material and to determine its Euler's buckling load and Young's modulus of elasticity.	2
5	To perform Impact test on a given material and to determine its resilience.	2
6	To perform a test on close and open coil spring and determine its various mechanical parameters.	2
7	To study and perform Fatigue test on a given material and to determine endurance strength and limit of the material.	2

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the philosophies of mechanics of materials in engineering and applied sciences problems.	**L2**
2	Evaluate any mechanical system as a model which is acted upon by various loads and stresses induced in it.	**L5**
3	Apply the concept of mechanics of materials on advance system for its stress analysis.	**L3**
4	Analyze the failure analysis under static loading in ductile and brittle materials using different theories of failures.	**L4**
5	Develop the vessels and other machine components.	**L6**
6	Ability to conduct various tests on materials to assess their mechanical properties.	**L4**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	3	1	-	-	-	-	-	-	-	-	3	1
CO3	3	2	2	1	-	-	-	-	-	-	-	-	3	1
CO4	2	3	2	3	-	-	-	-	-	-	-	-	3	1
CO5	2	3	3	1	-	-	-	-	-	-	-	1	3	1
CO6	1	1	1	3	-	-	-	-	2	2	-	1	2	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Engg. Mechanics of Solids, E.P. Popav, Pearson Education.	2003
2	Mechanics of Materials, FP Beer and R Johnson, Tata-McGraw Hill Publishers, India	2005
3	Mechanics of Materials, Gere, Thomson Books.	2004
4	An Introduction to the Mechanics of Solids, Crandall & Dahl, McGraw Hill.	2012

5	Mechanics of Material, Kirpal Singh, Standard Publisher.	2007
6	Strength of Material, D S Bedi, Khanna Book Publication.	2010
7	Strength of Material, R K Rajput, S Chand Publication.	2012

Course Name	**:**	**THEORY OF MACHINES**
Course Code	**:**	**ME1034**
Credits	**:**	**3**
L T P	**:**	**2 -1/2- 2/2**

Course Objectives: In this course, the student should be able to
1. Understand the basics of machines and mechanism.
2. Understand the concepts of kinematic diagrams, kinematic chains & mobility, mechanisms and Kinematic analysis.
3. Understand various components used in power transmission devices.

Total No. of Lectures – 28

Lecture wise breakup		**No. of Lectures**
1	**BASIC CONCEPTS:** Kinematics and Dynamics of Machines, Mechanisms, Pairs, kinematic chain, four bar chain, Inversions of single and double slider crank chains, Degrees of freedom, Kutzbach's equation. Grubler's criterion, Joints..	3
2	**VELOCITY AND ACCELERATION:** Relative motion, displacement, velocity, acceleration diagrams of different types of mechanisms, Relative velocity method, instantaneous center method; Kennedy theorem, Klien's construction, Coriolis component, Numerical problems.	3
3	**CAMS:** Type of cams and followers, definition-basic circle & least radius, angle of ascent. Dwell, Descent & Action; Displacement, Velocity and Acceleration diagrams of followers, Simple harmonic motion, Uniform and maximum velocity, acceleration and retardation, cycloidal motion.	3
4	**GEARS AND GEAR TRAINS:** ***Toothed gears:*** types, definitions and terminology, pressure angle, path contact, arc of contact and approach, law of gearing, gear tooth profiles, involute and cycloidal gear systems, interference in involute gears; ***Gear Trains*****:** Types, simple and compound, epicyclic and reverted gear trains; Sun and planet gear, differential; Velocity ratio of worm and worm wheel, Helical and spiral gears; spiral angle and efficiency; Numerical problems.	5
5	**GYROSCOPE:** Definition, axis of spin and precision, gyroscopic couple and effect on movement of ships and vehicles, stability of two and four wheel automobile; Numerical problems.	2
6	**FLYWHEEL AND GOVERNORS:** Turning moment and crank movement diagrams, dynamics of simple horizontal and vertical engine. Fluctuation of speed, co-efficient of fluctuation of speed and energy, Punching press. Simple problems; *Governors*: Functions, types and characteristics of governors, Sensitivity, stability, isochronism and hunting of governors, governor effort and controlling force curve, effect of sleeve friction. Numerical problems.	6
7	**BALANCING:** Classification, static and dynamic balancing, Primary and secondary balancing of rotary and reciprocating masses, swaying couple and variation of tractive effort, hammer blow, partial balancing of locomotive, multi cylinder in line engines, balancing of V-engines.	6

List of Experiments:		**No. of Hrs**
1	To find displacement, velocity and acceleration of slider in a single slider crank mechanism for different crank angles and draw various graphs.	2
2	Verify experimentally the gyroscopic couple is given by $T = I.\omega.\ \omega_p$	2

3	Draw experimentally the approximate straight line be watts mechanism.	2
4	Find out the positions of the four weights, so that the system becomes statically & dynamically balanced.	2
5	Find the moment of inertia of a given body about an axis passing through C.G. and perpendicular to the plane of the body also calculate the minimum oscillation of the point of suspension.	2
6	Balance experimentally as far as possible the known unbalanced force due to a rotating weight by introducing two balancing weights in two different planes (a) Balancing planes on either side of unbalanced force (b) Balancing planes on the same side of unbalanced force.	2
7	Determination of characteristics curve of the Watt, Porter, Proell and Hartnell Governors using universal governor set up.	2

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand and apply concepts of kinematics and dynamics on the mechanism & machines.	**L2 & L3**
2	Develop various cam profiles for engines and machines.	**L6**
3	Analyze and develop gear trains required for various applications.	**L4**
4	Understand the working of gyroscope, flywheel and governors.	**L2**
5	Ability to conduct various tests on machine & mechanism to assess their output characteristics.	**L4**

CO-PO & PSO Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	1	1	-	-	-	-	-	-	-	1	3	1
CO2	2	2	2	1	-	-	-	-	-	-	-	1	2	1
CO3	2	3	2	1	-	-	-	-	-	-	-	1	2	1
CO4	1	1	2	1	-	-	-	-	-	-	-	1	2	1
CO5	1	1	1	3	-	-	-	-	2	2	-	1	3	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Theory of Machines, V.P. Singh, Dhanpat Rai & Co. Pvt. Ltd, New Delhi	2014
2	Theory of Machines, P.L. Ballaney, Khanna publishers, New Delhi	1994
3	Theory of Machines, Shigley, Tata McGraw Hill.	1981
4	Mechanism & Machine Theory, J.S. Rao & R.V. Dukhipati, Wiley Eastren Ltd.	1992
5	Theory of Mechanisms, Amitabh Gosh & A.K. Mallik, East West Press Machines Private Ltd.	2006
6	Theory of Machines, S. S. Rattan, McGraw Hill Education (India)	2014

Course Name	**:**	**MANUFACTURING PROCESSES**
Course Code	**:**	**ME1041**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Course Objectives:

1.To impart the knowledge of tools and tooling system used for fabrication of metal powder, plastic and ceramics parts.
2.To impart the knowledge about various machine tools and their applications in the conventional and non-conventional machining processes used in metal cutting.
3.To impart the knowledge of advanced non-conventional machining techniques and their applications for processing of conductive and non-conductive materials.
4.To impart the knowledge of rapid prototyping methods, rapid product development technique and its applications.

Total No. of Lectures – 28

Lecture wise breakup		**No. of Lectures**
1	**MACHINE TOOLS:** Classification, Specifications, Working principle and Applications of Lathe, Milling, Drilling, Boring, Broaching, Slotting, Sawing, Shaping, Planning, Grinding machines.	4
2	**PRINCIPLE OF METAL CUTTING AND MACHINING OPERATIONS:** Single, Double and Multipoint point cutting tools; Advanced cutting tool materials; Oblique cutting, Orthogonal cutting; Mechanics of chip formation; Types of chips; Merchant Force diagram; Tool life; Machinability; Machining parameters and their influence on machining performance, taper turning, thread cutting, knurling, indexing, hexagonal head, spline shaft and gear cutting.	6
3	**POWDER METALLURGY AND PROCESSING OF CERAMICS:** Principles, Advantages and limitations, Methods of producing powders. Applications of powder metallurgy parts, properties, Machining and Joining of ceramic metal powder components.	5
4	**PROCESSING OF PLASTICS:** Polymerization, Types of plastics, Fabrication and Processing of Plastics, Calendering's, Rotational molding, Injection and Blow molding, Helmet manufacturing, Machining and Welding of plastics.	4
5	**ADVANCEDMACHININGPROCESSES:** Need and objective of non-conventional machining methods. ECM, EDM, WEDM, USM, EBM, LBM, AJM: Working principle, Process parameters, Effect of process parameters on machining responses, Applications.	6
6	**RAPID PROTOTYPING:** Introduction, classifications, RP methods and rapid product development, applications.	3

List of Experiments:		**No. of Hours**
1	Gear cutting on milling machine	6
2	EDM of hard materials and study the effect of process parameters	4
3	Micro drilling using EDM process	4
4	Fabrication of plastic components using Injection molding setup	4
5	Product Development using 3D printing	4
6	Design and Fabrication for production of metal powder set-up	6

Sr. No.	**Course Outcomes** **By the end of this course, the student will be able to:**	**Knowledge Level (Blooms Level)**
1	Remember and exhibit memory of previously learned from Elements of Manufacturing Processes (ME 1031).	**L1**
	Outline the basic concepts and understanding about the powder metallurgy, plastic moulding and machining processes, machine tools and tooling system.	**L2**
2	Select the appropriate machining process for different operations apply to the modern industry.	**L3**

3	Analyze the various activities of advanced machining processes and rapid prototyping.	**L4**
4	Evaluate and compare the performance of different manufacturing processes with varying parametric conditions.	**L5**
5	Formulate the ideas or innovative concepts for developing tools/machine components using appropriate sets of manufacturing processes.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	2	2	-	-	1	-	-	-	-	1	3	1
CO3	3	2	2	3	2	-	1	-	-	-	-	1	3	2
CO4	2	3	2	3	2	-	2	-	-	-	2	1	3	3
CO5	3	2	2	3	2	-	-	-	-	-	1	2	2	2
CO6	3	3	2	1	1	-	-	-	-	-	1	2	3	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Manufacturing Engineering and Technology, Serope Kalpakjian and Steven R.Schmid- 4thed., Pearson Edition.	2013
2	Manufacturing Science, Amitava Ghosh and Asok Kumar Mallik, East-West Press Pvt Ltd., New Delhi.	1993
3	Advance Machining Processes, V K Jain; Allied publishers, New Delhi.	2002

Course Name	**:**	**APPLIED THERMODYNAMICS**
Course Code	**:**	**ME1042**
Credits	**:**	**3**
L T P	**:**	**2 - ½ - 2/2**

Course Objectives:	
1	To develop an understanding of thermodynamics as it applies to real systems.
2	To develop problem solving skill through the application of thermodynamics and use of lab studies to reinforce knowledge gained in theory classes.
3	To introduce students about the various conventional applied thermal systems, such as IC Engines, Compressors, Turbines, Condensers, Nozzles and Diffusers.
4	To analyze, optimize and design newer thermodynamics systems.

Total No. of Lectures – 28

Lecture wise breakup		**No. of Lectures**
1	**I.C. ENGINES:** Introduction to I.C. Engines, Construction and operation of 2-S and 4-S engines, valve timing diagrams, Combustion in IC Engines. *Performance of IC Engines:* Performance curves of C.I. and S.I. engines. Overall IC Engine performance (engine sizing, mean effective pressure, power and torque), Effect of compression ratio and air fuel ratio on power and efficiency of an engine.	5
2	**RECIPROCATING COMPRESSOR:** Introduction, classification of air compressors, work input and the best index of compression, thermal and polytropic efficiency of compressor, Effect of clearance and volumetric efficiency, Multi stage compression and its advantages.	4
3	**CENTRIFUGAL COMPRESSOR:** Principle of operation, components of a	3

	centrifugal compressor complete thermodynamics analysis of centrifugal compressor stage, isentropic and Isothermal efficiencies, work done and pressure rise, Velocity vector diagrams for centrifugal compressors and power calculation, pre-guide vanes and pre-whirl, slip factor, power input factor, degree of reaction and its derivation, energy transfer in backward, forward and radial vanes.	
4	**AXIAL FLOW COMPRESSOR:** Component of axial flow compressor and their arrangement, Principle of operation, velocity vector diagrams, thermodynamics analysis and power calculation, Factors affecting stage pressure rise, work done factor, Degree of reaction and blade Efficiency and their derivation, Isentropic, Polytropic and isothermal efficiencies, Surging, choking and stalling in axial flow compressors, Characteristics curve for axial flow compressors.	3
5	**STEAM TURBINES:** Introduction, General description of Impulse and Reaction steam turbines, *Impulse Turbine*: General description, pressure and velocity compounding, Velocity diagram and work done, Blade efficiency and overall efficiency Reheat factor and condition curve, *Reaction Turbine:* Degree of reaction, Velocity diagrams, blade efficiency and its derivation, Losses in steam turbines, stages in turbine system, the HP and LP by-pass system, vacuum maintaining in a turbine, load and speed governing of turbine.	5
6	**GAS TURBINES:** Introduction, classification of gas turbines on the basis of system of operation and on the basis of combustion (at constant volume or at constant pressure), Thermodynamics of constant pressure gas turbine cycle, calculation of net output, work ratio and thermal efficiency of ideal and actual cycles. Thermal refinements and their effects on gas turbine cycle, i.e., gas turbine cycle with regeneration, inter cooling and reheating, multistage compression and expansion.	4
7	**NOZZLES AND DIFFUSERS:** Types and utility of nozzles, Flow of steam through nozzles, Effect of friction, Nozzle efficiency, Critical pressure conditions for maximum discharge, Supersaturated flow, Classification of diffusers, effect of friction and area change, converging-diverging super-sonic diffuser.	2
8	**CONDENSERS:** Introduction, Elements of condensing plants, Brief description of different types of condensers, Dalton's law of partial pressure applied to condenser problems, condenser and vacuum efficiencies, Cooling water calculations, Effect of air leakage, Method of checking and preventing air infiltration, Description of air pump and calculation of its capacity.	2

List of Experiments:		**No. of Turns**
1	To study the construction and operation of a two stroke and four strokes petrol & diesel engine and study of valve timing diagram for a Diesel Engine.	1
2	To find the Volumetric Efficiency, Brake Thermal Efficiency Mechanical Efficiency, Frictional Power, Indicated Power Heat Balance sheet of Variable Compression Ratio Petrol Engine at different Compression Ratios and study its effect on various parameters.	1
3	To estimate the Indicated Power, Friction Power and Mechanical Efficiency of a multi-cylinder Petrol Engine when running at constant speed under constant settings of a carburetor by cutting one, the power of one cylinder each in turn (Morse test).	1
4	To find the Volumetric Efficiency, Brake Thermal Efficiency, Mechanical Efficiency, Frictional Power, Indicated Power, Heat Balance Sheet of Variable Compression Ratio Diesel Engine at different Compression Ratios and Study its effect on various parameters.	2
5	To study and draw the vapor compression cycle for a refrigeration test kit under different variables.	1
6	To draw the fundamental vapor compression cycle for window AC test rig and calculate its COP and cooling capacity.	1

Sr. No.	Course outcome By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand various thermal systems such as engines, compressors, turbines, condensers, etc., and know-how their basic components.	**L2**
2	Develop problem solving skills through the application of thermodynamic principles.	**L3**
3	Examine the performance of IC Engines through lab scale experiments.	**L4**
4	Evaluate and optimize the performance of the existing thermal system.	**L5**
5	Propose changes in existing thermal system and formulate new-ones.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	1	-	-	-	-	-	-	-	-	1	-
CO2	3	2	1	1	-	-	-	-	-	-	-	1	2	-
CO3	3	3	2	2	1	-	-	-	2	-	-	-	2	1
CO4	3	3	3	2	1	-	1	-	-	-	-	-	3	2
CO5	3	3	3	3	1	-	1	-	1	-	-	-	3	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Heat Engineering, Vasandani and Kumar, Metorpolitan Co. Pvt. Ltd., Delhi.	2013
2	Thermal Engineering, P. L. Ballaney, Khanna Publisher Delhi.	2005
3	Applied Thermodynamics, R. Yadav, Central Publishers, Allahabad.	2011
4	Applied Thermodynamics for Engineering Technologists, T D Eastop and A McConkey, 5th Ed., Pearson.	2017
5	Basic and Applied Thermodynamics, P.K. Nag, 2nd Ed, Tata McGraw-Hill.	2017

Course Name	**:**	**REFRIGERATION AND AIR-CONDITIONING**
Course Code	**:**	**ME1043**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:	
1	To understand the basic principles of Refrigeration & Air Conditioning Systems.
2	To learn the working and understand the construction of the various components of Refrigeration System like evaporators, compressor etc.
3	To design air conditioning system for practical applications.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**REFRIGERATION**: Refrigeration effect, cooling capacity and C.O.P. of a refrigerator, E.P.R. of heat pump, Reversed Carnot Cycle	2
2	**AIR CYCLE REFRIGERATION: ANALYSIS OF BELL COLEMAN CYCLE;** Need of aircraft refrigeration and air conditioning; Analysis of different Air Cycle Refrigeration Systems for aircraft.	3
3	**VAPOUR ABSORPTION REFRIGERATION**: (Only Introduction: No Derivation) Simple vapour absorption refrigeration; Modifications to simple vapour absorption refrigeration system; Actual vapour absorption refrigeration	2

	system Electrolux system; Lithium BromideWater absorption refrigeration system; Solid-Vapour absorption and absorption refrigeration system.	
4	**VAPOUR COMPRESSION REFRIGERATION**: Vapour compression Cycle on P-V, P-H and T-S diagrams; Deviation of actual Cycle from theoretical one; Mathematical analysis of theoretical and actual vapour compression refrigeration cycle; effect of suction pressure, discharge pressure, sub-cooling, superheating and pressure drop in valves.	3
5	**MULTI-PRESSURE VAPOUR COMPRESSION REFRIGERATION** : Single load compound compression with single expansion and water intercooling; single load compound compression with individual expansion valve and flash intercooling; Multiple load systems with individual expansion valves and individual compressors; Single Load Compound Compression with flash tank and water intercooling; Single Load Compound with flash chamber as intercooler.	4
6	**NON-CONVENTIONAL REFRIGERANT SYSTEMS**: Steam Jet Refrigeration; Cascade Refrigeration System; Mixed Refrigeration System; Vortex Tube Refrigeration; Thermoelectric Cooling, Modern Air Condition Systems like HVAC, Variable refrigerant volume (VRV/VRF)	3
7	**CRYOGENICS**: Definition, Cryogenic fluids, storage and insulation; Linde-Hampson and Claude Liquification Cycles (NO ANALYSIS); Adiabatic Demagnetization; Applications.	2
8	**AIR-CONDITIONING**: Definition, Applications; Psychometric properties of air; Dry bulb, wet bulb and dew point temperatures; Relative and specific humidity; Enthalpy of air and water vapours; Human requirements of comfort; Effective temperature.	3
9	**BASIC PROCESSES IN CONDITIONING OF AIR AND AIR CONDITIONING EQUIPMENT**: Sensible cooling and heating of air; simple humidification and dehumidification of air concept of bypass factor; cooling and dehumidification; Evaporative cooling; chemical dehumidification; air washer.	3
10	**LOAD CALCULATIONS AND SUPPLY AIR CONDITIONS**: Sources of heat load; sensible and latent heat load; sensible heat factor; apparatus dew point temperature; quality and state of supply air for air conditioning of various buildings; Load calculations for comfort and cold storage air conditioning.	3

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the basic concepts of refrigeration, refrigeration systems, and environmental impact of refrigerants.	**L2**
2	Apply the laws of thermodynamics to solve various refrigeration and air-conditioning problems.	**L3**
3	Analyze and determine the performance of vapor compression cycle under different operating conditions.	**L4** **L5**
4	Understand the principles of non-conventional refrigeration system.	**L2**
5	Develop understanding of psychometric properties and chart, determine cooling load, and design the air conditioning systems.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	-	-	1	-	-	-	-	2	1	-
CO2	2	2	1	1	-	-	-	-	-	-	-	1	2	-
CO3	3	3	2	2	-	-	-	-	-	-	-	2	2	1
CO4	2	1	1	1	-	-	-	-	-	-	-	1	1	-
CO5	3	3	3	3	-	-	-	-	-	-	-	2	3	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Refrigeration and Air Conditioning, W.F. Stoecker, McGraw Hill.	1986
2	Refrigeration and Air Conditioning, Jordon and Priester, Prentice Hall of India	2009
3	Principles of Refrigeration, R.J. Dossat, Wiley Eastern	2001
4	Refrigeration and Air Conditioning, C.P. Arora, Tata McGraw Hill	1997
5	Refrigeration and Air Conditioning, Manohar Prasad, New Age International (Pvt.) Ltd., Publishers.	2010
6	Refrigeration and Air Conditioning, P.L. Ballaney, Khanna Publishers	2012

Course Name	**:**	**MECHANICAL VIBRATIONS**
Course Code	**:**	**ME1044**
Credits	**:**	**3**
L T P	**:**	**2-1/2-2/2**

Course Objectives: In this course, the student should be able to understand the
1. Causes, sources and the basic principles of mechanical vibrations. 2. Mechanical Vibration concepts to one, two, multi and infinite degree of freedom systems with different systems components. 3. Concept of numerical methods applicable to study vibration in any engineering system design. 4. Concepts of modal analysis in study of vibrations.

Total No. of Lectures – 28

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Basic concept of vibration, Importance and scope, definition and terminology, representation and analysis of harmonic motions/series and, Fourier series, beat phenomenon, work done by a harmonic force on an harmonic motion, introduction to various types of vibrations and types of excitation.	3
2	**SINGLE DEGREE OF FREEDOM SYSTEMS:** *Undamped free vibrations:* D' Alembert's Principle, Energy method, Rayleigh method, Newton's second law of motion and its applications in these problems, equivalent spring stiffness, *Damped free vibrations:* Introduction to viscous damping, sub-critical, critical and over-damping systems and its solutions, logarithmic decrement, frequency of damped oscillations; Dry friction, Structural damping and Slip damping and its analysis, *Forced vibrations:* Force vibration analysis for constant harmonic excitation, rotating & reciprocating unbalance masses, support excitation Vibration isolation and transmissibility, vibration measuring instruments.	11
3	**TWO DEGREE OF FREEDOM SYSTEMS:** Undamped and damped vibrations, principal mode of vibration, normal modes, nodes, natural frequencies, mode shapes, Torsional vibrations, application of Two degree of freedom in dynamic vibration absorber.	4
4	**MULTI-DEGREE OF FREEDOM SYSTEMS - EXACT ANALYSIS:** Undamped free vibrations, Reciprocity theorem, Matrix Inversion method, Eigen values & Eigen vectors, Free vibration analysis of string, longitudinal vibrations of bar.	5
5	**MULTI-DEGREE OF FREEDOM SYSTEMS- NUMERICAL METHOD:** Orthogonal properties of normal modes, Rayleigh, Dunkerley and Matrix Iteration as applied to multi degree of freedom systems, comparison of natural frequencies by these methods	5

List of Experiments:		No. of Hrs
1	To study the forced vibration of the beam for different damping.	2
2	To determine the radius of gyration 'k' of a given compound pendulum.	2
3	To determine the radius of gyration of bi-filar and tri-filar suspension.	2
4	To study the pressure profile of lubricating conditions of load and speed.	2
5	To determine the natural frequency of undamped torsional vibration of a single rotor shaft system.	2
6	To determine the frequency of undamped free vibration of a cantilever beam.	2
7	To determine the frequency of damped force vibration of a cantilever beam.	2

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand & apply the concept of Mechanical Vibration in engineering and applied sciences problems in general.	**L2 & L3**
2	Apply the concept of Mechanical Vibration to one, two, multi and infinite degree of freedom systems with different systems components.	**L3**
3	Evaluate any mechanical system for its dynamic characteristics.	**L5**
4	Develop the dynamic model of real-life problems and determine the natural frequencies and mode shapes.	**L6**
5	Compare different numerical and exact techniques to analyze multi degree freedom system.	**L2 & L4**
6	Ability to conduct various tests on machine to assess their dynamic characteristics.	**L4**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	1	1	-	-	-	-	-	-	-	1	3	1
CO2	3	3	2	1	-	-	-	-	-	-	-	1	3	1
CO3	2	3	3	1	-	-	-	-	-	-	-	-	2	1
CO4	2	3	3	1	-	-	-	-	-	-	-	1	3	1
CO5	3	3	2	2	-	-	-	-	-	-	-	-	2	1
CO6	1	1	1	3	-	-	-	-	2	2	-	2	3	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Mechanical Vibrations, G. K. Grover, Nem Chand & Bros, Roorkee	2009
2	Mechanical Vibrations, V. P. Singh, Dhanpat Rai & Sons, Delhi	2020
3	Theory and Practice of Mechanical Vibrations, J. S. Rao & K. Gupta, New Age International (Pvt.) Ltd., New Delhi	2002
4	Fundamental of Vibration, Balachandran and Magrab, Cengage Learning	2009
5	Mechanical Vibration & Noise Engineering, A. G. Ambekar, PHI	2006
6	Mechanical Vibration, D. Nag Wiley.	2012
7	Mechanical Vibrations, S. S. Rao, Pearson Education Inc.	2017

Course Name	**:**	**PRODUCTION ENGINEERING**
Course Code	**:**	**ME1051**
Credits	**:**	**3**

L T P	:	2 1 0

Course Objectives:	
1	To imparts the specialized knowledge of CNC machines and CNC programming for machining processes.
2	To impart the knowledge on design and fabrication of various types of Jigs, Fixtures, Dies and Tooling used in manufacturing of various products.
3	To impart the knowledge of geometrical tolerances, surface finishes and fits system used in mechanical assembly.
4	To impart the knowledge of process planning and process optimization, optimal machining speed and maximum production rate with optimal cost.

Total No. of Lectures – 28

Lecture wise breakup		No. of Lectures
1	**NC AND CNC MACHINES:** Introduction, Components, Control systems, CNC tooling and fixtures, CNC part programming: basic G-Codes and M-Codes, Canned cycles, Manual part programming, Computer aided part programming (APT).	4
2	**JIGS & FIXTURE DESIGN:** Principles, design of jigs and fixtures, degrees of freedom, principle of locating and clamping, hydraulic and pneumatic locating and clamping devices, jigs for drilling, drill bushes; ***Fixtures:*** milling, lathe, drilling, grinding.	6
3	**TOOL AND DIE DESIGN:** *Press tool operations:* Shearing, blanking, piercing, trimming, shaving, notching, nibbling, coining, bending, drawing, embossing, stretch forming; Press working equipment's, *Dies:* Types, components of cutting die; methods of reducing cutting forces; *Die design:* blanking die, piercing die, drawing die and bending die, forging dies, design of die blocks, punches and strippers; Strip layout.	6
4	**MANUFACTURING OF TOOLS AND DIES:** Manufacturing of Single, double and multi-point cutting tools, Carbide tool inserts, brazed tools, coated tools, Manufacturing of Dies, die materials, various conventional and non-conventional methods for die manufacturing, heat treatment of cutting tools and dies.	4
5	**METROLOGY& INSPECTION:** Limits, fits and tolerances, standard and limit gauges, design of gauges, steps of inspection, introduction to coordinate measuring machine and automated inspection technique, elements and relationship of surface finish related to production methods and measurement; measuring devices used in inspection and quality control.	4
6	**OPTIMIZATION OF MACHINING CONDITION:** Optimization of cutting speed for minimum cost and maximum production, machining parameters optimization, Machine Tool replacement, method of distributing depreciation, Introduction to reverse engineering and applications.	4

Sr. No.	Course outcome By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the hardware of CNC machines, supportive tooling system such as Jigs and Fixtures for smooth manufacturing activities.	**L2**
2	Understand the fact and idea of various types of press working tools/ dies, their manufacturing processes and quality inspection devices.	**L2**
3	Interpret different types of geometric fits and selection of suitable manufacturing process for required geometrical tolerances.	**L5**
4	Design different types of tools and dies	**L6**
5	Apply G-codes and M-codes for creating CNC part programming for various machining operations.	**L3**

6	Analyse the different processes and effect of parameters through optimization for effective manufacturing die and tools	**L4**

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	-	-	-	-	-	1	1	2	2
CO2	3	3	3	1	-	-	-	-	-	-	2	1	3	2
CO3	2	2	3	1	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	1	-		-	-	-	2	1	3	2
CO5	3	3	3	1	2	-	-	-	-	-	-	1	3	2
CO6	3	3	2	3	3	-	-	-	-	-	-	3	2	3

	Name of Book/ Authors/ Publisher	**Year of Publication/ Reprint**
1	Tool Design, Donaldson, TMH Publication	2010
2	Fundamentals of tool Design, ASTME	2010
3	Production Engineering, P.C. Sharma, S Chand Publications.	2014
4	Jig and Fixture Design, Edward G Hoffman, Cengage learning	2004
5	Manufacturing Technology (Machining), P.N. Rao, 2nd ed., Tata McGraw Hill.	2009

Course Name	**:**	**PRODUCTION & OPERATIONS MANAGEMENT**
Course Code	**:**	**ME1052**
Credits	**:**	**3**
L T P	**:**	**3-0-0**

Course Objectives:	
1.	To impart the knowledge about the concept and significance of Production Management and Capacity planning.
2.	To impart the knowledge about the plant layout heuristics/algorithms and applications of forecasting techniques.
3.	To impart the knowledge on the Scheduling and Inventory control methods.
4.	To impart the knowledge on the applications of PERT and CPM techniques and concepts of Reliability and maintenance.

Total No. of Lectures – 42

Lecture wise breakup		**No. of lectures**
1	**INTRODUCTION TO PRODUCTION MANAGEMENT:** Types of production systems, Product design, Standardization and simplification, Make/buy decision, Concurrent engineering.	5
2	**PLANT LOCATION AND LAYOUT:** Mathematical Models for single facility location, Euclidean and Rectilinear methods, Minimum location problem, Layout Design Heuristics/algorithms: CRAFT, ALDEP and CORELAP, Group Layout.	6
3	**FORECASTING:** Time Series Analysis; Correlation and regression, Exponential smoothing, Decomposition algorithm for seasonal data. Measuring and analysis of forecasting accuracy.	6
4	**CAPACITY PLANNING AND SCHEDULING**: Plant capacity and capacity planning strategies, Investment decisions. Appraisal of financial decision; Scheduling and sequencing techniques in job and mass production.	6

5	**MATERIALS MANAGEMENT AND INVENTORY CONTROL:** Methods, principles and needs of inventory control, EOQ, Probabilistic and deterministic models, Aggregate Planning, Materials Requirement Planning (MRP-I) and Manufacturing Resourse Planning (MRP-II).	6
6	**PROJECT MANAGEMENT:** PERT and CPM networks, Critical activities and floats. Crashing of activities, Project scheduling with resource constraints, Resource leveling.	6
7	**MAINTENANCE PLANNING AND RELIABILITY:** Types of Maintenance: planned and quality maintenance, reliability centered maintenance, predictive and proactive maintenance, total productive maintenance, reliability and availability of systems, reliability improvement.	7

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	**Knowledge Level (Blooms Level)**
1	Understand and illustrate the plant layouts using Design heuristics.	**L2**
2	Apply the concepts of Production management and capacity planning in Industries.	**L3**
3	Analyze the forecasting techniques used in industries and service sectors	**L4**
4	Apply the Scheduling and sequencing techniques in job shops.	**L3**
5	Analyze the various inventory models in industries.	**L4**
6	Recommend the different Project management techniques applicable in projects and understand the concepts of Maintenance methods in industries.	**L5**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	3	-	-	-	-	-	1	-	1	1
CO2	2	1	2	1	2	-	1	-	-	-	2	-	1	2
CO3	2	1	1	-	2	-	2	-	1	-	-	-	1	2
CO4	1	2	1	2	-	-	2	-	1	-	-	-	1	1
CO5	1	2	1	1	-	-	2	-	1	-	-	-	1	1
CO6	1	1	1	-	1	-	1	-	-	1	3	-	1	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Modern Production/Operation Management, Buffa and Sarin, John Wiley and Sons	2011
2	Operations Research - An Introduction, H. A. Taha, Pearson Publications	2010
3	Operations Management, P. B. Mahapatra, PHI Publication	2015
4	Operation Research, Gupta and Hira, S. Chand Publication, Delhi	2015
5	Production & Operations Management, Surya Prakash Singh, Vikas Publishing House Pvt. Ltd., Noida	2018

Course Name	**:**	**HEAT AND MASS TRANSFER**
Course Code	**:**	**ME1053**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Course Objectives:

1	To understand the fundamental principles and laws of heat transfer and explore the implications of these principles.
2	To formulate the models necessary to study, analyze and design heat transfer systems through the application of these principles.
3	To develop the problem-solving skills and practice of heat transfer in real-world applications.

Total No. of Lectures –28

Lecture wise breakup		**No. of Lectures**
1	**CONDUCTION HEAT TRANSFER:** Conduction, Convection, and Radiation Heat Transfer, Steady-State one, two and multi-Dimensional heat Conduction: Plane Wall, Insulation and R values, Radial Systems, Heat-Transfer Coefficient, Critical Thickness of Insulation, Heat-Source Systems, Thermal Contact Resistance, Mathematical Analysis of Two-Dimensional Heat Conduction, Graphical Analysis,Shape Factor, Numerical Analysis of Resistance Elements, Gauss-Seidel Iteration, Accuracy Consideration, Conduction-Convection System Fins with uniform cross-sections, Lumped-Heat-Capacity System, Transient Heat Flow in a Semi-Infinite Solid.	6
2	**PRINCIPLES OF CONVECTION:** Viscous Flow, Inviscid Flow, Laminar Boundary Layer on a Flat Plate, Energy Equation of the Boundary Layer, Thermal Boundary Layer, Relation between Fluid Friction and Heat Transfer, Turbulent-Boundary-Layer Heat Transfer, Turbulent Flow in a Tube, Empirical and Practical Relations for Forced-Convection Heat Transfer. Empirical Relations for Pipe and Tube Flow, Flow Across Cylinders, Spheres and Tube banks, Liquid-Metal Heat Transfer.	5
3	**NATURAL CONVECTION SYSTEMS:** *Free-Convection*: Heat Transfer on a Vertical Flat Plate, Empirical Relations, Vertical planes and Cylinders, Horizontal Cylinders, Plates, Inclined Surfaces, Spheres, Empirical co-relation and analogy for turbulent flow forced convection over extension surface.	2
4	**RADIATION HEAT TRANSFER:** Physical Mechanism, Radiation Properties/laws, Shape Factor and their relations, Heat exchange between non-black bodies, Infinite Parallel Planes, cylinders, spheres, Radiation shields. Solar radiation, Effect of Radiation on Temperature Measurement.	6
5	**BOILING AND CONDENSATION:** Boiling types, mechanism, Pool Boiling: Nucleate Boiling, CHF Flow Boiling: Plug/Slug flow, types, Mechanism Film-wise / Drop wise Condensation	2
6	**HEAT EXCHANGERS:** Introduction, Analysis of Heat Exchangers: LMTD for parallel flow HX, LMTD for counter Flow HX, Effectiveness for parallel Flow /Counter Flow HX, Design of HX, Compact Heat Exchangers, Cross flow Heat Exchangers, Some Important Topics from current research.	4
7	**MASS TRANSFER:** Velocities and mass fluxes, *Governing equations of mass transfer*: Species mass balance, Heat and mass transfer analogy, Impermeable surface model, Mass transfer driven flows.	3

List of Experiments:		**No. of Turns**
1	To determine thermal conductivity of metal rod (Al, Brass and Steel)	1
2	To determine thermal conductivity of insulting metal.	1
3	To determine thermal conductivity of composite wall	1
4	To determine thermal conductance of heat pipe & compare it with other metal rods.	1
5	To determine thermal conductivity of insulator specimen by guarded hot plate method	1
6	To determine heat- transfer coefficient in natural convection	1
7	To study heat transfer from a pin-fin in natural & forced convection mode	1
8	To determine heat - transfer coefficient in forced convection.	1
9	To find heat transfer coefficient for drop-wise and film-wise condensation process	1
10	To determine overall heat transfer coefficient & compare it with value obtained	1

	from standard correlation	
11	Study of CHF & pool-boiling	1
12	To determine effectiveness of parallel/counter flow heat exchange	1
13	To determine Stefan Boltzmann constant of radiation heat transfer.	1
14	To determine the emissivity of a non-black surface	1

Sr. No.	**Course Outcomes** By the end of this course, the student will be able to:	**Knowledge Level (Bloom Level)**
1.	Understand basic concepts of heat transfer through different modes.	**L2**
2.	Apply the concepts of heat transfer to different devices, e.g., cooling fins, heat sink, radiation shields, etc.	**L3**
3.	Analyze and design thermal systems, for e.g., heat exchangers, boilers using scientific and engineering principles.	**L6**
4.	Solve real time problems applicable to heat conduction, heat convection, and heat radiation.	**L4**
5.	Relate the skill of mass transfer and its applications in cooling tower, air conditioner, etc.	**L5**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	1	1	1	-	-	-	-	-	-	-	-	1	1
CO2	3	2	3	2	-	-	-	-	-	-	-	-	3	1
CO3	3	2	2	2	-	-	1	1	-	-	-	-	2	1
CO4	3	2	3	2	-	-	1	-	-	-	-	-	2	1
CO5	3	2	2	2	-	2	1	1	-	-	-	-	3	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Engineering Heat Transfer, R.C. Sachdeva, New Age	2012
2	Fundamentals of Heat and Mass Transfer, Incropera, Dewitt, Wiley India Edition.	1997
3	Heat Transfer, J.P. Holman, Mc Graw Hill	2014
4	Engineering Heat and Mass Transfer, M.M. Rathor, University Science Press	2015
5	Fundamentals of Heat & Mass Transfer, C. P. Kothandaraman, New Age	2012

Course Name	**:**	**DESIGN OF MECHANICAL SYSTEMS**
Course Code	**:**	**ME1054**
Credits	**:**	**3**
L T P	**:**	**3-0-0**

Course Objectives: In this course, the student should be able to
1. Understand the mechanical systems consisting of wide range of machine elements.
2. Understand the design procedure representing empirical, semi-empirical and analytical approaches.
3. Design and analyze a real engineering system.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**GENERAL DESIGN CONSIDERATION:** Scope and meaning of design with special reference to machine design, design processes, Concept of tearing, bearing, shearing,	5

	crushing, bending, etc. Selection of materials, Factors of safety under different loading conditions, stress-concentration factors, Design stresses for variable and repeated loads. Endurance limit and strength, Fits, tolerances and surface finish.	
2	**FASTENERS:**Screws, bolts, preloaded bolts, uniform strength screws, bolts subjected to shear, tension and torque, eccentrically loaded bolted joints. Welded and riveted connection, eccentrically loaded welded and riveted connections.	5
3	**SHAFTS AND AXLES:** Review of torsional equation for circular shafts, Design of circular shafts subjected to axial, bending and torsional loading and its combinations under different theory of failures.	4
4	**DESIGN OF FLEXIBLE MACHINE ELEMENTS:** *Belts* (Flat & V), types of drives and orientations of driving & driven shaft covered by flat and V belts along with design of belts, pulleys, keys & shafts. Types of V-belts, their power ratings & design thereof, Concept and application of timing belt. *Chains*- roller chains, their designation by IS, designing w.r.t. sagging, centrifugal & transmittal loads, Complete sizing of sprockets.	6
5	**BEARINGS:** Types of bearings, Selection of a sliding and Rolling Bearings, *Design of Journal Bearing:* Somerfield number, bearing modulus, material for journal bearing, types of lubricants, their designated numbers. Concept of bearing body, oil & environment temperatures, Calculation of heat generation and dissipation, Design of bearing cap & bolts, *Design of Rolling Contact Bearings:* their designation w.r.t. duty, type & diameter, Concepts of catalogue, average and rating life, Bearings subjected to different loads for different time during one cycle and their equivalent dynamic load carrying capacity.	6
6	**DESIGN OF CLUTCHES & BRAKES:** *Design of Clutches:* Axial and Radial friction clutches, clutch load characteristics, mechanical (friction) clutches, design for uniform wear & pressure theories, Centrifugal clutches design, *Brakes:* Design of single & double block brakes, Concepts of self-locking brakes, Design of External & Internal shoe brakes, Band Brakes and Band & Block brakes.	6
7	**DESIGN OF GEAR DRIVES:** Factors influencing the choice of a gear, Design Details of Spur, Helical, worm and bevel gears, Nomenclature & designing of all these gears from basics of tooth loading as done by Lewis and checks for dynamic loading by Buckingham equations, beam strength, Wear load calculations and design of shafts for all these gears.	10

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the basic causes of failure.	**L2**
2	Select the suitable materials, fits, tolerances and surface finish considering manufacturing aspects.	**L5**
3	Analyze stresses involved with static, dynamic and fatigue loading acting on a mechanical system.	**L4**
4	Apply the causes of failure in designing/sizing of mechanical components.	**L3, L6**
5	Design a mechanical system with special focus on power transmission.	**L6**

CO-PO & PSO Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	1	1	1	-	-	-	-	-	-	-	2	3	1
CO2	3	3	2	2	-	-	-	-	-	-	-	2	3	1
CO3	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO5	3	3	3	3	-	-	-	-	-	-	-	2	3	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Mechanical Engineering Design, Shingle, J.E. Shigley & Charles R. Mischke, 6th ed., Tata McGraw Hill.	2003
2	A Text Book of Machine Design, P.C.Sharma & D.K.Aggarwal,12th ed., S.K.Kataria & Sons, New Delhi	2012
3	Machine Design, Robert L Norton, Pearson.	2012
4	Fundamentals of Machine Component Design, Robert C. Juvinall & Kurt M. Marshek, 3rd ed., John Wiley & Sons.	2000
5	Design of Machine Elements, V.B. Bhandari,2nd ed.,Tata Mc Graw Hill	2007

Departmental Elective Courses

Course Name	**:**	**FINITE ELEMENT METHOD IN ENGINEERING**
Course Code	**:**	**ME2001/ME4001**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

1.To learn basic principles of finite element method as a numerical tool in engineering analysis& design procedure.

2.To learn the theory and modeling of finite elements that represent engineering structures.

3.To learn finite element solutions to structural & dynamic problems through hands-on and simulation exercises.

4.To impart the knowledge and skills needed to effectively evaluate and interpret finite element analysis.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Introduction to FEM and historical background, Brief overview of the steps used in FEM, Various approaches to formulate elemental equations, Difference among FEM, FDM and closed form solutions, Need to study FEM, Review of the concept of stresses, strains, displacements and their relations, Von-Mises stresses, equilibriums, boundary conditions, temperature effect, Concept and application of Minimum Potential energy method, Rayleigh Ritz method, Galerkin Method and Principle of Virtual Work as applied to elasticity problems.	6
2	**MATRIX ALGEBRA & GAUSS ELIMINATION METHOD:** Matrix algebra and its different operations, Special feature of matrix algebra useful to FEM, Eigen values and Eigen vectors, Positive definite matrix, Gauss elimination method to solve large linear equations.	2
3	**1-D PROBLEMS:** Introduction, finite element modelling using bar element, shape functions, Iso, super and sub parametric FEM formulation, Potential energy approach to solve 1-D problems, assembly of elemental equations, Properties of global stiffness matrix, types and applications of boundary conditions, higher order 1-D element and their shape functions, its application to 1-D problem, Accounting of temperature effect in 1-D problems.	8
4	**TRUSSES PROBLEMS:** Introduction, 2-D and 3-D trusses, concept of local and global coordinate system and its transformation matrix, solution of 2-D and 3-D trusses, stress calculations, Accounting of the temperature effect.	4
5	**2-D PROBLEMS USING CONSTANT STRAIN TRIANGLES (CST):** Introduction, finite element modelling using CST elements and shape functions, Potential energy approach, solution of 2-D problems, Accounting of temperature effect, Problem modelling and boundary conditions for symmetrical problems, orthotropic materials.	6
6	**2-D ISO-PARAMATRIC ELEMENTS AND NUMERICAL INTEGRATION:** Introduction, Four-noded quadrilateral element-based FE Modelling and its solution, Numerical integration, Concept of weights and Gauss points and its values, Formulae, 2-D & 3-D numerical integration and applications, Higher order quadrilateral and triangular elements and it's numerical integration.	6
7	**BEAMS AND FRAMES:** Introduction, Potential energy-based FE formulation using beam and frame elements, Boundary consideration, shear stress and bending moment, beams on elastic supports, plane frames, 3-D frames.	6
8	**DYNAMIC PROBLEMS:** Introduction, mass matrix as used in the FEM, elemental mass matrix for different types of elements as studied above, Evaluation of Eigen values and Eigen vectors.	4

List of experiments	No. of Hrs
Students shall be solving the different engineering problems on relevant CAD software available in the laboratory.	28

Sr. No.	Course outcome By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recall the concepts of stresses, strains, displacements, matrix algebra.	**L1**
2	Understand & apply the concepts behind various formulation methods used in FEM.	**L2, L3**
3	Select suitable type of elements for a problems and generation of global equations.	**L5**
4	Analyze and apply boundary conditions to form global equations for its solutions.	**L3, L4**
5	Interpret the output of FEM based software in more meaningful manner.	**L2**
6	Ability to create model and simulate various machine elements for engineering analysis.	**L6**

CO-PO & PSO Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	1	-	-	-	-	-	-	-	-	1	1
CO2	3	3	2	2	1	-	-	-	-	-	-	1	3	3
CO3	3	3	3	3	-	-	-	-	-	-	-	1	3	3
CO4	3	3	3	3	1	-	-	-	-	-	-	1	3	3
CO5	2	2	3	2	3	-	-	-	-	2	-	1	3	3
CO6	3	2	3	3	3	-	-	-	2	2	-	2	3	3

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Introduction to Finite Elements in Engineering, Chandrupatala & Belegundu, 4th ed., Pearson.	2015
2	Finite Element Method, J. N. Reddy, 2nd ed., McGraw Hill.	1993
3	Concept & Application of Finite Element Analysis, Cook et al., 4th Ed., John Wiley.	2004
4	The Finite Element Method for Engineers, Huebner et al., 3rd ed, John Wiley.	1982
5	Finite Element Analysis (Theory & programming), C. S. Krisnamoorthy, 2nd ed., Tata McGraw Hill.	2004

Course Name	**:**	**MEASUREMENT AND METROLOGY**
Course Code	**:**	**ME2002/ME3001/ME4002/ME6001**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives: At the end of the course, the student will be able to:	
1	Understand the significance of calibration, traceability and uncertainty.
2	Understand measurement errors and techniques to minimize the errors.
3	Understand the methods and instruments required for dimensional metrology.
4	Have a clear concept about the design of limit gauges and their applications.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	**INTRODUCTION:** Elements of Measurement System, Selection of Measuring Instruments, Types and Performance Characteristics of various Instruments, Static and Dynamic Characteristics of Instruments, Type of Errors, Calibration, Accuracy, precision, limits fits and tolerances, types of assemblies, linear and angular measurements, design of limit gauges and applications.	4
2	**DISPLAY OF MEASUREMENT SIGNALS**: Electronic Output Display, Recording of Measurement Data, Ultra-Violet, Fiber Optics and Digital Recorders, Presentation of Measurement Data, Sensor Technologies, Capacitive, Resistive, Magnetic, Hall Effect, Piezo-resistive and Optical Sensors, Intrinsic, Extrinsic, Distributed Sensors, Ultrasonic Transducer, Ultrasound in Tracking 3D Object Motion, Ultrasound range sensor.	3
3	**SURFACE ROUGHNESS MEAURMENT**: Types of Surface Texture, Surface Roughness Measurement Methods, Comparison, Contact and Non-Contact type roughness measuring devices, 3D Surface Roughness Measurement, Nano Level Surface Roughness Measurement, Analysis of surface roughness texture.	3
4	**MESUREMENT OF FLOW, TEMPERATURE & PRESSURE:** *Temperature Measurement*: Radiation thermometers, optical pyrometers, radiation pyrometer, thermography, fiber optic temperature sensor, acoustic thermometer, *Pressure Measurement:* Capacitive pressure sensor, fiber optic pressure sensor, intelligent pressure transducer, *Flow Measurement:* Corilis Flow meter, Thermal Mass Flow Measurement, Positive Displacement Flow meter, Electro-magnetic and Ultrasonic Flow meter	4
5	**MEASUREMENT OF FORCE AND TORQUE:** *Mass Measurement:* Electronic, Pneumatic, Smart and Intelligent load cells, *Force Measurement*: accelerometer, vibrating wire sensor, *Torque Measurement:* Optical Torque Measurement, *Rotational Displacement Measurement:* Circular and Helical Potentiometer, Rotational differential transformer, gyroscopes, *Rotational Velocity Measurement:* Digital and analogue tachometer, fiber optic gyroscope, Mechanical Flyball, *Viscosity Measurement:* Rotational Viscometer, Falling Body Viscometer.	4
6	**LIMITS, FITS AND TOLERANCES:** Concept and types of interchange ability, need for standard systems of limits, fits and tolerances, BIS standard system, selection of limits and fits, design principles for limit gauges. Types and tolerance of limit gauges, Taylor's principle for gauges, problems on hole and shaft based fit systems.	4
7	**MEASURING AND GAUGING INSTRUMENTS:** *Design principles of measuring instruments*: kinematics design, principle of alignment pivots and bearings, sources of error in measurement, calibration and standardization of measuring instruments, linear and angular measuring instruments, venire callipers, micro –meters dial gauges, bevel protectors, sine bar, spirit level, *Optical instruments*: autocollimators, tool room microscope length measuring machines, *Comparators:* magnification principles types of comparators, mechanical optical, pneumatic, electrical and electronic comparators.	4
8	**SCREW THREAD AND GEAR METROLOGY**: Elements of screw thread, measurement of major, minor and effective diameters of external and internal screw threads, measurement of pitch and screw thread angle, effect of pitch error, elements of gear metrology, measurement of gear tooth thickness, gear profile, gear concentricity, pitch and run-out for involute gear, gear rolling test	3
9	**MEASURMENT OF FORM ERRORS:** Straightness, flatness, alignment errors-surface texture-various measuring instruments-run out and concentricity, Computational techniques in measurement of form errors.	3
10	**INTERFEROMETERY**: Introduction, Principles of light interference, Interferometers, Measurement and Calibration, Laser Interferometry.	3

11	**COMPUTER AIDED LASER METROLOGY**: Tool Makers Microscope, Coordinate Measuring Machines, Applications, Laser Micro meter, Laser Scanning gauge, Computer Aided Inspection techniques, In-process inspection, Machine Vision System, Applications, LASER micro meter, Optical-LASER interferometers, applications**.**	3
12	**IMAGE PROCESSING FOR METROLOGY:** Overview, Computer imaging systems, Image Analysis, Pre-processing, Human vision system, Image model, Image enhancement, grey scale models, histogram models, Image Transforms.	4

List of Experiments		
Sr. No.	**Experiments**	**Hours**
1	Measurement of screw thread element using tool makers microscope & optical projector.	4
2	Measurement of angle using Sine Centre / Sine bar / bevel protractor	4
3	Measurement of gear tooth thickness using gear vernier caliper.	4
4	Measurement of surface roughness using tally surf	4
5	Calibration of Pressure Gauge, Thermocouple, LVDT, load cell, micrometer	4
6	Determination of modulus of elasticity of a mild steel specimen using strain gauges	4
7	Measurements using Optical Projector / Toolmakers' Microscope.	4

Sr. No.	**Course outcome**	Knowledge Level (Blooms Level)
1	Remember and recall the basics of measurement system and equipments used in industries.	**L1**
2	Understand the principle of flow, mass, force, torque etc.	**L2**
3	Apply the required knowledge of different equipment's and comparators used in industrial measurement.	**L3**
4	Analyse the surface texture through knowledge of computer aided LASER metrology technique.	**L4**
5	Measure form error and identify the quality of product.	**L5**
6	Design and calibrate the different measuring the equipments used in day to day industrial activities.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	1	1	-	1	-	-	-	1	1	2	2
CO2	3	3	3	1	-	-	-	-	-	-	2	1	3	2
CO3	3	2	3	1	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	1	-	-	-	-	-	2	1	3	2
CO5	3	3	3	1	2	-	-	-	-	-	-	1	3	2
CO6	2	2	3	2	2	-	-	-	-	-	1	2	2	2

Course Outcomes: By the end of this course, the student will be able to:	
1	Apply the basic principles of measurements, various techniques and measuring parameters.
2	Demonstrate a critical awareness of the underlying principles of the different measuring instruments and devices.
3	Apply the measurement methods and techniques of computerized image processing.
4	Recognize the latest measuring instruments for measurement of various mechanical and other quantities.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	A text-book of Metrology, M. Mahajan, Dhanpat Rai & Co.	2009
2	Engineering Metrology, K. J. Hume, Mc Donald & Co (Publishers), London	1970
3	Metrology for Engineers, J.F.W. Galyer and C.R. Shotbolt, ELBS Edition,	1993
4	Engineering Metrology, Thomas. G. G, Butterworth Publiher	1974
5	Engineering Metrology, R. K. Jain, Khanna Publishers	2005

Course Name	**:**	**AUTOMOTIVE ENGINEERING**
Course Code	**:**	**ME2003/ME3002/ME4003/ME6002**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:	
1	To develop an understanding of all the sub-components of an automotive vehicle.
2	To give knowledge about all the controlling and electronic components.
3	To gain the knowledge about new technologies being used in automotive vehicles.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** History of Automotive engineering, Classification of Automotive vehicles, Different sub-systems in automotive vehicles.	2
2	**COOLING AND LUBRICATION SYSTEMS:** Cooling systems and their components, anti-freeze mixtures. Lubrication purpose and various systems of lubrication, types and desirable properties of lubricants, components like oil filters, oil pumps, and oil pressure indicators, air supply system, air filters, turbo charger and super charger.	5
3	**FUEL SUPPLY SYSTEMS:** Fuel injection system for petrol and diesel engines, fuel pumps (mechanical and electrical), air fuel ratio requirements, carburetors: types and general operation throttle body and multipoint fuel injection systems, electronic control module and sensing devices.	5
4	**TRANSMISSION SYSTEMS:** Clutch function and types, torque converters; fluid flywheel; manual and automatic transmission/ trans axles; constant mesh & synchro mesh gearboxes, epi-cyclic gearbox, differential, propeller shafts and universal joint front and rear axles.	4
5	**BRAKE SYSTEMS, WHEEL & TYRES:** Braking efficiency and stopping distances. Types of brakes, Drum and disc brakes. Detailed description of hydraulic and pneumatic brake. Mechanical, vacuum and electrical methods of brake actuation, servo brakes, ABS, type of wheels, tyres, type of tyres; cross ply, radial tubeless etc. specification of tyres.	5
6	**SUSPENSION SYSTEM:** Road springs, shock absorbers, independent suspension, road springs, air suspension, hydro-elastic suspension.	4
7	**STEERING SYSTEM:** Steering geometry, details, correct steering angle, Ackerman steering mechanism. Cornering power, over steering and under steering. Worm wheel and Rack pinion types of steering gears. Safety steering columns, power steering.	5
8	**IGNITION SYSTEM:** Various ignition systems (coil and magneto) and detailed study of their components, electronic ignition system, distributor less ignition system	4
9	**BATTERY AND STARTING SYSTEMS:** Storage battery (lead acid type), Maintenance free batteries, various components, Charging system, starting motors,	4

	starting drives, Bendix drive, Electronic starter control, starting system trouble shooting.	
10	**EMISSION CONTROL:** Emission norm like EURO and BHARAT norms, methods and devices to control emissions.	2
11	**MISCELLANEOUS TOPICS:** Automotive accessories, hydraulic single lever and two lever hydraulic systems for tractors, Technical specifications, controlling devices such as fuel gauge, temperature gauge, indicator lights speedometer odometer, HVAC etc.	2

List of Experiments		**No. of Turns**
1	To study and prepare report on the constructional details, working principles and operation of the Automotive Engine Systems & Sub Systems.	2
2	To study and prepare report on the constructional details, working principles and operation of the Fuels supply systems.	1
3	To study and prepare report on the constructional details, working principles and operation of the Automotive Clutches.	1
4	To study and prepare report on the constructional details, working principles and operation of the Automotive Transmission systems.	2
5	To study and prepare report on the constructional details, working principles and operation of the Automotive Drive Lines & Differentials.	2
6	To study and prepare report on the constructional details, working principles and operation of the Automotive Suspension Systems.	1
7	To study and prepare report on the constructional details, working principles and operation of the Automotive Steering Systems.	2
8	To study and prepare report on the constructional details, working principles and operation of the Automotive Tyres & wheels.	1
9	To study and prepare report on the constructional details, working principles and operation of the Automotive Brake systems.	1
10	To study and prepare report on the constructional details, working principles and operation of Automotive Emission / Pollution control systems.	1

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	**Knowledge Level (Blooms Level)**
1	Realize the need and importance of study of automobile engineering for mechanical engineers.	L4
2	Identify and compare the relative merits, demerits and applications of different systems and components in an Automobile.	L3, L4
3	Explain working of IC engines (Gasoline and Diesel) and various parameters related to it.	L5
4	Classify and Illustrate various elements of Automobile like, Transmission, Brakes, Suspension, and Steering etc.	L2, L4
5	Explain recent advancements in field of Automobile engineering, like, Electric Vehicles, Hybrid Vehicles, CRDI engines, ABS etc.	L2
6	Explain and illustrate various emission and safety regulations along with their importance in automobile engineering.	L5

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	1	-	-	-	-	-	-	-	-	-	2	-	-
CO2	3	1	-	-	-	-	-	-	-	-	-	2	-	-

CO3	3	1	-	-	-	-	-	-	-	-	-	2	-	-
CO4	3	1	-	-	-	-	-	-	-	-	-	2	-	-
CO5	3	1	-	-	-	-	-	-	-	-	-	2	2	2
CO6	3	1	-	-	-	3	-	-	-	-	-	2	-	-

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Automobile Engg., Kirpal Singh, Standard Publication distributors, Delhi Vol. I & Vol. II	2009
2	Encyclopaedia of Automotive Engineering, D. Crolla, D. E. Foster, T. Kobayashi and N. Vaughan (Editors-in-Chief), Parts 1-6, Wiley	2015
3	Automotive Engineering Fundamentals, R. Stone and J. K. Ball, SAE International.	2004
4	The Motor Vehicle, T. K. Garrett, K. Newton, and W. Steeds, 13thed., SAE International.	2001
5	Internal Combustion Engines, V. Ganesan, 3rd Edition, Tata McGraw Hill.	2007
6	Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, M. Ehsani, Y. Gao and A. Emadi, 2nd Edition, CRC Press.	2010
7	Car Suspension and Handling, D. B. Astow, G. Howard and J. P. Whitehead, 4th ed., SAE International.	2004

Course Name	**:**	**OPTIMIZATION TECHNIQUES IN ENGINEERING**
Course Code	**:**	**ME2004/ME3003/ME4004/ME6003**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: In this course, the student will be able to	
1	Understand engineering minima/maxima problems into optimization framework.
2	Learn computational procedures to solve optimization problems.
3	Learn software tool(s) to implement important optimization methods.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Introduction to Optimization, Adequate and Optimum Design, Principles of Optimization, Statement of an Optimization Problem, Classification, Formulation of Objective Function, Design Constraints.	4
2	**ONE-DIMENSIONAL UNCONSTRAINED OPTIMIZATION METHODS:** Optimality Criteria - necessary and sufficient conditions, Bracketing methods, Region-elimination methods, Point estimation method, Gradient based methods, Sensitivity analysis. Introduction to MATLAB tool and its application to these methods.	8
3	**MULTI-DIMENSIONAL UNCONSTRAINED OPTIMIZATION METHODS:** Optimality Criteria, Unidirectional search, Direct search methods, Gradient-based methods. Conjugate-direction methods, Quasi-Newton methods. MATLAB application.	8
4	**CONSTRAINED OPTIMIZATION METHODS:** Constrained Optimization Criteria, Penalty Methods, Method of Multipliers, Direct search methods, Linearization methods, Feasible Direction method, Generalized Reduced Gradient Method.	6
5	**NON-TRADITIONAL OPTIMIZATION TECHNIQUES:** Traditional vs non-traditional optimization, need for nontraditional optimization techniques, evolution of non-traditional optimization techniques in engineering.	4

6	**GENETIC AND ANN TECHNIQUES:** Genetic Algorithms, Simulated Annealing, Particle Swarm Optimization, Fuzzy logics, Artificial Neural Network (ANN) based Optimization. MATLAB application.	12

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the fundamentals of Linear and Dynamic Programming problems.	**L2**
2	Apply classical optimization techniques and numerical methods of optimization to solve problems.	**L3**
3	Analyze and make inferences of different evolutionary algorithms.	**L4**
4	Explain and identify the importance of Integer programming technique and apply different techniques to solve engineering problems	**L5**
5	Adapt software as a tool(s) to implement optimization algorithms.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	3	3	-	-	-	-	-	-	-	1	2	1
CO3	2	1	2	1	-	-	-	-	-	-	-	1	2	1
CO4	2	3	2	3	2	-	-	-	-	-	-	2	3	1
CO5	2	1	2	3	2	-	-	-	-	-	-	1	2	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Optimization for Engineering Design: Algorithms and Examples, Kalyanmoy Deb, PHI, New Delhi.	2005
2	Genetic Algorithms in Search, Optimization and Machine Learning, Goldberg, D.E., Addision-Wesley.	1989
3	Multi-objective Optimization using Evolutionary Algorithms, Deb, K., John Wiley and Sons.	2009
4	Engineering Optimization Theory and Practice, S. S. Rao, John Wiley and Sons.	2009
5	Modern Heuristic Optimization Techniques: Theory and Applications, Kwang Y. Lee, Mohamed A. El-Sharkawi, Kluwer.	2008

Course Name	**:**	**MECHANISMS AND MACHINES**
Course Code	**:**	**ME2005/ME4005**
Credits	**:**	**4**
L T P	**:**	**3 -1- 0**

Course Objectives: In this course, the student will be able to understand the

1. Concepts of various basic Mechanisms and Machines.
2. Kinematic analysis and synthesis of mechanisms.
3. Design process based on different mechanisms for a given application.
4. Mechanisms to be used for various machines and do failure analysis.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Mechanisms, classifications, relative and absolute motion, four	6

	bar mechanisms, planar and spatial mechanisms, inversion and equivalent linkage, transmission deviation and pressure angles, kinematic analysis of planar motion, relative velocity and velocity difference, pole and centrodes, relative acceleration and acceleration difference.	
2	**KINEMATIC SYNTHESIS OF MECHANISMS:** Movability, Number synthesis, Frudenstein's equation, Chebyshev spacing of precision points, Stages of kinematic synthesis and errors, Two and three position synthesis of Four-bar mechanism & slider crank mechanism, Overlay method, Bloch's method, Transmission angle in four bar and slider crank mechanism, function and path generation, Limit position & Least square techniques.	10
3	**LOWER PAIRS:** Universal joint- single and double, calculation of maximum torque, Oldham's Coupling, steering mechanism including Ackermann's and Davis steering mechanism, concepts of power steering, Mechanism with lower pairs, pantograph, exact and approximate straight-line motion, engine indicator, elliptical trammel.	6
4	**BELTS, ROPES AND CHAINS:** Materials, type of drive, idle pulley, intermediate or counter shaft pulley, angle and right-angle drive, quarter turn drive, velocity ratio, crowning of pulleys, loose and fast pulleys, stepped or cone pulleys, ratio of tensions on tight and slake sides of belts. Power transmitted by belts including consideration of creep and slip, centrifugal tension and its effect on power transmitted. Use of gravity, idler, flat, V-belts and rope, materials, Length of belt, rope and chain drive, types of chains.	6
5	**FORCE ANALYSIS:** Couple, equilibrium of forces and force systems, Free body diagrams, D-Alembert principle, Forces on slider crank mechanism, quick return mechanism & four-bar mechanism with more than two forces acting on a link, slider crank mechanism, Forces and couples for link and reciprocating parts; Dynamically equivalent system. analytical and graphical methods of solutions; Torque, inertia and gravitational force of a four bar linkage.	6
6	**BRAKES AND DYNAMOMETERS:** Types of brakes, principles of friction brakes, band, band & block and internal expanding shoe brakes, differential band brake, description of vacuum brake, types of dynamometers, measurement of power by prone brake and rope brake dynamometers, Heenan and Froude's Hydraulic dynamometer, Bevis-Gibson"s flash light torsion dynamometer, belt transmission dynamometer.	8

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recall the basic concepts of Kinematics and Dynamics	**L1**
2	Understand and apply concepts of kinematics and dynamics on the mechanism & machines.	**L2, L3**
3	Analysis and synthesis of mechanisms using different techniques.	**L4, L6**
4	Understand and evaluate various power transmission elements for their kinematic domain.	**L2, L5**
5	Dynamic analysis of various power transmission elements and mechanisms.	**L4**

CO-PO & PSO Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	-	-	-	-	-	-	-	1	1	1
CO2	3	3	3	2	-	-	-	-	-	-	-	1	3	1
CO3	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	2	-	-	-	-	-	-	-	2	3	1
CO5	3	3	3	2	-	-	-	-	-	-	-	1	3	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Theory of Machines, V.P. Singh, Dhanpat Rai & Co. Pvt. Ltd.,	2014
2	Theory of Machines, P.L. Ballaney, Khanna publishers.	1994
3	Theory of Machines, Shigley, Tata McGraw Hill.	1981
4	Mechanism & Machine Theory, J.S. Rao & R.V. Dukhipati, Wiley Eastren Ltd.	1992
5	Theory of Mechanisms, Amitabh Gosh & A.K. Mallik, East West Press Machines Private Ltd.	2006
6	Theory of Machines, S S. Rattan, McGraw Hill Education (India)	2014

Course Name	**:**	**VIBRATION AND NOISE CONTROL**
Course Code	**:**	**ME2006/ME4006**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: In this course, the student should be able to understand	
1	Theoretical and practical aspects of noise and vibration.
2	About the sources of vibration and noise in mechanical systems.
3	About the measurement techniques and instruments used in industry.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Review of vibration theory, one degree, two degrees, and multi-degrees of freedom vibration systems.	3
2	**VIBRATIONS UNDER GENERAL FORCING CONDITIONS:** Response under periodic force of regular and non-regular form, non-periodic force using Convolution Integral and Laplace transform.	7
3	**MEASUREMENT AND ANALYSIS OF VIBRATIONS:** Vibration measuring and analyzing instruments. Various types of transducers, data acquisition system, vibration analysis techniques.	6
4	**VIBRATION CONTROL:** Reduction of Vibration at the Source, Vibration Isolation, Vibration absorbers, active and semi-active vibration control systems.	7
5	**FUNDAMENTALS OF NOISE:** One dimensional wave equation, Sound propagation in 3-D space, important acoustic quantities and their relations, additive effects of sound.	6
6	**MEASUREMENT OF SOUND:** Various types of transducers, measurement of sound pressure, sound intensity and sound power.	6
7	**NOISE CONTROL:** Principles of passive noise control, sound absorption, noise barriers, and active noise control.	7

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Review the fundamentals of vibrations and sound.	**L1**
2	Evaluate the vibration under general forcing condition.	**L5**
3	Measure, analyze and control vibrations in a machine.	**L2, L4**
4	Design and develop vibration and noise control systems.	**L6**
5	Apply the vibration and noise standards on engineering systems.	**L3**

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	1	-	1	1	-	-	-	-	1	2	1
CO2	3	3	3	2	-	-	-	-	-	-	-	1	3	1
CO3	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	-	2	1	-	-	-	-	1	3	1
CO5	3	3	3	3	-	2	1	-	-	-	-	2	3	2

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Mechanical Vibrations, S. S. Rao, Pearson Education Inc.	2017
2	Mechanical Vibrations, V. P. Singh, Dhanpat Rai & Sons, Delhi	2012
3	Fundamental of Vibrations, Leonard Meirovitch, Mc-Graw Hill Inc.	2001
4	Noise control in industry: a practical guide, Cheremisinoff, Nicholas, Noyes Publications, New Jersey.	2003
5	Fundamentals of noise and vibrations analysis for engineers, Norton, M.P and Karczub, D.G, Cambridge University press, New York.	2003
6	Fundamentals of noise and vibration, Fahy, Frank and Walker, John, Taylor and Francis, London.	1998

Course Name	**:**	**COMPUTER AIDED DESIGN**
Course Code	**:**	**ME2007/ME4007**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives: In this course, the student will be able to

1. Learn the basic principles of geometric modeling and surface visualization.
2. Learn the theory and characteristics of curves and surfaces used to represent engineering structures.
3. Acquire the knowledge for generating high quality images of geometric models.
4. Learn how the CAD tools are used to integrate databases.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	**OVERVIEW OF CAD SYSTEMS:** Historical Development, Geometrical Modeling, Explicit and Implicit Equations, Intrinsic Equations, Parametric Equations, Coordinate Systems.	3
2	**MATHEMATICAL REPRESENTATION OF CURVES:** Fundamental of Curve Design, Parametric Space of a Curve, Blending Functions, Re-parameterization, Space Curves, Straight lines, Spline Curves, Bezier Curves, B-Spline Curve, Rational Polynomials, NURBS.	10
3	**MATHEMATICAL REPRESENTATION OF SURFACE**S: Fundamental of Surface Design, Parametric Space of a Surface, Re-parameterization of a Surface patch, Sixteen Point form, Four Curve Form, Plane surface, Cylindrical and Ruled Surfaces, Surface of Revolution, Bezier Surface, B-Spline Surface.	8
4	**SOLID MODELING:** Topology and Geometry, Set Theory, Boolean Operators, Set-membership Classification, Euler operators, Graph Based Models, Boolean Models, Instances and Parameterized Shapes, Cell Decomposition and Spatial Occupancy Enumeration, Sweep Representation, Constructive Solid Geometry, Boundary Representation.	10
5	**GEOMETRIC TRANSFORMATIONS:** Translation, Rotation, Scaling, Symmetry and Reflection, Homogeneous Transformations, Orthographic Projections,	6

	Axonometric Projections, Oblique Projections, Perspective Transformation.	
6	**ASSEMBLY DESIGN:** Assembly-Modeling, Analytical Properties, Relational Properties and Intersections, Data Transfer Formats.	5

List of experiments	No of Hrs
Students shall be practicing on how to generate the curves and surfaces used in CAD softwares with the help of computer programming.	28

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Create the different wireframe and surface primitives using parametric representations.	**L6**
2	Apply the concepts of transformations to evaluate the projections.	**L3, L5**
3	Understand and apply the concepts of curves and surfaces to engineering problems.	**L2, L3**
4	Identify and compare the techniques for the representation of solid in CAD tools.	**L2, L4**
5	Ability to create 2D and 3D models of various machine elements using CAD software.	**L6**

CO-PO & PSO Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	3	2	3	-	-	-	-	-	-	1	3	2
CO2	3	2	2	3	3	-	-	-	-	-	-	1	3	1
CO3	3	3	2	3	3	-	-	-	-	-	-	1	3	1
CO4	3	2	3	3	3	-	-	-	-	-	-	1	3	2
CO5	3	2	3	2	3	-	-	-	1	1	-	1	3	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	CAD/CAM Theory and Practice, Ibrahim Zeid, McGraw-Hill.	2009
2	Procedural Elements for Computer Graphics, Rogers, D. F., McGraw Hill.	2008
3	CAD/CAM/CIM, Radhakrishnan and Subramanyan, New Age International (P) ltd.	2008
4	Computer Aided Design (Software and Analysis Tools), Krishnamoorathy, C. S. and Rajeev, J. S., Narosa Publication House.	2005

Course Name	**:**	**FRACTURE MECHANICS AND FATIGUE**
Course Code	**:**	**ME2008/ME4008**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: In this course student will be able to understand

1.The physical and mathematical principles of fracture mechanics and fatigue.
2.Crack problem formulation through stress, displacement and energy methods.
3.The design principles of materials & structures using various fracture mechanics approaches with lower factor of safety.
4.The modern theory of fatigue dealing with nucleation and rate of propagation of crack.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	**BACKGROUND:** Introduction, kinds of failure & history, brittle and ductile fracture, modes of fracture failure, different techniques of fracture mechanics, potency of a crack, damage tolerance.	3
2	**ENERGY RELEASE RATE (ERR):** Introduction, Griffith's work and his dilemma, Surface energy, Griffith's realization and analysis, Mathematical formulation of ERR, ERR of Double Cantilever Beam specimen, anelastic deformation at crack tip, crack resistance, stable and unstable crack growth, R- curve for brittle crack, Thin plate v/s thick plate, critical ERR.	6
3	**STRESS INTENSITY FACTOR (SIF):** Introduction, Linear Elastic Fracture Mechanics, stress and displacement fields in isotropic elastic material, SIF and its mathematical background, Approach of Westergaard for different mode of fracture and its analysis.	9
4	**SIF OF MORE COMPLEX CASES:** Other applications of Westergaard approach, application of the principles of superposition, crack in a plate of finite dimensions, Edge and embedded cracks, Relationship between ERR and SIF, critical SIF, bending and twisting of cracked plates.	5
5	**ANELASTIC DEFORMATION AT THE CRACK TIP:** Investigation at the crack tip, approximate shape and size of the plastic zone, effective crack length, effect of plate thickness.	4
6	**ELASTIC PLASTIC ANALYSIS THROUGH J-INTEGRAL:** Relevance and scope, definition of J-integral, path independence, stress-strain relation, discussion on J-integral, Engineering Approach of J-integral.	4
7	**CRACK TIP OPENING DISPLACEMENT (CTOD):** Introduction, relationship between CTOD, SIF and ERR for small scale yielding, Equivalence between CTOD and J integral,	4
8	**TEST METHODS:** K_{IC} test techniques, Test methods to determine J_{IC}, Test methods to determine G_{IC} and G_{IIC}, Determination of critical CTOD.	2
9	**FATIGUE FAILURE:** Introduction, Terminology, S-N curve, crack initiation, crack propagation, Effect of an overload, crack closure, variable amplitude fatigue load.	3
10	**CRACK DETECTION THROUGH NDT:** Visual, LPI, Magnetic Methods, Radiography, Ultrasonic	2

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recall various kind of failures, ductile and brittle fracture of metals.	**L1**
2	Understand various modes of fracture and analyze the behavior of engineering materials having microscopic flaws by various approach	**L2, L4**
3	Apply the concepts of fracture mechanics philosophy to design of structural components taking into account presence of flaws, nature of loading and constitutive behavior of the material.	**L3, L6**
4	Apply the concept of fatigue failure of structure under variable fluctuation loading to engineering problems	**L3**
5	Understand the various test procedures to determine the fracture mechanics parameters of the materials.	**L2, L5**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	2	3	-	-	-	-	-	-	-	1	3	1

CO3	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO4	3	3	2	3	-	-	-	-	-	-	-	1	3	1
CO5	3	3	3	2	-	-	-	-	-	-	-	1	2	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Elements of Fracture Mechanics, Prashant Kumar, 1st ed., TMH, New Delhi.	2017
2	Elementary Engineering Fracture Mechanics, David Broek, Kluwer Academic Publishers Group, Dordrecht, Netherlands.	1986
3	Fracture Mechanics - Fundamentals and Applications, T. L. Anderson, 3rded., CRC Press, Taylor and Francis Group	2005
4	Fracture Mechanics by E. E. Gdoutos, 2nd ed., Springer International Publishing, Springer Nature Switzerland AG.	2005
5	Elementary Fracture Mechanics, S. A. Meguid, 1st ed.,Springer Netherlands,	1989
6	Introduction to Fracture Mechanics, Kare Hellan, McGraw Hill Book Company.	1985
7	e-book on Engineering Fracture Mechanics: K Ramesh, Published by IIT Madras, India, URL: https://apm.iitm.ac.in/smlab/kramesh/book_4.htm	2015

Course Name	**:**	**EXPERIMENTAL STRESS ANALYSIS**
Course Code	**:**	**ME2009/ME4009**
Credits	**:**	**4**
L T P	**:**	**3-1/2-2/2**

Course Objectives: To understand the

1.Relation between the theory of solid mechanics with experimental stress analysis.
2.Principles of photo elasticity in stress analysis.
3.Fundamental concepts about the experimental methods of stress analysis.
4.Use the experimental stress techniques on the practical problems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Stress at a point on an arbitrary plane in 3-D state of stress, differential equations of equilibrium, Laws of stress transformation, principal stresses and maximum shear stress, 2-D state of stress, displacement and strain, principal strains, compatibility conditions, stress-strain relations, Plane stress and plane strain problems, boundary conditions, Mohr's circle and stress plane, Three-dimensional stress-strain relations.	6
2	**BASIC OPTICS:** Basic concept and nature of light, polarization, decomposition of elliptically polarized light, passage of light through isotropic media and crystalline medium, normal incidence and oblique incidence, optic axis in refracting surface, absolute and relative phase difference, quarter and half wave plates, production of plane polarized light, light ellipse characteristics.	4
3	**2-DIMENSIONAL PHOTOELASTICITY:** Stress optics law, plane and circular polariscopes, isochromatics and isoclinics, white light and monochromatic light source, analysis of plane and circular polariscopes through trigonometric resolutions and Jones Calculus method, dark and bright field arrangement of circular polariscopes, isoclinics and isochromatics fringe order at a point, methods of compensation, calibration methods, use of white light in Photoelasticity, reversibility of optical system.	7
4	**PHOTOELASTIC DATA COLLECTION, ANALYSIS AND APPLICATIONS:** Photoelastic data, stress components, stress separation techniques and applications,	3

	properties of an ideal photoelastic material, casting technique, machining of photoelastic casting, stress relieving, 2-D and 3-D applications.	
5	**BIREFRINGENT COATING METHOD:** Theory of Birefringent coatings, reflection polariscope, sensitivity of Birefringent coating, separation of principal stresses, sources of errors, Birefringent coating materials and applications.	4
6	**MOIRÉ-FRINGEMETHODS AND ANALYSIS:** Mechanism of formation of Moiré fringes, geometrical approach to Moiré-Fringe analysis, displacement field approach to Moiré-Fringe analysis for in-plane and out of plane problems, out of plane slope measurements, sharpening and multiplication of Moiré-Fringes, experimental procedure and techniques.	4
7	**BRITTLE COATING METHODS:** Brittle coating materials, Relation between the state of stress in coating and in the model, law of failure of brittle coatings and interpretation of crack-pattern data, Isostatics and Isoentatics, relative merits of stress coat and all temperature coating, Accuracy of brittle coating application, crack detection techniques, calibration of brittle coating materials.	4
8	**STRAIN MEASUREMENT:** Classification and brief over-view of the strain measurement devices, Electrical resistance strain gauge and types, gauge materials, backing material of strain gauge, adhesives used, bonding of strain gauge, checking accuracy of bonding, performance of strain gauge, strain gauge circuits, strain gauge rosettes.	6
9	**DIGITIZATION OF PHOTOELASTICITY:** Basic concepts and methodologies of digitization in photoelasticity, formulation of problems and applications, data acquisition by digital image processing techniques, data analysis by statistical techniques, data presentation by computer graphics.	4

List of experiments	No of Hrs
Students shall be practicing to solve the engineering problems using photo-elastic bench and other experimental methods of stress analysis.	14

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recall and review principles of solid mechanics	**L1**
2	Understand the basics of optics as used in photo-elasticity	**L2**
3	Interpret photo-elasticity data and evaluate stress & strain from these	**L3, L5**
4	Apply coating techniques to analyze crack in the structure	**L3, L4**
5	Understand and apply strain measurement device to determine the strain in mechanical components	**L2, L3, L5**
6	Acquire the knowledge on Moiré fringe method, digitization of photo-elasticity and its application in experimental stress analysis.	**L2**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	2	1	2	-	-	-	-	-	-	-	1	2	1
CO3	3	3	3	3	1	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO5	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO6	3	3	3	3	1	-	-	-	-	-	-	1	3	1

Suggested Books:		
Sr.	**Name of Book/ Authors/ Publisher**	**Year of**

No.		Publication/ Reprint
1	Experimental Stress Analysis, L S Srinath, MR Raghavan, K Lingaiah, G Gargesha, B Pant, K Ramachandra, Tata McGraw Hill.	1984
2	Experimental Stress Analysis, Dally, J.W. and Riley, W.F, 3rd ed., McGraw Hill Education.	1991
4	e-book on Experimental Stress Analysis: K Ramesh, Published by IIT Madras, India, URL: http://apm.iitm.ac.in/smlab/kramesh/book_5.htm	2009
5	Photoelastic Stress Analysis, Kuske A and G Robertson, John Wiley & Sons, London.	1974
6	Digital Photoelasticity - Advanced technique and application, K Ramesh, Springer-Verlag.	2000
7	Experimental Stress Analysis, UC Jindal, Pearson	2012

Course Name	**:**	**MECHANICS OF COMPOSITE MATERIALS**
Course Code	**:**	**ME2010/ME4010**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:

1.To acquire basic understanding of composites materials.
2.To develop an understanding of themacro & micro mechanical analysis of a lamina.
3.To develop an understanding of the micromechanical analysis of laminates.
4.To impart the knowledge about the failure analysis and design of laminates.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	**INTRODUCTION TO COMPOSITE MATERIALS:** Introduction and Need of composite materials, *Classification of composite materials*: Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, Carbon–Carbon Composites, Characteristics of reinforcements and Matrix Materials, Recycling Fiber-Reinforced Composites, Mechanics Terminology.	6
2	**MACRO MECHANICAL ANALYSIS OF A LAMINA:** Definitions, Stress, Strain, Elastic Moduli, Strain Energy, Hooke's Law for Different Types of Materials, Hooke's Law for a 2-D Unidirectional Lamina, Reduction of Hooke's Law from 3-D to 2-D, Relationship of Compliance and Stiffness Matrix to Engineering Elastic Constants of a Lamina, Hooke's Law for a 2-D Angle Lamina, Invariant Form of Stiffness and Compliance Matrices for an Angle Lamina, *Failure Theories of an Angle Lamina*: Maximum Stress Failure Theory, Strength Ratio, Failure Envelopes, Maximum Strain Failure Theory, Tsai-Hill Failure Theory, Tsai–Wu Failure Theory, Comparison of Experimental Results with Failure theories. Hygrothermal Stresses and Strains in a unidirectional and angle Lamina.	11
3	**MICRO-MECHANICAL ANALYSIS OF A LAMINA:** Introduction, Volume and Mass Fractions, Density, Void Content, *Evaluation of the Four Elastic Moduli*: Strength of Materials Approach, Semi-Empirical Models, Elasticity Approach and Elastic Moduli of Lamina with Transversely Isotropic Fibers for various types of modulus, Ultimate Strengths of a Unidirectional Lamina for tensile, longitudinal compressive, transverse compressive and in-plane shear, Longitudinal and transverse Thermal Expansion Coefficients, Thermo-elastic Deformation Analysis, Coefficients of Moisture Expansion.	10
4	**MICROMECHANICAL ANALYSIS OF LAMINATES:** Introduction, Laminate Code, Stress–Strain Relations for a Laminate, One-Dimensional Isotropic Beam, Stress-Strain Relation, Strain-Displacement Equations, Strain and Stress in a Laminate, Force	9

	and Moment Resultants Related to Mid-plane Strains and Curvatures, In-Plane and Flexural Modulus of a Laminate, Hygrothermal Effects in a Laminate like Hygrothermal Stresses and Strains, Coefficients of Thermal and Moisture Expansion of Laminates, Warpage of Laminates.	
5	**FAILURE ANALYSIS AND DESIGN OF LAMINATES:** Introduction, *Special Cases of Laminates*: Symmetric Laminates, Cross-Ply Laminates, Angle Ply Laminates, Anti-symmetric Laminates, Balanced Laminate, Quasi-Isotropic Laminates, Failure Criterion for a Laminate, Design of a Laminated Composites, Other Mechanical Design Issues, Sandwich Composites, Long-Term Environmental Effects, Inter-laminar Stresses, Impact Resistance, Fracture Resistance, Fatigue Resistance.	6

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recall the basics of Solid Mechanics.	**L1**
2	Understand the mechanical properties of various commercial composite materials.	**L2**
3	Analyze and evaluate the mechanical properties of Lamina at Macro and Micro level.	**L4 & L5**
4	Analyze and evaluate the mechanical properties of Laminates at Micro level.	**L4 & L5**
5	Develop a methodology for stress and progressive failure analysis of laminated composite structures to apply in aerospace, automobile, marine and other engineering applications.	**L3 & L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	2	1	-	-	-	-	-	-	-	1	2	1
CO2	2	2	1	1	-	-	-	-	-	-	-	1	2	1
CO3	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO5	3	3	3	3	-	-	2	-	-	-	-	1	3	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Mechanics of Composite Materials, Autar K. Kaw, 2nd ed., CRC Press.	2005
2	Mechanics of Composite Materials, Jones. R. M., Taylor & Francis Press	1999
3	Composite Material Science andEngineering,K.K.Chawla,3rd ed., Springer.	2012
4	Engineering Mechanics of Composite Materials, I.M. Daniel, O. Ishai, Oxford University Press.	2006
5	Analysis and Performance of Fiber Composites, B D Agarwal, L J Broutman, John Wileyand Sons.Inc.,New York.	1995
6	Stress analysis of fiber Reinforced Composite Materials, Michael W, Hyer, McGraw Hill International.	2009

Course Name	**:**	**VEHICLE DYNAMICS**
Course Code	**:**	**ME2011/ME4011**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:	
1	To understand the basic principles used in dynamic analysis of vehicles.
2	To gain the basic knowledge in the field of vehicle vibrations.
3	To understand the stability of vehicles and their effects related to longitudinal, vertical & lateral dynamics.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**BASICS OF MODELING:** Introduction to Vehicle dynamics, Fundamental approach of Modeling, lumped mass, Euler Angles, Vehicle fixed and Earth fixed coordinate systems, motion variables, Newton's second law, Dynamic axle load, static loads on level ground, Role of inertia, Road modeling.	6
2	**TYRE DYNAMICS:** Tyre forces and moments, Tyre structure, Size and Load Rating, Terminology and Axis System, Tractive and cornering property of tyre, Camber Thrust, Castor, Aligning Moment, Combined Braking and Cornering, Conicity and Ply Steer, Performance of tyre on wet surface, Ride property of tyres, Magic formulae tyre model, Estimation of tyre road friction, Test on Various road surfaces, Tyre vibration and chattering.	6
3	**VEHICLE VIBRATIONS**: Measures of Ride quality, predictions of vibrations, suspension stiffness and damping, road roughness models, response to speed breakers, Heave, pitch and roll phenomenon of dynamic motion, quarter, half and full vehicle model, Seat suspension, relation to human body vibrations.	6
4	**SUSPENSIONS:** Suspension Kinematics, Suspension types, Solid Axles, Independent Suspensions, Anti-Squat and Anti-Pitch Suspension Geometry, Anti-Dive Suspension Geometry, Roll Center Analysis, Suspension Dynamics, Multi-body vibration, Body and Wheel hop modes, Invariant points, *Controllable Suspension Elements*: Active, Semi-Active. Choice of suspension spring rate, Calculation of effective spring rate, Vehicle suspension in fore and apt directions.	6
5	**STEERING SYSTEM:** Steering Linkages, Steering System Forces and Moments, Steering System Models, Steering Geometry, Steady Handling (2 DOF steady state model), Under and Over-steer, Effect of Tyre Camber and Vehicle Roll (3 DOF steady-state model), Transient Handling and Directional Stability (2 DOF unsteady model), Effect of Vehicle Roll on Transient Handling (3 DOF unsteady model), Steady-State and Transient Handling of Articulated Vehicles.	6
6	**LONGITUDINAL DYNAMICS:** *Dynamic wheel loads*: Simple vehicle model, influence of grade, Aerodynamic Forces and Moments, Resistance, Rolling Resistance, Load Distribution for Three Wheeler and Four Wheeler, Calculation of Maximum Acceleration, Reaction Forces for Different Drives, Braking and Driving Torque, Prediction of Vehicle Performance.	6
7	**LATERAL DYNAMICS:** Steady State Handling Characteristics, Steady State Response to Steering Input, Testing of Handling Characteristics, Transient Response Characteristics, Direction Control of Vehicles Roll Center, Roll Axis, Vehicle Under Side Forces, Stability of Vehicle Running on Slope, Banked Road and During Turn, Effect of Suspension on Cornering, Latest Trends in Vehicle Dynamic Testing Like Four Poster, Multi Axis Simulator.	6

List of experiments	No of Hrs
The experiment work in this course is intended to be carried out to simulate and study a quarter, half and full vehicle models, behavior of sprung / un-sprung mass & lumped mass system and the effect of different conditions on vehicle loading using MATAB and ANSYS software in the CAD Lab. In addition, study of latest technologies available nowadays in vehicles helping to maintain stability of the vehicle on the road.	28

Sr. No.	Course outcome By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recall the basic concept of vibrations and automobile.	**L1**
2	Understand the vehicle dynamics and apply the vibration concepts when the vehicle is in dynamic condition.	**L2 & L3**
3	Analyze the tyre dynamics with respect to force & moments.	**L4**
4	Evaluate the effective steering geometry, vehicle handling and directional control of vehicle.	**L5**
5	Develop the aerodynamic forces & moments, load distribution in the different vehicles.	**L6**
6	Ability to model and simulate the vehicle using MATLAB and ANSYS software to analyze the vehicle dynamics.	**L4**

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	3	2	-	-	-	-	-	-	-	1	3	1
CO3	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO5	3	3	3	3	-	-	-	-	-	-	-	-	3	1
CO6	2	2	2	3	3	-	-	-	2	2	-	1	2	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Fundamentals of Vehicle Dynamics, Thomas D. Gillespie, Society of Automotive Engineers Inc.	1992
2	Theory of Ground Vehicles, Wong. J. Y., 3rd ed., Wiley-Interscience.	2001
3	Vehicle Dynamics and Control, Rajesh Rajamani, 1st ed., Springer.	2005
4	Vehicle Stability, Dean Karnopp, 1st ed., Marcel Dekker.	2004
5	Vehicle Dynamics: Theory and Application, Nakhaie Jazar. G., 1st ed., Springer.	2008
6	Tyre and Vehicle Dynamics, Hans B Pacejka, 2nd ed., SAE International.	2005

Course Name	**:**	**KINEMATIC AND DYNAMICS OF ROBOTS**
Course Code	**:**	**ME2012/ME4012**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:	
1	To impart the knowledge about anatomy of the robots.
2	To demonstrate the concepts of kinematics & dynamics of robot.
3	To demonstrate the robot programming and their applications in industrial robots.
4	To provide the knowledge of how industrial robots' functions.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION OF ROBOTICS:** Definition of a robot, Robot Anatomy, types of robotic joints and motions, *Classifications of robot*: Physical configurations, actuators	5

	and motion control, Terminologies used for robotics specification and selection for industrial applications, Design and Control issues, manipulation and control, end effector.	
2	**COORDINATE FRAMES, MAPPING AND TRANSFORMS:** *Coordinate frames:* Mapping between rotated frames, Mapping between translated frames, Mapping between combined rotated and translated frames, Description of objects in space, Transformation of vectors, composite transformation, inverting a homogeneous transform, *Fundamental rotation matrices*: Principal axes rotation, fixed angle representation, Euler angle representation, equivalent angle axis representation.	7
3	**ROBOT KINEMATICS:** Mechanical structure and notation, description of links and joints, kinematic modeling of the Robot, Denavit-Hartenberg notation, Kinematic relationship between adjacent links, Robot transformation matrix, forward and inverse kinematics for basic industrial robotic configurations.	8
4	**JACOBIAN FOR VELOCITY AND STATIC FORCES:** Notation for time varying position and orientation, linear and rotational velocity of rigid bodies, angular velocity, motion of the link of a robot, velocity propagation of link to link, Jacobians, singularities, static forces in robots, Jacobian in the force domain, Cartesian transformation of velocities and static forces.	6
5	**ROBOT DYNAMICS:** Introduction to Lagrangian mechanics and Dynamic equation for 2 DOF robots, Introduction to position control and force control of robotic robots, Robot actuation and control using PID controllers.	6
6	**ROBOT PROGRAMMING:** Programming methods, Robot language classification, Robot language structure, elements and its functions, Motion, End-effecter and sensor commands in VAL programming language.	4
7	**ROBOT VISION:** Sensing and digitization of vision data, *Image Processing*: image data reduction, segmentation, feature extraction, object recognition and training of vision system.	6

List of experiments	No of Hrs
The experiment work in this course is intended to be carried out in the area of basic of Industrial Robotics, Robot Analyzer for learning different robot configuration, robot kinematics and programming in the Simens CoE Robotics Lab.	28

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the basics concepts of robots and apply the transformations for mapping of frames and axis rotations	**L2 & L3**
2	Develop the forward and inverse kinematics of robots.	**L6**
3	Analyze the forces in links and joints of a robot.	**L4**
4	Apply the Lagrange equation to evaluate the dynamics of a robotic arm.	**L3 & L5**
5	Understand the robot vision and robot Programming methods and language to perform tasks in industrial applications.	**L2**
6	Ability to program a robot for different robot configuration to perform different tasks.	**L4**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2	2	-	-	-	-	-	-	-	1	3	1
CO2	3	2	2	3	-	-	-	-	-	-	-	1	3	1
CO3	3	3	2	3	-	-	-	-	-	-	-	1	3	1

CO4	3	3	2	3	-	-	-	-	-	-	-	1	3	1
CO5	1	1	1	1	-	1	-	-	-	-	-	1	2	2
CO6	2	2	3	2	3	2	1	-	2	2	-	2	3	3

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Fundamental concepts and analysis, Ashitava Ghosal, Robotics, Oxford University Press.	2006
2	Robotics Control, Sensing, Vision and Intelligence, K. S. Fu, R. C. Gonzalez, C. S. G. Lee, McGraw-Hill.	1987
3	Introduction to Robotics: Mechanics and Control, John. J. Craig, PHI.	2005
4	Robotic Engineering An Integrated Approach, R. D. Klafter, T.A. Chmielewski, M. Negin, PHI.	2007
5	Fundamentals of Robotics: Analysis & Control, Robert J. Schilling, Pearson Education.	2000
6	Robotics, K. K. Appuu Kuttan, I K Internationals	2007

Course Name	**:**	**WORK STATION DESIGN AND NEURO-ERGONOMICS**
Course Code	**:**	**ME2013/ME4013**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:	
1	This course is designed to teach the fundamentals of Designing of Ergonomically correct Work Stations
2	To study latest techniques used in the evaluation of human work in all contexts that leads systematically to the investigation of all the factors which affect the efficiency and economy of human energy at the work place
3	It helps in designing and improvement in the methods and procedures which are most effective, require the least efforts and are the best suited to the industrial workers.

Total No. of Lectures – 42

S. No.	**Contents**	**No. of Lectures**
1	**WORK STUDY FUNDAMENTALS:** Definitions, Scope and applications, Productivity and Work Study, Analysis of Work Content, Introduction to Industrial Engineering and Productivity, Measurement tools of productivity.	3
2	**METHOD STUDY:** Process Analysis, Process and Activity Charts, Operation Analysis, Basic Procedure, Micro Motion Study, Principles of Motion Economy.	5
3	**WORK MEASUREMENT:** Purposes and Uses, Basic Procedure, *Techniques*: Work Sampling, Rating and Allowances, Setting Standard Times for Jobs, Standard Data, Predetermined Motion Time Systems, MTM, Work factor and MOST, Job Evaluation of Merit Rating, Wage Incentive Plans.	8
4	**ERGONOMICS AND RISK ASSESSMENT:** Concepts, Issues in Work System Design, Measuring Work by Physiological Means, Work Posture, Fatigue Measurement & Evaluation, Work Systems, Limitation of Man & Machine with respect to each other by risk assessment techniques such as RULA, REBA, OCRA, NIOSH, SI, PLIBEL, QEC and OWAS.	8
5	**WORK LOAD MEASUREMENT:** Human Motor Activity, Anatomy of human muscles and brain lobes, Metabolism, Physical and Mental Work load and their Measurement, Introduction to work related musculoskeletal disorders and mental	10

	fatigue, Introduction to Neuro-ergonomics and quantification of neuro-signals from electro-encephalography and electromyography by linear and non-linear techniques with respect to work duration and rest periods, Introduction to Digital Human Modelling Techniques.	
6	**CLIMATES AND NOISE EVALUATION:** *Heat Humidity*: Body heat Balance, Effective Temperature Scales, Zones of Discomfort, Effects of Heat on Body and Work Performance, *Vibration*: Response of Body to Low Frequency Vibration, Vibrations and Discomfort, Effect on Health of Worker, Effect of High Frequency Vibrations, Methods of Reducing Vibrations, Analysis, *Noise*: Physiological Effects of Noise, Annoyance of Noise, Speed Interference, Hearing Loss, Temporary and Permanent Threshold Shift, Effect of Noise on Performance, Reduction of Noise, Personal Noise Protection.	8

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Assess all industrial activities with respect to motion study and there by design work stations.	**L5 & L6**
2	Quantification of physical and mental work load of the workers by latest neurological techniques.	**L5**
3	Identify and assess the environmental and climatic working conditions in industry.	**L2 & L5**
4	Analyze and apply different risk assessment techniques to predict risk involved in work with respect to development of musculoskeletal disorders.	**L3 & L4**
5	Application of all latest time study techniques to calculate standard time to carry-out any industrial job.	**L3**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	3	1	2	-	-	-	-	1	1	2	1
CO2	3	3	3	3	3	2	-	-	-	-	1	1	2	1
CO3	2	3	3	2	-	2	2	-	-	-	1	1	1	1
CO4	3	3	3	3	-	2	-	-	-	-	1	1	2	1
CO5	3	3	2	3	-	-	-	-	-	-	1	1	1	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Motion and Time Study, Design and Measurement of Work, Ralph M. Barnes, Wiley India.	2009
2	Neuro-Ergonomics, Raja Parasuraman & Mathew Rizzo, Oxford University Press.	2007
3	Handbook of Digital Human Modelling, Vincent G. Duffy, CRC Press Taylor & Francis Group.	2009
4	Ergonomics Laboratory Exercises, Timothy Joseph Gallwey & Leonard William O' Sullivan, CRC Press Taylor & Francis Group.	2009
5	International Standard Manual of Ergonomics, Part-1: Lifting and Carrying; Part-2: Pushing and Pulling, Part-3: Handling of Low Loads at High Frequency.	2009

Course Name	**:**	**COMPUTER AIDED MANUFACTURING**
Course Code	**:**	**ME2014/ME4014**
Credits	**:**	**4**

L T P	:	3-0-2

Course Objectives: To impart the knowledge of	
1	Automation and NC, CNC machining techniques.
2	Industry 4.0, importance and application of robots in manufacturing.
3	Design of automated guided vehicle and flexible manufacturing system systems.
4	Design the manufacturing cell, concept of group technology, computer aided process planning and cellular manufacturing system.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	**INTRODUCTION TO CIM:** Definition, scope and elements of CIM system, benefits, Production system facilities, Manufacturing support systems, Automation in production systems, Automated manufacturing systems, Computerized Manufacturing Support Systems, Need, principles and strategies of automation.	4
2	**NC and CNC MACHINES:** Basic components, NC coordinate and motion control systems, Machine Control Unit for CNC and DNC, CNC Software, advantages, disadvantages and applications; *Construction of CNC machines*: Machine structure, Static, dynamic and thermal load; *Guide ways:* Friction, V-guide, Flat & dove-tail, Cylindrical, Anti frictional linear motion; *Feed drives:* Servomotors, Mechanical transmission system, Spindle and drives; *Bearings*: Hydrodynamic, Hydrostatic and Antifriction bearings; *Measuring systems*: direct, indirect measuring and gauging, tool monitoring; Automatic tool and pallet changer.	8
3	**PART PROGRAMMING:** Coordinate system, Dimensioning, Axes and motion nomenclature, Importance of reference systems like machine zero, part zero and machine reference point, CNC part programming: Structure of part programme, Preparatory functions (G); Miscellaneous functions (M), Tool compensation, Subroutines (Macros) (L), Canned cycles, Mirror image, Simple part programming's for milling and turning operations.	6
4	**COMPUTERISED PROCESS PLANNING:** Process planning and Computer Aided Process Planning (CAPP), Aggregate Production Planning and the Master Production Scheduling, Material requirement planning, Capacity planning, computerize shop floor and inventory control, Enterprise Resource Planning (ERP), Simple Problems.	4
5	**CELLULAR MANUFACTURING:** Group Technology(GT), Part Families, Parts Classification and coding, Simple Problems in Optiz Part Coding system, Cellular Manufacturing, Composite part, Machine cell design and layout, Rank and Order Clustering Method, Arranging Machines in a GT cell-Hollier Method.	4
6	**FLEXIBLE MANUFACTURING SYSTEM AND AUTOMATED GUIDED VEHICLE SYSTEM:** Types of Flexibility, *FMS:* Components, planning, control and quantitative analysis, application & benefits; *AGVS:* Vehicle Guidance technology, Vehicle management and safety, Applications.	4
7	**INDUSTRIAL ROBOTICS:** Robot anatomy and attributes, Classification, Robot Control systems, End Effectors, Sensors, Accuracy and Repeatability; Applications, Robot Part Programming for pick and place for Simple Problems.	8
8	**INTRODUCTION TO INDUSTRY4.0:** The Fourth Revolution, Smart Factories, Industry 4.0: Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis	4

Sr. No.	Course outcome By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the computer Integrated Manufacturing systems comprising CNC	L2

	machines, Industrial robots and IoT enabled activities.	
2	Compare and judge the various components of CNC machines including machine controller, servomotors, guide ways, spindles, bearings, tool changers, positions sensors etc.	**L5**
3	Apply the principle of part-programming for computer aided process planning in manufacturing systems.	**L3**
4	Design automated material handling and storage systems using computer integrated data management system.	**L6**
5	Analyzing the flexible manufacturing cells using concept in group technology, industrial robotics and computer aided process planning.	**L4**
6	Understand the opportunities, challenges of Industry 4.0 for organizations and individuals.	**L2**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	3	1	1	-	-	-	-	-	1	1	3	1
CO3	3	3	3	2	2	-	-	-	-	-	2	1	3	2
CO4	3	3	3	3	3	-	2	-	-	-	1	2	3	2
CO5	3	3	3	1	2	-	2	-	-	-	-	2	3	2
CO6	3	3	2	1	1	-	1	-	-	-	-	1	2	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Automation, production Systems and Computer Integrated Manufacturing, Mikell P Groover, 3rd Edition, Prentice Hall Inc., New Delhi	2012
2	System Approach to Computer Integrated Manufacturing, Nanua Singh, Wiley &Sons Inc.	1996
3	CAD/CAM/CIM, Radhakrishnan P, Subramanyan S. and Raju V., 2nd Edition, New Age International (P) Ltd, New Delhi.	2000
4	Computer Aided Manufacturing, Rao. P, N Tewari &T.K. Kundra, Tata McGraw Hill Publishing Company,	2000

Course Name	**:**	**PRECISION ENGINEERING**
Course Code	**:**	**ME2015/ME4015**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
1.To understand the concept of precision engineering and its principles. 2.To familiarize the importance as applicable to instruments and machines. 3.To familiarize with MEMS-principle, elements-characteristics-design and application. 4.To familiarize with the nanotechnology and electrochemical atomic bit processing.

Total No. of Lectures – 42

Lecture wise breakup	**No. of**

		Lectures
1	**CONCEPT OF PRECISION ENGINEERING:** Introduction to accuracy & precision, need and applications of precision engineering, Tool based Micro & Ultra precision processes, Materials for tools and machine elements, ceramic, CBN & diamond micro tools.	6
2	**ULTRA-PRECISION MACHINE ELEMENTS:** Introduction of Guide ways, Drive systems, Spindle drive, preferred numbers, Rolling elements, hydrodynamic & hydrostatic bearings, pneumatic bearing.	6
3	**MEMS**: Introduction, Principle, Elements, Characteristics, Design, applications in automobile, defense, aerospace, medical sectors.	6
4	**ERROR CONTROL*:*** Error, Sources, Static stiffness, Variation of the cutting force, total compliance, *Machining methods:* milling, drilling, grinding; *Thermal effects:* heat source, heat dissipation, Stabilization, decreasing of thermal effects; effects of forced vibration on accuracy, clamping & setting errors, errors due to locations and Control, principle of constant location surfaces.	7
5	**SURFACE ENGINEERING:** Surface finish, Relationship between attainable tolerance grades and different machining processes, Cumulative effect of tolerances, sure fit law, normal law and truncated normal law related to surface finish.	5
6	**FUNDAMENTALS OF NANOTECHNOLOGY:** System of nano-meter accuracies, Mechanism of metal Processing, Nano physical processing of atomic bit units, Nanotechnology and Electrochemical atomic bit processing.	6
7	**MEASURING SYSTEMS**: In-processing and in-situ measurement of position, Post process and on-machine measurements, dimensional, mechanical and optical measuring systems.	6

List of practical's / mini-projects		**Hours**
1	Experiments on Micro EDM and analysis of accuracy & precision of machined surface finish	8
2	Mini project on MEMS.	8
3	Micro gear cutting and analysis of accuracy, clamping & setting errors.	6
4	Grinding analysis of thermal effects.	6

Sr. No.	**Course outcome** By the end of this course, the student will be able to	Knowledge Level (Blooms Level)
1	Understanding the concept and need for Precision Engineering.	**L2**
2	Apply the concept of precision engineering and its principle in the ultra-precision domain.	**L3**
3	Analyse the tolerance grades and physical processes applied to surface engineering.	**L4**
4	Design the various components of MEMS for different industries.	**L6**
5	Measure and Judge to select different measuring systems used in precision engineering.	**L5**
6	Estimate the error and analyse the thermal effects on machining methods applied to manufacturers of precision components.	**L5**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	1	1	1	1	-	-	-	-	-	-	1	1	1
CO2	2	1	1	1	2	-	-	-	-	-	-	1	2	1
CO3	2	2	2	2	2	-	-	-	-	-	-	2	2	2

CO4	3	3	3	3	2	-	-	-	2	-	-	2	3	2
CO5	2	2	2	2	3	-	1	-	-	-	-	2	2	3
CO6	3	3	3	2	3	-	-	-	-	-	-	2	3	2

Text Books:		
Sr. No.	**Name of the Book/ Authors/Publisher**	**Year of Publication/Reprint**
1	Nakazawa, H. Principles of Precision Engineering, Oxford University Press,	1994
2	Nano Technology, Norio Taniguchi, Oxford University Press.	1996
3	Precision Engineering in Manufacturing, Murthy R. L., New Age International (P) Limited.	1996
4	Geometric Dimensioning and Tolerancing, James D. Meadows, Marcel Dekker Inc.	1995

Course Name	**:**	**ADVANCE MANUFACTURING TECHNIQUES**
Course Code	**:**	**ME2016/ME4016**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: To impart the knowledge of	
1.	Surface modification, PVD, CVD, cladding, diffusion and diamond coating.
2.	Rapid prototyping, hybrid and micro machining.
3.	Advance mechanical, thermal, chemical and electrochemical non-conventional machining.
5.	Advance finishing process and fabrication of microelectronic devices.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION**: Trends in modern manufacturing, Classification of advanced manufacturing, *Surface modification:* Advanced ceramic and organic methods, cleaners, Electro forming, physical and chemical vapour deposition, thermal spraying, ion implantation, diffusion coating, diamond coating and cladding.	6
2	**NON-TRADITIONAL MACHINING:** ***Mechanical methods*****:** USM, AJM, AWJM processes: Principle, process parameters, description, mechanics of material removal rate, effect of parameters on machining responses, capabilities, limitations and applications; *Chemical and electrochemical methods:* Fundamental and mechanics of material removal; CH, ECM, ECG, Electrochemical deburring, Electrochemical honing processes: description, material removal rate, effect of process parameters on performance characteristics, capabilities, limitations and applications; *Thermal methods:* EDM, WEDM, LBM, EBM, PAM, PAW processes: Principles, mechanics of material removal rate, equipment, analysis of circuits, performance characterization, effect of process parameters on MRR and surface finish, capabilities, limitations and applications.	10
3	**HYBRID AND MICRO MACHINING:** *Hybrid machining:* Concept, Classification. ECSM, TWECDM, LAECSM, VAEDM, EDG, Process description, performance characterization, parametric effect, capabilities, limitations and applications; *Micromachining:* Introduction to micro machining, micro-turning, micro-milling, micro-drilling, micro EDM, micro-WEDM, micro ECM: Process parameters, MRR, performance characterization, parametric effect, capabilities, limitations and applications.	8
5	**RAPID PROTOTYPING:** Importance and Types, Principles and advantages, Stereo lithography, FDM, SLS, factors effecting the responses of RP, Accuracy and Economic considerations.	5

6	**ADVANCE FINISHING PROCESS:** AFM, MRF, MRAFF, MFP, EEM, CMP: Process description, mechanics of finishing, performance characterization, parametric effect, capabilities, limitations and applications.	6
7	**FABRICATION OF MICROELECTRONIC DEVICES:** Crystal growth and wafer preparation, Film Deposition oxidation, lithography, bonding and packaging, reliability and yield, Printed Circuit boards, computer aided design in microelectronics, Integrated circuit and surface mount technology, E-Manufacturing, nanotechnology and MEMS.	7

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recall previously learnt basic concept of manufacturing and trends in modern manufacturing	**L1**
2	Understand the philosophies of advanced and modern manufacturing	**L2**
3	Plan and apply the concept of non-traditional and hybrid machining	**L3**
4	Analyse the effects of various process parameters on process performance characteristics.	**L4**
5	Ability to decide the appropriate manufacturing processes for quality finishing in nano domain.	**L5**
6	Adapt e-manufacturing, nanotechnology and MEMS for fabrication of microelectronic devices.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	3	1	-	-	-	-	-	-	-	1	2	2	3
CO2	3	2	3	1	2	-	-	-	-	-	1	2	3	1
CO3	3	3	3	2	2	-	-	-	-	-	2	3	3	2
CO4	2	3	1	3	1	-	-	-	-	-	1	2	2	1
CO5	2	2	3	3	3	-	-	-	-	-	2	1	3	1
CO6	1	1	1	2	3	-	-	-	-	-	1	1	2	2

	Name of Book/ Authors/ Publisher	**Year of Publication/ Reprint**
1.	Manufacturing Engineering and Technology, Kalpakijian, Adisson Wesley	1995
2.	Process and Materials of Manufacturing, R. A. Lindburg, 4th edition, PHI	1990
3.	Foundation of MEMS, Chang Liu, Pearson publications.	2012
4.	Advanced Machining Processes, V.K.Jain, Allied Publications	2007
5.	Introduction to Manufacturing Processes, John A Schey, Mc Graw Hill	2012

Course Name	**:**	**PRODUCTION PLANNING & CONTROL**
Course Code	**:**	**ME2017/ME4017**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: To impart the knowledge about the:	
1.	Concept and significance of Production planning & control.
2.	Plant capacity, location, layout and its applications.
3.	Routing, Scheduling, Purchasing and Dispatching.
4.	New trends in operations management used in industries.

Total No. of Lectures – 42

Lecture wise breakup		**No. of lectures**
1	**INTRODUCTION:** Objectives of production planning and control, functions and its advantages, types of controls and procedures.	4
2	**PLANNING:** Capacity planning, types of capacity plans, factors affecting the plant capacity, capacity planning strategies, investment decisions, comparison of alternatives, planning for making or buying, types of plans, mathematical planning techniques, analysis of machine capacity, planning for labour, aggregate production planning.	8
3	**ROUTING**: Definition, routing procedure including bills of materials, route sheet, route file, routing for two or more items, standard route chart and recent techniques of routing. **SCHEDULING:** Master schedule, departmental and shop schedule charts for scheduling, Gantt chart, loading and scheduling.	8
4	**PURCHASING AND STORING:** Planning for purchasing, procurement schedule, purchase requisition, calling tenders, comparative statements, placing orders, receiving materials, inspection entry and payment, foreign purchase: imports, documents and books. Location and layout of store-room, bins, racks, bar-codes and boxes used in storing, centralized and decentralized stores, functions of stores.	6
5	**DISPATCHING:** Procedure, types, MIS systems for department and shop, bulletin boards, move tickets, operation tickets, machine control boards, inspection ticket, time ticket, communication systems for dispatching, follow up.	4
6	**PLANT LAYOUT AND LOCATION*:*** *Plant layout:* objectives, principles and types, factors affecting plant layout, production line flow patterns, *Plant location:* factors affecting the selection of location. Location of factory in small town, suburban areas, location pattern of Indian industries.	6
7	**NEW TRENDS IN OPERATIONS MANAGEMENT:** Toyota Production System, Just in Time manufacturing, Kanban, lean manufacturing systems, Total quality management, Business process re-engineering, Logistics and supply chain management.	6

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	**Knowledge Level (Blooms Level)**
1	Understand the concepts of 'Production planning & control' and aggregate production planning in Industries.	**L2**
2	Apply the Routing, scheduling and sequencing techniques used in industries.	**L3**
3	Apply the concepts of storing and purchasing procedure in various organizations.	**L3**
4	Choose the Dispatching procedure used in various industries.	**L5**
5	Design and develop the plant layouts using Design heuristics.	**L6**
6	Analyze the concepts new trends in operations management like TPS, JIT, TQM and SCM.	**L4**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	2	1	1	-	-	-	2	1	1	2
CO2	2	1	1	1	2	-	2	-	-	-	2	1	1	1
CO3	2	1	1	-	2	-	2	-	1	-	2	1	1	2
CO4	1	1	1	2	1	-	1	-	1	-	-	1	1	1
CO5	2	1	1	1	2	1	2	-	1	-	-	1	1	1
CO6	1	1	1	-	3	1	1	-	-	2	3	1	1	2

	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Industrial Engineering and Management, Hicks, Tata McGraw Hill, New Delhi	2003
2.	Production Control, John F. Biegal, Prentice Hall of India, N.Delhi	1974
3.	Modern Production/Operation Management, Buffa and Sarin, John Wiley and sons	2015
4.	Industrial Engineering and Production Management, M. Mahajan, Dhanpat Rai and sons	2016
5.	Production & Operations Management, Surya Prakash Singh, Vikas publishing House Pvt.. Ltd., Noida	2018

Course Name	**:**	**SURFACE ENGINEERING**
Course Code	**:**	**ME2018/ME4018**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:	
1	To impart the knowledge of Surface properties and their impact on performance of components.
2	To get familiar with the various techniques of surface treatment and characterizations of metallic components.
3	To acquire the knowledge of various fields of applications for implementing the surface engineering to improve the product performance.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Importance and necessity of surface engineering; past, present and future scenario of surface engineering; *Properties of Solid Surfaces:* Tribological and optical properties; Electric and opto-electronic properties, Importance and objectives of surface properties, Corrosion of solid surfaces, Surface preparation techniques.	5
2	**WEAR AND CORROSION:** *Wear:* Classification, Abrasive, Solid particle erosion, Liquid erosion, Slurry erosion and adhesive wear; Fretting, Rolling-contact wear, wear measurement; *Corrosion:* Types and conditions of corrosion, Electrochemical, Uniform, Galvanic, Crevice, Inter-granular, Fretting and Erosion corrosions; Pitting, Cavitation, Exfoliation, Stress-corrosion cracking, Corrosion fatigue, Hydrogen embrittlement, corrosion measurement.	8
3	**SURFACE TREATMENT TECHNIQUES:** Selective surface hardening, Flame hardening**,** Induction hardening, High-energy beam hardening, Laser melting and curing, Shot peening, Friction stir processing; Chemical conversion treatment, Diffusion heat treatment of surfaces, Carburizing, Nitriding, powder bed chemical case hardening.	10
4	**THIN FILM COATING:** Organic and inorganic paintings, Ceramic coatings and linings, Hot dip and electrochemical deposition, Thermal spray and vapour deposition, Powder mixed electric discharge alloying and film deposition, Ion implantation and metal alloying by laser beam.	7
5	**CHARACTERIZATION OF ENGINEERED SURFACES:** Characterization of surface properties, Thickness of coatings and films, Bond strength of coating, Substrate, Micro-hardness, Phase determination using X-Ray Diffraction (XRD) analysis, Scanning Electron Microscopy (SEM), Metallographic examination.	7
6	**APPLICATIONS OF SURFACE ENGINEERING**: Surface engineering for cutting tools, automotive engine components, Gas turbine engines, Bio-Medical implants and aerospace industry.	5

Sr. No.	List of Experiments	Hours
1	Wear and corrosion analysis of treated surface.	6
2	Thermal spray deposition of metal powder on surface of cylindrical work-piece.	6
3	Powder mixed EDM operation for surface alloying and analyzing the characteristics of machined surfaces.	8
4	A case study and project work on mechanical treatment and surface modification of metal components.	8

Sr. No.	Course outcome By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the basic surface properties and their importance towards the performance of components and overall economics.	**L2**
2	Interpret various types of wear and corrosion phenomenon occurring on different types of materials.	**L4**
3	Understand the facts and ideas on different types of surface modification and coating techniques used in various fields of engineering.	**L2**
4	Evaluate the surface texture and quality of surface modified by different applied surface treatment techniques.	**L5**
5	Apply surface modification techniques to modify the surface properties of metallic components.	**L3**
6	Design surface modification technique for better quality of surface	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	3	1	-	-	-	-	-	-	-	1	3	1
CO3	3	2	3	2	-	-	2	-	-	-	-	2	3	1
CO4	3	3	3	3	-	-	-	-	-	-	1	2	3	2
CO5	2	3	3	2	-	-	2	-	-	-	1	2	3	3
CO6	3	3	3	1	-						1	2	3	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Introduction to Surface Engineering and Functionally Engineered Materials, Peter M. Martin, Wiley & Sons Publishing	2011
2	Coating Technology Handbook, Arthur A. Traction, 3rd Edition, Taylor & Francis.	2006
3	Surface engineering for Corrosion and Wear Resistance, J.R. Davis & Associates, ASM International	2001
4	Modern Surface Engineering Treatments, Mahmood Aliofkhazraei, Intechopen.com	2013

Course Name	**:**	**ENGINEERING METALLURGY**
Course Code	**:**	**ME2019/ME4019**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives: To impart the knowledge about the:

1	Structure and properties of ferrous and non-ferrous metals that will definitely help to select the materials for various engineering applications.
2	Heat treatment, testing and applications of metals and non-metallic materials
3	Phase-diagram, Iron-Carbon diagram and classifications of ferrous and non-ferrous alloys.
4	Brinell, Vickers and Rockwell tests, Impact test, IZOD and Charpy, fatigue and creep test, and analysis of failure mechanisms.

No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**ALLOYS AND PHASE DIAGRAMS:** Constitution of alloys, Solid solutions, substitutional and interstitial, phase diagrams, Isomorphism, eutectic, eutectoid, peritectic, and peritectoid reactions, Iron-carbon equilibrium diagram, Classification of ferrous and non-ferrous metals, Cast-iron microstructure, properties and application.	4
2	**FERROUS AND NON-FERROUS METALS:** Effect of alloying elements on properties of steels, α and β stabilizers, stainless and tool steels, HSLA, OHNS, Grey, white, malleable, nodular cast iron, spheroidal cast irons, Copper and copper alloys: Brass, Bronze and Cupronickel, Al and Al-Cu, precipitation strengthening treatment, white metal, bearing alloys, Mg-alloys, Ag and its alloys, Zn and its alloys, Ni-based super alloys, Ni-Cr alloys, Inconel, monel, Titanium alloys, applications	10
3	**HEAT TREATMENT:** Definition, Normalizing, full and process annealing, hardening, case hardening, nitiriding, carburizing, flame and induction hardening, stress relieving, re-crystallization and spheroidising, tempering, Isothermal transformation, cooling curves superimposed on I.T. diagram, CCR, Hardenability, Jominy end quench test, Austempering, Martempering , Vacuum and Plasma hardening.	10
4	**NON-METALLIC MATERIALS:** Polymers, types of polymer, commodity and engineering polymers, Properties and applications of various thermosetting and thermoplastic polymers (PP, PS, PVC, PMMA, PET,PC, PA, ABS, PI, PAI, PPO, PPS, PEEK, PTFE, Urea and Phenol formaldehydes), Engineering Ceramics - Properties and applications of Al_2O_3, SiC, Si_3N_4, PSZ and SIALON, Composites, Classifications, Metal Matrix and FRP, Applications of Composites.	10
5	**MECHANICAL PROPERTIES AND DEFORMATION MECHANISMS:** Mechanisms of plastic deformation, slip and twinning, Types of fracture, Testing of materials under tension, compression and shear loads, Hardness tests, Relation among Brinell, Vickers and Rockwell tests, Impact test, IZOD and Charpy, fatigue and creep test, analysis of failure mechanisms.	8

Sr. No.	**List of Experiments**	**No of Hours**
1	Preparation and study of crystal models for simple cubic, body centered cubic, Face centered cubic and hexagonal close packed structured.	6
2	Preparation and study of the Microstructure of pure metals like Iron, Cu and Al.	4
3	Study of the Microstructure of Cast Irons and alloy steels.	6
4	Study of the Microstructure and hardness of Heat treated steels.	4
5	Hardenability of Steels by Jominy end quench test.	4
6	Behavior of ferrous and non-ferrous metals under creep and fatigue loading	4

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understanding the concept of alloys and phase diagram of different materials.	**L2**
2	Analyse the effect of alloying element on properties and characteristics of materials.	**L4**
3	Apply the principle of heat treatment processes to modify the properties of	**L3**

	different materials at solid state.	
4	Compare and judge the material based on the knowledge of mechanism of deformation, fracture and mechanical properties of different materials	**L5**
5	Adapt non-metallic materials for industrial applications based on compile information of properties and characterization.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	-	-	-	-	-	-	1	2	2	2
CO2	3	2	2	3	-	-	1	-	-	-	1	2	3	2
CO3	3	3	3	2	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	1	-	1	-	-	-	1	2	3	2
CO5	3	2	2	2	1	-	-	-	-	-	-	1	3	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Introduction to Physical Metallurgy, Avner, S.H., McGraw Hill Book Company.	1997
2	Material Science and Engineering, Williams D Callister, Wiley India Pvt Ltd, Revised Indian Edition.	2014
3	Engineering Materials, Kenneth G. Budinski and Michael K. Budinski, Prentice Hall of India Private Limited.	2010
4	Materials Science and Engineering, Raghavan.V, Prentice Hall of India Pvt. Ltd.	2015
5	Materials Science and Engineering, Upadhyay. G.S. and Anish Upadhyay, Viva Books Pvt. Ltd., New Delhi.	2006

Course Name	**:**	**PRODUCT DESIGN AND DEVELOPMENT**
Course Code	**:**	**ME2020/ME4020**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: At the end of the course, the student will be able to**:**	
1	Understand the reverse engineering, redesign methodologies and theories.
2	Identify the significance of analytical and numerical techniques in product development engineering.
3	Understand about the physical models and concepts of product design theory.
4	Understand the principles in product development taking care with social, environmental and ethical concerns.

Total No. of Lectures –42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION**: Modern Product Development and Design Theories: Understanding the opportunity, Development and Implementation of a concept, Reverse engineering and redesign methodologies.	4
2	**PRODUCT DESIGN PROCESS**: Need, Identification, Kano diagram, Establishing Engineering Characteristics, Quality Function Deployment (QFD), Product Design Specification (PDS), Information Gathering.	8
3	**CONCEPT GENERATION**: Creative methods for design, Functional decomposition and synthesis, Morphological methods, Theory of Inventive Problem solving, Axiomatic Design.	10

4	**CONCEPT EVALUATION AND DECISION MAKING**: Concept evaluation and decision making: Decision Theory, Evaluation methods, Pugh's concept, weighted decision Matrix.	8
5	**EMBODIMENT DESIGN:** Product Architecture, Configuration and Parametric Design Concepts, Ergonomics and Design for Environment and detailed design.	6
6	**ETHICAL ISSUE AND TEAM MANAGEMENT**: Ethical issues considered during Engineering design process, Product liability, Tort law, functioning, discharge, Team Dynamics and problem solving tools in design, Case studies.	6

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understanding the principle and theories of Product Design and Development.	**L2**
2	Apply the concept of creative methods for generation and development of product.	**L3**
3	Analyse the engineering characteristics and quality function deployment for gathering the information to develop new product.	**L4**
4	Design the product architecture and configuration of new product.	**L6**
5	Develop Ergonomics and consciousness for environmentally sustainable manufacturing and product.	**L6**
6	Judge and evaluate the methods and decision metrics to develop the product.	**L5**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	2	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	3	1	-	-	-	-	-	-	1	2	3	2
CO3	3	3	2	2	1	-	-	-	-	-	-	2	3	1
CO4	3	3	3	3	2	-	-	-	-	-	1	2	3	2
CO5	3	3	3	2	-	-	-	-	-	-	1	2	3	3
CO6	3	3	3	3	-	-	-	-	-	-	-	1	3	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Engineering Design, George E Dieter, 3rd ed., McGraw Hill	2001
2	Product Design Kevin N. Otto, Kristin L. Wood, Pearson Education	2004
3	Engineering Design, Gahl, W Beitz J Feldhusun, K. G. Grote, 3rd ed., Springer.	2007
4	Design Engineering, W. Ernest Eder, S. Hosendl., CRC Press.	2008
5	Engineering Design and Rapid Prototyping, Ali K. Kamrani and EmadAbouel Nasr, Springer.	2010

Course Name	**:**	**COMPOSITE MATERIALS**
Course Code	**:**	**ME2021/ME4021**
Credits	**:**	4
L T P	**:**	**3-0-2**

Course Objectives: To impart the knowledge about the

1. Matrix, interfaces, fibers, whiskers being used in fabrication of composites.
2. Polymer matrix composites, metal matrix composites, ceramic matrix composites, carbon-carbon composites and their manufacturing.
3. Testing, properties and applications of different composite materials.
4. Post processing and micromechanics of composites.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**Composite:** Definition, characteristics, functions, classification based on structure and matrix, smart composites, advantages and limitations, industrial scene and applications, **Interfaces:** wettability and bonding interface in composites, types of bonding at interface. **Fibers:** types, natural, glass, boron, carbon, Ex-Pan carbon, Ex cellulose carbon, Ex-Pitch carbon, and aramid fibers, fiber structure, properties, applications, and recycling; **Whiskers:** characteristics, properties and applications.	7
2	**Polymer matrix composites (PMC):** Thermoset, thermoplastic and elastomeric polymers, properties, characteristics and applications as matrix materials, processing of polymer matrix composites: hand methods, Lay up method, spray up method, moulding methods, pressure bagging and bag moulding methods, pultrusion and filament winding process.	6
3	**Metal matrix composites (MMC):** Classification of metals, inter-metallic's, alloys and their potential role as matrices in composites; properties, characteristics and applications of MMCs, production techniques: powder metallurgy, diffusion bonding, melt stirring, squeeze casting, liquid infiltration under pressure, spray code position, in-situ process.	6
4	**Ceramic matrix composites (CMC):** Classification of ceramics and their potential role as matrices; properties, characteristics and applications of CMC; *Production techniques:* cold pressing and sintering, hot pressing, reaction bonding, hot pressing and reaction bonding, liquid infiltration, pultrusion, lanxide process, in-situ chemical technique, sol-gel technique, *Post processing of CMC*: machining, cutting, polishing, welding, riveting, painting, and plasma coating.	7
5	**Carbon Carbon Composites (CCC):** Classification of carbon and their potential role as matrices; Production techniques of CCC; Properties, characteristics and applications of CCC.	4
6	**Testing of Composites:** Mechanical testing of composites, tensile and compressive testing, Intra-laminar and Inter-laminar shear testing, Fracture testing; *Stiffness and Strength:* Geometrical aspects-volume and weight fraction. Effect of unidirectional continuous fiber, discontinuous fibers, short fiber, woven reinforcements on mechanical properties.	5
7	**Laminates:** Types, Symmetric Laminates, Anti-symmetric Laminate, Balanced Laminate, Quasi-isotropic Laminates, Cross-ply Laminate, Angle-ply Laminate. Orthotropic Laminate, Volume and Mass Fractions, Density and Void Content, Laminate Moduli, Approaches and Models of Four Elastic Moduli, Hygrothermal Stresses. Strengths of unidirectional Lamina, Coefficients of thermal, moisture expansion and Warpage of laminates.	7

Sr. No.	**List of Experiments**	**Hours**
1	Fabrication of Al/SiC-MMC specimen	6
2	Fabrication of PMC by Layup method	6
3	Fabricate and prepare the MMC specimens as per standard size, perform tensile and compressive tests, and analyze the test results	8
4	A project work on machining and joining of CMC materials	8

Sr.	**Course outcome**	**Knowledge Level**

No.	By the end of this course, the student will be able to:	(Blooms Level)
1	Understand the mechanical behavior of layered composites compared to isotropic materials.	L2
2	Design and develop the process to fabricate different types of composite materials.	L6
3	Evaluate the mechanical properties and strength of composite materials.	L5
4	Select and apply the process to develop composites, and apply constitutive equations to acquire the knowledge mechanical behavior at micro, macro and meso level.	L3
5	Analyze the mechanical behavior of composites due to variation in temperature and moisture.	L4

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	-	-	-	-	-	-	-	2	3	1
CO2	2	2	3	3	-	-	-	-	-	-	-	2	2	1
CO3	2	3	2	2	-	-	-	-	-	-	-	2	2	1
CO4	2	3	2	2	-	-	-	-	-	-	-	2	2	1
CO5	3	3	1	2	-	-	-	-	-	-	-	2	3	1

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Composite Materials: Science and Engineering, K. K. Chawla, Springer, 3e,	2013
2	Composite Materials, Engineering and Sciences, F.L.Matthews & R.D.Rawlings, Chapman & hall, London,	1994
3	Hand Book of Composites, George Lubin. Van Nostrand, Reinhold Co.	1982
4	Fiber-reinforced composites, P.K.Mallicak, Monal Deklar Inc., New York, 1988	1988
5	Principles of Composite Mechanics, R.F. Gibson, 2nd Ed., CRC Press.	2007

Course Name	**:**	**FLUID MECHANICS**
Course Code	**:**	**ME2022/ME4022**
Credits	**:**	**4**
L T P	**:**	**3-1/2-2/2**

Course Objectives:	
1	To understand the basic concept of fluid mechanics.
2	To understand statics, dynamics and various approaches to fluid mechanics.
3	To correlate fundamentals of fluid mechanics with various mechanical systems
4	To model and solve the problem on a commercial software/open source platform.

Total No. of Lectures –42

Lecture wise breakup		No. of Lectures
1	**Introduction:** Basic Concepts and Definitions, Properties of Fluid, Viscosity, Capillarity, Surface Tension, Compressibility, Normal and Shear Stresses in Fluid Flows.	3
2	**Fluid Statics:** Types of Forces on Fluid Element, Mechanics of Fluid at Rest and in Rigid Body Motion, Manometry, Hydrostatic Forces on Fully and Partially Submerged Bodies, Stability of a Floating Body.	4
3	**Kinematics of Fluid Flow:** Langrangian and Eulerian Methods, Description of Properties	6

	in a Moving Fluid, Local and Convective Acceleration, Streamlines, Path Lines, Streak Lines, Acceleration and Rotation of a Fluid Particle, Vorticity and Circulation, Stream Function, Frictionless and Irrotational Flow, Velocity Potential Function.	
4	**Dynamics of Fluid Flow:** Basic Physical Laws of Fluid Mechanics, The Reynolds Transport Theorem, Equation of Conservation of Mass, Differential Form of Continuity Equation, Navier-Stokes Equations, Euler's Equation of Motion, Frictionless Flow - Bernoulli's Equation, Angular Momentum Theorem, Applications to Flow Measurement and other Real Flow Problems.	6
5	**Viscous Flow:** Regimes of Flow, Pressure Gradient in Steady Uniform Flow, Qualitative Aspects of Viscous Flows, Exact solutions of Navier-Stokes Equations, Laminar Flow Through a Pipe - Hagen-Poiseulli's Flow, Transition from Laminar to Turbulent Flow, Turbulent Flow Through a Pipe, Friction Factor, Applications to Pipe Networks.	6
6	**Flow Past Immersed Bodies:** Reynolds Number and Geometry Effects, Momentum Integral Estimates, Boundary Layer (BL) Equations, Flow Over a Flat-Plate, Boundary Layers with Pressure Gradients, Laminar and Turbulent BL, Separation of BL and Control of Flow Separation, Streamlined and Bluff Body.	6
7	**Introduction to CFD:** Need of Computational Fluid Dynamics (CFD), Solving Partial and Ordinary Differential Equations: Brief Introduction to Numerical Methods (FDM, FVM, and FEM), Need of Discretization, Meshing Requirements in Laminar and Turbulent Flows, Boundary Conditions, Solution Techniques, and Convergence Criterion. Modelling/Solving Some Basic Fluid Flow Problems on a Commercial Software/ Open Source Platform and Post-Processing.	7
8	**Dimensional Analysis and Similitude:** Buckingham's Theorem, Non-Dimensional Groups, Geometric, Kinematic and Dynamic Similarity, Modeling of Fluid Flows, Applications.	4

List of Experiments:		**No. of Turns**
1	To determine the metacentric height of a given vessel under unloaded condition.	1
2	Verification of Bernoulli's theorem and measurement of velocity using Pitot tube.	1
3	To determine the Coefficient of discharge through Venturi meter and Orifice meter.	1
4	To determine the different types of flow Patterns by Reynolds's experiment.	1
5	To determine the Friction factor and loss coefficients for the different pipes.	1
6	To model a simple fluid flow problem on a commercial software/open source platform and post-processing the data.	2

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	**Knowledge Level (Blooms Level)**
1	Understand the basic concept of fluid mechanics.	**L2**
2	Apply the principles of fluid statics and dynamics to real life problems.	**L3**
3	Correlate and implement the fundamentals of fluid mechanics to analyze simple hydrodynamics systems.	**L4**
4	Examine the basic fluid flow problems through analytical and numerical (commercial/open source) tools.	**L5**
5	Introduction to the concept of boundary layer and its implementation to solve practical fluid flow problems.	**L4**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	-	-	-	-	-	-	-	1	1	-
CO2	2	1	1	1	-	-	-	-	-	-	-	2	2	-
CO3	3	2	2	2	-	-	-	-	-	-	-	2	3	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	3	3

CO5	3	3	3	3	-	-	-	-	-	-	-	1	3	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Fluid Mechanics by Frank .M. White, McGraw Hill Publishing Company Ltd.	2017
2	Fluid Mechanics and Fluid Power Engineering by D.S. Kumar, S.K.Kataria & Sons	2013
3	Fluid Mechanics and Hydraulic Machines by R.K. Bansal, Laxmi Publications	2018
4	Fundamentals of Fluid Mechanics by Munson, Wiley India Pvt. Ltd, 7th edition	2015
5	Fluid Mechanics: Fundamentals and Applications, Yunus A. Cengel, John M. Cimbala, McGraw Hill Education; 4th edition	2019

Course Name	**:**	**INTERNAL COMBUSTION ENGINES**
Course Code	**:**	**ME2023/ME4023**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: Students will learn about	
1	The basic cycles of operation of internal combustion engines.
2	Basic configuration of I.C. engines and its different parts.
3	Different sub-systems of IC engines.
4	The design/operating characteristics of different types of internal combustion engines which affect its performance.
5	Recent developments in the field of IC engine fuels and other non-conventional engines.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION**: Heat Engines, Internal and external combustion engines, classification of I.C. Engines, Cycles of operation in 4 stroke /2stroke /SI/CI engines, Valve timings diagram, low speed and high-speed engines, Rotary /Wankel Engines, Applications, Performance parameters.	4
2	**WORKING CYCLES**: *Air standard cycles*: assumptions, Otto, Diesel and Dual cycles, efficiency, M.E.P. & their comparison. *Fuel Air Cycles*: effect of dissociation and operating variables, comparison of air standard and fuel-air cycles. *Actual Cycles*, losses, comparison with air standard cycles.	4
3	**IC ENGINES' SYSTEMS:** *Carburetion System*: definition, Air-Fuel ratio, simple carburetor, essential parts of carburetor, compensating devices. *Fuel Injection Systems:* classification, parts of mechanical fuel injection systems and brief study of electronic injection systems. *Ignition Systems*: energy requirement, Battery/ Magneto/ Modern ignition systems, i.e., TCI and CDI systems, Ignition timing and firing order, Spark advance mechanism. *Cooling and Lubrication Systems:* wet, mist and dry sump lubrication systems, Factors affecting mechanical friction, Lube properties SAE rating, necessity of cooling, parameters affecting engine heat transfer, air and water cooling, Radiators	9
4	**COMBUSTION IN I.C. ENGINES:** Homogeneous/Heterogeneous mixtures, stages of combustion in S.I. Engines, velocity of flame propagation; detonation, effects of engine variables on detonation; theories of detonation, pre-ignition, S.I. engine combustion chambers. Stages of combustion in C.I. Engines; delay period; variables affecting delay period; knock in C.I. engines, C.I. engine combustion chambers.	8
5	**ENGINE EMMISSION AND CONTROL:** Pollution due to IC Engines, Exhaust Emissions -Hydrocarbons, Carbon Monoxide, Oxides of Nitrogen (NO_x), Other	4

	Emissions. Controls: Thermal Converters, Catalytic Converters, Particulate Traps, Chemical Methods, Exhaust Gas Recirculation (EGR), Evaporation Control Device, Crankcase Blow-by.	
6	**ENGINE TESTING AND PERFORMANCE:** Measurement of Power, Fuel/ Air Consumption, Speed etc. Performance Parameters: BHP, IHP, FHP, Mechanical, Indicated and Brake Thermal Efficiency, Mean Effective Pressure, Charging Efficiency, Volumetric Efficiency, bsfc, isfc, Heat Balance Sheet, Performance Curves	5
7	**SPECIAL TOPICS:** Supercharging, Variable Compression Ratio (VCR) Engine, Two stroke engines, Common Rail Direct Injection (CRDI) Engines, Dual fuel /multi-fuel engines, Homogeneous charge compression ignition (HCCI) engine, Wankel Engine, Stratified Charge engines, Alternate fuels for IC engines, Hybrid Electric Propulsive System, Comparison of automatic propulsion system.	8

S. No.	**Course Outcome** By the end of this course, the student will be able to:	**Knowledge Level (Bloom Level)**
1.	Identify and rationally choose the appropriate type of I.C. Engine(s) for a particular application.	**L2**
2.	Apply the basic concepts to select the different subsystems of an IC engine.	**L3**
3.	Analyze the performance of engines at different operating parameters.	**L4**
4.	Analyze and justify the suitability of conventional and non-conventional fuel for existing and futuristic IC engines.	**L4**
5.	Select and modify the combustion system integrals to minimize pollution	**L5 & L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	1	1	1	-	-	-	-	-	-	-	-	1	1
CO2	3	3	2	2	-	-	2	-	-	-	-	1	3	2
CO3	3	3	2	2	-	-	2	-	-	-	-	1	1	2
CO4	3	3	2	2	-	1	3	-	-	-	-	2	1	1
CO5	3	3	3	2	-	-	3	-	-	-	-	2	2	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Internal Combustion Engines, V Ganeshan, 4th ed., Mc Graw Hill	2017
2	Internal Combustion Engines, M.L. Mathur and R.P. Sharma, Dhanpat Rai Publication	2010
3	Engineering Fundamentals of Internal Combustion Engines, Willard W. Pulkrabek, Pearson	2007
4	Internal Combustion Engines Fundamentals, John B. Heywood, Mcgraw Hill Science	2017
5	Internal Combustion Engines Applied Thermo-sciences, Colin R. Ferguson, Allan T. Kirkpatrick, 3rd ed., Wiley, Student Edition	2015

Course Name	**:**	**COMPUTATIONAL FLUID DYNAMICS**
Course Code	**:**	**ME2024/ME4024**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:	
1	To understand mathematical characteristics of partial differential equations.
2	To understand basic properties of computational methods.

3	To learn computational solution techniques for time integration of ordinary and partial differential equations.
4	To learn to solve computationally the Euler and Navier-Stokes equations
5	To acquire basic programming and graphic skills to conduct the flow field calculations and data analysis.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1.	**INTRODUCTION:** CFD and its Applications, Numerical vs Analytical vs Experimental approach, Modeling Vs Experimentation, Fundamental principles of conservation, Reynolds transport theorem, Principles of mass, momentum and energy conservation, General scalar transport equation.	4
2.	**PARTIAL DIFFERENTIAL EQUATIONS AND PHYSICAL BEHAVIOUR:** Mathematical classification of Partial Differential Equation, Illustrative examples of elliptic, parabolic and hyperbolic equations, Applications of elliptic, parabolic and hyperbolic partial differential equations	2
3	**ORDINARY DIFFERENTIAL EQUATIONS:** Error Minimization Principles, Functional involving higher order derivatives, Approximate solution of differential equations through variational formulation, Boundary conditions in the variational form: Primary and secondary variables, Essential and natural boundary conditions, Approximate solutions of differential equations.	3
4	**FUNDAMENTALS OF DISCRETIZATION:** Pre-processing, Solution, Post-processing, Finite difference method (FDM), Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Finite volume method (FVM), Illustrative examples:1-D steady state heat conduction without and with constant source term. 1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme. The basic structure of a CFD code: Pre-processor, Solver and Post-processor, User-defined-subroutines, Solution to some basic problems in heat transfer and fluid flow.	6
5	**FINITE VOLUME METHOD:** Concepts and Illustrations through 1-D Steady State Diffusion Problems: Physical consistency, Overall balance, FV Discretization of a 1-D steady state diffusion-based problem, Composite material with position dependent thermal conductivity, Source term linearization, Implementation of boundary conditions. FVM for 2-D unsteady state diffusion problems. *Finite volume discretization of convection-diffusion problem*: Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power law scheme, Generalized convection-diffusion formulation, Finite volume discretization of two-dimensional convection-diffusion problem, The concept of false diffusion, QUICK scheme. Stream Function-Vorticity approach and Primitive variable approach, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorithm.	14
6	**DISCRETIZATION OF TIME DEPENDENT DIFFUSION TYPE PROBLEMS:** Consequences of time-discretization in finite discretization, Consistency, Stability, Convergence, LAX Equivalence theorem, Grid independent and time independent study, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): Forward time central space (FTCS) scheme, Stability analysis of parabolic equations (1-Dunsteady state diffusion problems): Central time central space (CTCS) scheme (Leap frog scheme), Dufort-Frankel scheme, Stability analysis of hyperbolic equations: FTCS, FTFS, FTBS and CTCS Schemes, Stability analysis of 2^{nd} order hyperbolic equations: CTCS scheme.	7
7	**LINEAR ALGEBRAIC EQUATIONS:** Criteria for unique solution, infinite	6

	number of solutions and no solution, Solution techniques for systems of linear algebraic equations: L-U decomposition technique, Tridiagonal matrix algorithm (TDMA): Thomas algorithm, Illustrative examples, *Iteration methods*: Jacobi's method and Gauss Siedel method, Illustrative examples of Jacobi's method and Gauss-Siedel method, ADI (Alternating direction implicit) method.	

List of Experiments		**No. of Hours**
1	Ansys Simulation of lid driven cavity.	4
2	Ansys Simulation of heat transfer and fluid flow through pipe.	4
3	Ansys Simulation of flow past regular and irregular bodies.	4
4	Ansys Simulation of Conduction, Convection and Radiation	4
5	Ansys Simulation of flow through porous media.	6
6	Ansys Simulation of Phase Change Materials	6

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	**Knowledge Level (Blooms Level)**
1	Understand the use and stepwise procedure to completely solve a fluid flow and heat transfer problem using computational methods.	L1, L2
2	Develop basic governing equations for fluid flow and heat transfer by examining the physical boundary conditions.	L3
3	Construct and Analyze the consistency, stability and convergence of various discretization schemes of finite difference based equations according to the nature (i.e. elliptic, parabolic and hyperbolic) of the flow problem.	L4, L6
4	Predict and implement various implicit and explicit CFD schemes to solve steady and unsteady 1/2/3 dimensional fluid and heat transfer problems.	L3, L5
5	Analyze and evaluate various finite volume based CFD schemes to solve fluid and heat transfer problems.	L3, L5
6	Practice CFD software to simulate practical fluid flow and heat transfer problems	L3

CO-PO & PSO Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2	2	1	-	-	-	-	-	-	1	3	2
CO2	2	3	3	2	1	-	-	-	-	-	-	1	2	3
CO3	2	2	3	2	1	-	-	-	-	-	-	1	2	3
CO4	2	2	3	3	2	-	-	-	-	-	-	1	2	2
CO5	2	2	3	3	2	-	-	-	-	-	-	1	2	2
CO6	2	2	2	2	3	-	-	-	-	3	-	2	2	3

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Numerical Heat Transfer and Fluid Flow, S. V. Patankar, McGraw-Hill.	2018
2	Computational Fluid Dynamics, T. J. Chung, Cambridge University Press.	2010
3	An Introduction to Computational Fluid Dynamics, H. K. Versteeg & W. Malalasekera, 2nded. Longman Scientific &Technical	2007
4	Computational Methods for Fluid Dynamics, J. H. Ferziger and M. Peric, 3rd ed. Springer	2002

5	Computational Fluid Mechanics and Heat Transfer, John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, 3rd ed., Taylor & Francis	2016
6	Computational Fluid Dynamics, John D. Anderson Jr, McGraw Hill Book Company	2017
7	Computational Fluid Dynamics: Principles and Applications, J. Blazek, 3rd ed. Elsevier.	2015

Course Name	**:**	**HYDRAULIC MACHINES**
Course Code	**:**	**ME2025/ME4025**
Credits	**:**	**4**
L T P	**:**	**3-1/2-2/2**

Course Objectives:	
1	Understand the basic principles of Hydraulic Machines.
2	To review the development of Hydel power plants and its eco-system.
3	Understand the working and design of hydraulic turbines and hydraulic pumps.
4	Basic understanding of various hydraulic systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**HYDRO-ELECTRIC DEVELOPMENT:** Development of water turbines, Types of water wheels, components of hydropower plant. Types of hydroelectric power plant. Types of turbine losses and efficiencies in hydraulic turbines.	3
2	**PRINCIPLES OF HYDRAULIC MACHINES:** Impulse Momentum equation, Impact of Jets Force on Stationery Plates, Force on moving plates force on series of vanes. Euler Equation for hydraulic machines, Degree of Reaction, Vortex motion and flow in turbine.	4
3	**HYDRAULIC IMPULSE TURBINES:** Components of Pelton Turbines, Dimension of bucket of Pelton turbine, Number of buckets Diameter of jets, speed ratio jet ratio, no. of jets, Energy conversion in Pelton turbines.	4
4	**HYDRAULIC REACTION TURBINE:** Evolution of Reaction turbines, Francis Turbine Draft tube, power losses and efficiencies of Francis turbine, Francis turbine proportions outward Vs inward flow reaction turbine. Axial flow turbines. Components of an axial flow turbine blade. Performance at part loads. Adjustment of Kaplan turbine, Kaplan turbine proportions Application of aerofoil theory.	7
5	**GOVERNING OF HYDRAULIC TURBINES:** Necessity of governing of hydraulic turbines, Requirements of a good governing system in hydraulic turbines, Essential elements of governing system, double regulation of turbines governing of Impulse turbines, governing mechanism of impulse and reaction turbines	3
6	**PERFORMANCE OF HYDRAULIC TURBINES:** Unit quantities, specific speed, characteristics of turbine, Types of characteristic curve, constant head characteristics, constant speed characteristics and instant efficiency or Muschel curve.	3
7	**CENTRIFUGAL PUMPS:** Classification of centrifugal pumps, components of centrifugal pump, working of centrifugal pump, Heads of pumps, Energy Conversion in centrifugal pump, variation of Euler's head with vane shapes. Effect of finite no. of vanes on Euler's head, losses and efficiencies, Minimum starting speed, Net positive suction head, Multi stage pumps, Pumps in parallel and series primary devices, concept of specific speed and performance of centrifugal pump Cavitation in Hydraulic pumps.	7
8	**RECIPROCATING PUMP:** Components and working of reciprocating pump, classification of reciprocating pump, Discharge through reciprocating pump, slip, Power input, Indicator diagram Effect of piston acceleration head on indicator diagram, Maximum speed of reciprocating pump, Arrangement of delivery pipe in reciprocating pump, air vessels, pressure head in cylinder with Air vessels during suction and delivery stroke, Maximum speed with air vessels comparison with centrifugal and	6

	Reciprocating pump	
9	**HYDRAULIC SYSTEMS AND MACHINES:** Hydraulic system, Hydraulic accumulator, Hydraulic intensifier, Hydraulic Jigger, Hydraulic left Hydraulic Crane, Hydraulic Press, Hydraulic coupling Hydraulic Torque converter, Hydraulic pump Hydraulic Ram, Air lift pump, jet pump.	5

List of Experiments:		**No. of Turns**
1	To determine the characteristics curve of a Pelton wheel.	1
2	To determine the characteristics curve of a Francis turbine.	2
3	To determine the characteristics curve of a centrifugal pump.	2
4	To obtain the efficiency of a reciprocating pump under various heads.	1
5	To study the hydraulic ram and determine its efficiency.	1

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recognize the basic fluid machineries and their components.	**L2**
2	Apply the basic principles of hydraulic machines.	**L3**
3	Analyze the performance of hydraulic machines.	**L4**
4	Determine the performance characteristics curves of hydraulic machines.	**L5**
5	Investigate and optimize the design parameters of hydraulic systems.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	1	1	1	-	-	-	-	-	-	-	1	1	1
CO2	3	2	1	1	-	-	-	-	-	-	-	1	2	1
CO3	3	3	2	2	-	-	-	-	-	-	-	-	2	1
CO4	3	3	3	3	-	-	-	-	-	-	-	-	3	1
CO5	3	3	3	3	-	-	-	-	-	-	-	-	3	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Hydraulic Machines by T.R. Banga and S. Sharma, Khanna Publisher	1995
2	Fluid Mechanics & Hydraulic Machines, SS Ratta, Khanna Publisher	2019
3	Theory and Design of Hydraulic Machines, V.P. Vasandani, Khanna Publisher.	1990
4	Fluid Mechanics and Hydraulic Machines, R.K. Rajput, S. Chand publisher.	2016

Course Name	**:**	**CONVECTIVE HEAT AND MASS TRANSFER**
Course Code	**:**	**ME2026/ME4026**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:	
1	To understand basic principles of free and forced convection heat transfer processes.
2	To be able to formulate and solve convective heat transfer problems.
3	To be able to evaluate energy requirements for operating a flow system.

4	To understand the mass transfer processes.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Basics of thermodynamics, Fluid mechanics and heat transfer, Continuity, momentum and energy equations, Reynolds transport theorem, Rules of scale analysis, Concept of heat line visualization.	4
2	**LAMINAR FORCED CONVECTION - EXTERNAL FLOWS:** Boundary layer concept, velocity and thermal boundary layer, Governing equations, Similarity solutions, Various wall heating conditions, Flow over sphere, wedge and stagnation flow.	9
3	**LAMINAR FORCED CONVECTION - INTERNAL FLOWS:** *Fully developed laminar flow*: Constant heat flux, Constant wall temperature, Mean temperature, Fully developed temperature and velocity profile, Thermally developing flow and thermal-hydraulical developing flow.	5
4	**EXTERNAL NATURAL CONVECTION:** Governing equations for natural convection, Boussinesq approximation, Dimensional analysis, Boundary layer equations, Scale analysis, Low and high Prandtl number fluids, Combined natural and forced convection.	7
5	**INTERNAL NATURAL CONVECTION:** Scaling analysis, Natural convection in enclosures: Isothermal and constant heat flux, Side-walls and triangular enclosures, Heated from below, Inclined enclosures, Annular space between horizontal cylinders.	6
6	**TURBULENT BOUNDARY LAYER FLOW:** Transaction to turbulent flow, Turbulent flow and its characteristics, Boundary layer equations, Mixing length model, Flow over a single cylinder, Cross-flow over array of cylinders, Natural convection along vertical walls, Turbulent duct flow and Free turbulent flows.	6
7	**MASS TRANSFER:** Introduction to mass transfer, Concentrations, velocities and mass fluxes, *Governing equations of mass transfer*: Species mass balance, constitutive equations, Boundary conditions, Heat and mass transfer analogy, Impermeable surface model, Mass transfer driven flows and Simultaneous heat and mass transfer.	5

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Revisit the basics of thermodynamics, heat transfer and fluid mechanics.	**L2**
2	Apply the concepts of convective heat transfer to solve the problems of theoretical and practical interest.	**L3**
3	Analyze thermo-hydrodynamics of internal and external, laminar and turbulent, and natural and forced convection flows.	**L4**
4	Optimize, evaluate, and design the convective heat transport based thermal systems.	**L5 & L6**
5	Analysis and application of mass transport principles to cooling tower, condensers, and humidifier/dehumidifier.	**L4**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	-	-	-	-	-	-	-	1	1	1
CO2	2	2	2	1	-	-	-	-	-	-	-	1	1	1
CO3	3	3	2	2	-	-	-	-	-	-	-	-	2	2
CO4	3	3	3	3	1	-	-	-	-	-	-	-	3	3
CO5	3	3	3	2	-	-	-	-	-	-	-	-	3	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Convection Heat Transfer, A. Bejan, John Willey and Sons, New York.	2001
2	Convective Heat Transfer, Louis, C. Burmeister, John Willey and Sons, New York.	2003
3	Convective Heat and Mass Transfer, Kays and Crawford, 4th Ed., McGraw Hill.	2017
4	Convective Heat and Mass Transfer, S. Mostafa Ghiaasiaan, South Asian Edition, Cambridge India	2014
5	Fundamentals of Convective Heat Transfer, Gautam Biswas, Amaresh Dalal, Vijay K. Dhir, 1st ed., CRC Press.	2019

Course Name	**:**	**TWO-PHASE FLOW HEAT TRANSFER**
Course Code	**:**	**ME2027/ME4027**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:	
1	To understand the phenomena occurring at micro and nano scale.
2	To understand the basic mechanisms involved in two phase flow and heat transfer.
3	To understand the concepts of pool boiling and flow boiling heat transfer
4	To introduce the film wise and drop wise mode of condensation.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	**LIQUID-VAPOR INTERFACIAL REGION:** Molecular Perspective on Liquid-Vapor Transitions, Molecular Theories of Capillarity, Nano-scale Features of the Interfacial Region, *Interfacial Tension Effects*: Determination of Interface Shapes, Effect of Temperature and Surfactant Effects, Near Critical Point Behavior and Effects of Interfacial Tension Gradients.	6
2	**WETTING PHENOMENA AND CONTACT ANGLES:** Equilibrium Contact Angles, Wettability, Cohesion and Adhesion, Effect of Surface Tension on Contact Angle, Adsorption and Spread Thin Films, Contact-Angle Hysteresis, Wettability of Micro-structured and Nano-structured Surfaces.	5
3	**HOMOGENEOUS NUCLEATION:** Thermodynamic Aspects of Homogeneous Nucleation in Superheated and Super-cooled Liquids, Kinetic Limit of Superheat and Super-saturation, Effect of Wall Interaction.	4
4	**HETEROGENEOUS NUCLEATION AND BUBBLE GROWTH:** Heterogeneous Nucleation at a Smooth Interface, Nucleation from Entrapped Gas or Vapor in Cavities, Criteria for the Onset of Nucleate Boiling, Bubble Growth in an Extensive Liquid Pool, Bubble Growth Near Heated Surfaces, Bubble Departure Diameter and Frequency of Bubble Release.	5
5	**POOL BOILING**: Regimes of Pool Boiling, Mechanisms and Models of Transport during Nucleate Boiling, Correlation of Nucleate Boiling Heat Transfer Data, Limitations of Nucleate Boiling Processes and the Maximum Heat Flux Transition, Minimum Heat Flux Conditions, Film Boiling, Transition Boiling, Leiden frost Phenomenon, Fluid-Wall Interactions and Disjoining Pressure Effects and Pool Boiling Heat Transfer on Micro and Nano Structured Surfaces.	7
6	**TWO-PHASE FLOW REGIMES**: Basic Models and Governing Equations for One-Dimensional Two-Phase Flows, Determination of the Two-Phase Multiplier and Void Fraction, Analytical Models of Annular Flow, Effects of Flow Passage Size and	7

	Geometry.	
7	**FLOW BOILING**: Regimes of Convective Boiling in Conventional (Macro) Tubes, Onset of Boiling in Internal Flows, Sub-cooled Flow Boiling, Saturated Flow Boiling, Critical Heat Flux Conditions, Post-CHF Internal Flow Boiling, Flow Boiling in Micro-Channels.	4
8	**CONDENSATION:** *Nusselt theory*: Importance, Limitations and Modifications, Film Condensation on a Flat Vertical Surface, Effects of Vapor Motion, Interfacial Waves and Non-condensable Gases, Heterogeneous Nucleation in Vapors, *Drop wise Condensation*: Surface Requirements, Fundamentals and Recent Advancements.	4

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Identify the important forces and their characteristics at small scale.	**L2**
2	Apply the basics of two-phase heat transfer processes on simple and complex systems.	**L3**
3	Examine the performance of two-phase heat transfer systems.	**L4**
4	Select the suitable phase-change heat transfer process and evaluate the important process parameters for practical applications.	**L5**
5	Design heat transport systems for boiling and condensation heat transfer.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	1	1	1	-	-	-	-	-	-	-	1	1	1
CO2	3	2	2	1	-	-	-	-	-	-	-	1	2	1
CO3	3	3	2	2	-	-	-	-	-	-	-	-	3	2
CO4	3	3	3	3	-	-	-	-	-	-	-	-	3	2
CO5	3	3	3	3	-	-	-	-	-	-	-	-	3	3

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Liquid-Vapor Phase-Change Phenomena: An Introduction to the Thermo physics of Vaporization and Condensation Processes in Heat Transfer Equipment, Van P. Carey, 3rd Edition, CRC Press.	2020
2	Convective Boiling and Condensation, J.G. Collier, Clarendon Press.	1996
3	Boiling Heat Transfer and Two-phase Flow, L. S. Tong, and Y.S. Tang, 1st ed., Rutledge.	2018
4	Encyclopedia of Two-phase Heat Transfer and Flow, John R Thome, A 4-volume Set, World Scientific.	2018

Course Name	**:**	**AUTOMOTIVE COMBUSTION AND EMISSIONS**
Course Code	**:**	**ME2028/ME4028**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:	
1	To understand the basics of combustion.
2	To acquire the knowledge of stages of combustion in IC engine.
3	To acquire the knowledge of kinetics of combustion used particularly in combustion chamber design.

4	To understand the formation of pollutants and its mitigation principles

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Engine Combustion and Emissions	2
2	**THERMODYNAMICS OF COMBUSTION:** Combustion Stoichiometry, Heat of Reaction, Enthalpy of Formation, Adiabatic Flame Temperature, Equilibrium Combustion Products, Unburned Mixtures, Low Temperature Combustion Products, High Temperature Combustion Products, Chemical Kinetics	5
3	**COMBUSTION IN SI ENGINES**: Premixed Charge Combustion, SI Engine Combustion Conceptual Models, Combustion Rate Characterization, Thermodynamics Analysis of Combustion, Cycle-To-Cycle Combustion Variations, Knocking Combustion	6
4	**COMBUSTION IN CI ENGINES:** Fuel Injection and Spray Structure, CI Engine Combustion Conceptual Models, Diesel Combustion Process Characterization, Thermodynamic Analysis	4
5	**ENGINE COMBUSTION SYSTEMS:** Fluid Motion in Engine Cylinder, Valve Arrangement and Variable Valve Actuation, Classification of Engine Combustion Systems, Premixed Homogeneous Charge SI Engines, Direct Injection Stratified Charge Engines, Heterogeneous Charge CI Engines, HCCI/CAI Engines, Engine Management and Sensors, Laser diagnostic and optical measurement.	6
6	**FORMATION OF ENGINE EMISSIONS:** Emission effect on health and environment, sources of engine emissions, formation of carbon monoxide, NO formation, unburned hydrocarbon emissions, soot and particulate formation, diesel NO_x - particulate trade off, effect of SI engine design and operating variables, effect of diesel engine design and operating variables.	5
7	**EMISSION STANDARDS AND MEASUREMENT**: Emission Standards, Emission Test Cycles, Emission Measurement: Instrumentation and Methods, Euro/Bharat Stage norms.	2
8	**EMISSION CONTROL TECHNOLOGY:** ***SI Engine*** -Design Parameters, Add-On Systems for Treatment of Emissions Within Engine, Exhaust After-treatment, Direct Injection Stratified Charge (DISC) Engines, Summary of SI Engine Emission Control. ***CI Engine*** - Design Parameters, Application of EGR in CI Engines, Exhaust After-treatment in Diesel Engines, Summary of Diesel Emission Control, HCCI Engines for Emission Control.	6
9	**ENGINE FUELS AND EMISSIONS:** Common Hydrocarbon Components, General Fuel Quality Requirements, Motor Gasoline, Diesel Fuels, Alternative Fuels, antiknock fuels, Alcohols, Natural Gas, Liquefied Petroleum Gas, Biodiesel, Gas-to-Liquid (GTL) Fuels, Dimethyl Ether (DME), Hydrogen, Greenhouse Gas Emissions, various fuel additives	6

S. No.	**Course Objectives** By the end of this course, the student will be able to:	**Knowledge Level (Bloom Level)**
1	Apply the basic concepts of combustion in automotive engine combustion, and understand the emission standards.	**L2** **L3**
2	Interpret the process of combustion in automotive engines.	**L3**
3	Analyze and examine the combustion process, and measurement techniques, and challenges.	**L4 & L5**
4	Select the suitable fuel for the current and future needs of the society.	**L5**
5	Design the engines to minimize the emissions with suitable control strategies.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	1	-	-	-	-	-	-	-	1	1	1
CO2	3	3	1	1	-	-	-	-	-	-	-	1	2	1
CO3	3	2	1	2	-	-	2	-	-	-	-	-	2	3
CO4	3	3	3	3	-	-	3	-	-	-	-	-	3	3
CO5	3	3	3	2	-	2	3	-	-	-	-	-	3	3

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Internal Combustion Engines Fundamentals, John B. Heywood, McGraw Hill Science	2000
2	Combustion and Emissions in IC Engines, Murari Mohan Roy (Published Independently with Amazon)	2019
3	Internal Combustion Engines: Performance, Fuel Economy and Emissions, IMechE, London, Elsevier.	2013
4	IC Engines: Combustion and emissions, B P Pundir, Alpha Sciences.	2010

Course Name	**:**	**THERMAL SYSTEM MODELING AND SIMULATION**
Course Code	**:**	**ME2029/ME4029**
Credits	**:**	**4**
L T P	**:**	**3-1/2-2/2**

Course Objectives:	
1	To understand the significance of modelling and simulation of different engineering problems using various techniques.
2	To understand various mathematical techniques in solution of variety of problems related to design and optimization of Thermal Systems.
3	To understand the application of software for modelling, simulation and optimization of engineering systems problems.
4	To design and analyze of industrial equipment's and hydraulic systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION TO THERMAL DESIGN:** Design, Mathematical Modelling and Numerical Simulation of Thermal Systems, Approach to Robust Design, Numerical Methods for thermal and energy systems, Closed form solutions of heat transfer problems, Finite Difference and Finite Volume Formulations, TDMA Method	07
2	**DESIGN AND ANALYSIS OF THERMAL EQUIPMENT:** Design Strategies, Design of Heat Exchanger, Refrigeration System, Solar Thermal System, Heat Pump, Cooling of Electronic Components, Energy Storage System and Design Consideration for Engineering Material Selection.	07
3	**DESIGN AND ANALYSIS OF HYDRAULIC SYSTEM:** Introduction to Hydraulic Systems, Constituents of Hydraulic System, Directional Control Valve, Pressure Control Valve and Flow Control Valve, Hydraulic Circuit Design and Analysis.	07
4	**OPTIMIZATION:** Basic Concepts, Objective Function, Methods, Optimization of Mechanical System and case studies, Practical Aspects in Optimal Design, Constrained and Unconstrained Problems: Langrage Multiplier, Geometric & Dynamic	07

	Programming based optimization.	
5	**THERMAL SYSTEM SIMULATION:** Simulation of Periodic Heat Transfer, Laminar and Turbulent Convection, Compressible Flow in Nozzle, Cavitation and Solidification, Flow Past a Cylinder, Flat Plate Boundary Layer.	07
6	**ECONOMIC AND EXERGO-ECONOMIC ANALYSIS:** Estimation of Total Capital Investment, Principal of Economic Evaluation, Calculation of Revenue Requirements, Levelized Cost Rates, Cost Rate of Exergy Destruction, Exergy Destruction, Percentage Relative Cost Difference, Total Operating Cost Rate and Exergo-economic Factor.	07

Experiments:	
Thermal system modelling and simulation experiments on Heat Exchanger, refrigeration system, hydraulic system, solar energy, energy storage etc. will be performed using ANSYS Fluent /CFX, COMSOL etc.	14

Sr. No.	**Course Outcome** By the end of this course, the student will be able to:	**Knowledge Level (Blooms Level)**
1	To have knowledge of different aspects of designing of a thermal system.	**L1, L3**
2	To identify and examine a design problem associated to a thermal system.	**L4**
3	To integrate thermal component models and simulate a thermal system.	**L6**
4	To design, formulate analysis and solve engineering problems using knowledge of various disciplines.	**L7**
5	To inculcate an ability to identify, formulates, and solves engineering problems using mathematical techniques.	**L2, L5**
6	To perform technoeconomic analysis of thermal system using commercial software techniques.	**L3**
7	To communicate thermal system designs both orally and in writing.	**L6**
8	To understand some of the ethical and societal issues associated with design and optimization of thermal system.	**L4**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	1	-	-	-	-	-	-	-	-	-	2	1
CO2	-	3	2	1	-	-	-	-	-	-	-	-	2	1
CO3	-	-	-	3	2	1	-	-	-	-	-	-	3	2
CO4	-	-	-	-	3	2	1	-	-	-	-	-	3	2
CO5	-	-	-	-	1	2	1	-	-	-	-	-	1	3
CO6	1	2	3	-	-	-	-	-	-	-	-	-	1	3
CO7	-	-	-	-	-	-	-	-	-	1	2	3	1	3
CO8	3	-	2	-	-	-	-	1	1	1	-	-	1	3

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Design and Optimization of Thermal System with MATLAB Applications, Y Jaluria, 3rd ed., CRC Press.	2020
2	Heat Transfer, Cengel and Boles, 2nd ed., McGraw Hill.	2002
3	Thermal Design and Optimization, A Bejan, G. Satsoranis and M Moran, 2nd ed., Wiley Inderscience.	1996
4	Computational Fluid Dynamics, Versteeg and Malalasekhera, 1st ed., Longman Scientific & Technical.	2007

Course Name	**:**	**DESIGN OF THERMAL SYSTEM**
Course Code	**:**	**ME2030/ME4030**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:	
1	To provide the knowledge of various mathematical techniques used in design and optimization of thermal systems.
2	To model and simulate the different thermal engineering problems.
3	To give an insight of a commercial software for modelling, simulation and optimization of the thermal systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**ENGINEERING DESIGN:** Design versus Analysis, Design versus Synthesis, Selection versus Design, Design as part of Engineering Enterprises, Basic Characteristics of Thermal System, Basic Consideration in Design, Conceptual Design, Basic steps in design process, Computer Aided Design of Thermal System, Material Properties and Selection for Thermal System.	07
2	**MODELING OF THERMAL SYSTEM:** Introduction, Types of Model, Mathematical Modeling, Physical Modeling and Dimensional Analysis, Importance of Modeling in Design, Basic Features of Modeling, Type of Models, General procedure of mathematical modeling, physical modeling and dimensional analysis.	07
3	**NUMERICAL MODELLING AND SIMULATION:** Numerical Model, Solution Procedure, Numerical Model of a System, System Simulation, Methods of Numerical Simulation.	07
4	**ACCEPTABLE DESIGN OF THERMAL SYSTEM:** Initial Design, Design Strategies, Design of System in different application areas such as manufacturing, electronics, environment, heat transfer and fluid flow, Additional Considerations in Large Practical Systems.	07
5	**PROBLEM FORMULATION FOR OPTIMIZATION:** Introduction to Optimization in Design, Basic Concepts, Optimization methods, Important Considerations for Optimization of Thermal System, Different Types of Thermal System, Practical Aspects of Thermal Design.	07
6	**THERMAL SYSTEM ANALYSIS AND SIMULATION USING COMMERCIAL SOFTWARE:** Modelling Periodic Flow and Heat Transfer, Laminar Flow Convection, Turbulent Forced Convection, Compressible Flow in Nozzle, Modelling Cavitation, Solidification and Steady and Unsteady Flow Past a Cylinder, Flat Plate Boundary Layer.	07

Sr. No.	**Course Outcome** By the end of this course, the student will be able to:	**Knowledge Level (Blooms Level)**
1	To have knowledge of different aspects of designing of a thermal system.	**L1, L3**
2	To identify and examine a design problem associated to a thermal system.	**L4**
3	To have understand basics of modeling and their associated techniques.	**L6**
4	To inculcate an ability to solve engineering problems using knowledge of various disciplines.	**L7**
5	To inculcate an ability to identify, formulates, and solves engineering problems.	**L2, L5**
6	Top inculcate an ability to use the mathematical tools for optimization of engineering problems.	**L3**

7	To design, formulate analysis and solve engineering problems using mathematical as well as commercial software tools.	**L6**
8	To explain economic and exergoeconomic aspect associated with designing and optimization of thermal system.	**L4**

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	-	-	-	-	-	-	-	-	-	2	1
CO2	-	3	2	1	-	-	-	-	-	-	-	-	2	1
CO3	-	-	-	3	2	1	-	-	-	-	-	-	3	2
CO4	-	-	-	-	3	2	1	-	-	-	-	-	3	2
CO5	-	-	-	-	1	2	1	-	-	-	-	-	1	3
CO6	1	2	3	-	-	-	-	-	-	-	-	-	1	3
CO7	-	-	-	-	-	-	-	-	-	1	2	3	1	3
CO8	3	-	2	-	-	-	-	1	1	1	-	-	1	3

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Design and Optimization of Thermal System, Y Jaluria, 2nd ed., CRC Press.	2020
2	Heat Transfer, Cengel and Boles, 2nd ed., McGraw Hill.	2002
3	Thermal Design and Optimization, A Bejan, G Satsoranis and M Moran, 2nd ed., Wiley Inderscience.	1996
4	Computational Fluid Dynamics, Versteeg and Malalasekhera, 1st ed., Longman Scientific & Technical.	2007

Course Name	**:**	**MICRO-NANO SCALE HEAT TRANSFER**
Course Code	**:**	**ME2031/ME4031**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:	
1	To understand the basic concept of micro/nano scale heat transfer and micro/nano-fluids.
2	To understand the conduction, convection and radiation heat transfer at micro/nano scale.
3	To study the thermal energy storage and transport system.
4	To know the basics of micro-fluidics based devices for micro-flow and biological systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Micro-Nano Scale Phenomena, Basics of Micro/Nano Scale Heat Transfer and Fluid Mechanics, Miniaturization, Difference between Micro and Macro Scale Heat Transfer Phenomena, Impact of Micro-Nano Technology, Statistical Thermodynamics, Quantum Mechanics, Thermal Properties of Molecules and Kinetic Theory.	7
2	**THERMAL TRANSPORT IN SOLID MICRO-NANO STRUCTURES:** Electron and Phonon Scattering, Size Effects, Quantum Conductance, Electronic Band Theory, Tunneling, Non-equilibrium Heat Conduction and Analysis of Solid State Devices like Thermoelectric Refrigeration and Optoelectronics.	7
3	**HEAT TRANSFER AT MICRO-NANO SCALE:** Fundamentals and Engineering	10

	Applications, Methods and Observations of Thermo-Physical Phenomena in Size-Affected Domains, Principal Concepts and Practical Design Engineering, *Modern Engineering Applications*: Micro-channel Heat Sinks, Micro Heat Exchangers and Micro Heat Pipes. *Fundamentals of Nano Scale Thermal Phenomena in Fluids*: Nano Scale Thermal Phenomena, Nano-scale Thermal Radiation and Radiative Properties of Nano-materials, Surface Electromagnetic Waves, Problems on Micro-scale Conduction, Convection and Radiation Heat Transfer and Modeling.	
4	**THERMAL ENERGY STORAGE AND TRANSPORT:** Storage by Conduction in Natural and Engineered Structures, Thermal Energy in Two Carriers, I.E. Phonons and Electrons, Solid-State Transport, Quantum of Thermal Conductance, Ballistic Interface Resistance and Carrier Scattering, *Bulk Material Properties*: Thermal and Electrical Conductivity Derived from Particle Transport Theories, Effects of Spatial Confinement on Bulk Properties.	7
5	**MICRO-FLUIDICS:** Introduction, Important forces and scaling analysis, Governing equations, Fluids flowing in miniaturized systems, *Applications*: Fluid control devices, gas and fluid measurement devices, medical testing equipments and implantable drug pumps.	5
6	**NANO-FLUIDICS:** Introduction, Fundamentals of Nano-fluidics, *Nano-fluidic Energy Absorption*: Converting Mechanical Energy to Thermal Energy, *Nano-fluidic Energy Tapping*: Temporarily Storing Mechanical Energy, *Nano-fluidic Actuation*: Converting Thermal/Electrical Energy to Mechanical Energy, *Nano-fluidic Energy Harvesting*: Converting Thermal/Mechanical Energy to Electrical Energy.	6

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the difference among the heat transports phenomena at macro, micro, and nano-scale.	**L2**
2	Apply the concepts of the thermal energy storage and transport at micro-nano scale systems.	**L3**
3	Analyze the heat transfer processes occurring by means of conduction, convection and radiation at small scale.	**L4**
4	Examine heat storage and heat transfer in solids at micro-nano structure levels, and transport behaviour in micro-nano fluidic applications.	**L5**
5	Evaluate the performance of micro-fluidic and nano-fluidic system, and develop new system.	**L5 & L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	-	-	-	-	-	-	-	1	1	1
CO2	2	2	1	1	-	-	-	-	-	-	-	1	2	1
CO3	3	3	2	2	-	-	-	-	-	-	-	-	2	2
CO4	3	3	3	3	-	-	-	-	-	-	-	-	3	2
CO5	3	3	3	3	-	-	-	-	-	-	-	-	3	3

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Micro-scale and nano-scale heat transfer - Fundamentals and engineering applications, C.B. Sobhan, G.P. Peterson, CRC press.	2008

2	Micro-scale heat transfer - Fundamentals and applications in biological and micro-electro-mechanical systems, Editors: S. Kakaç, L.L. Vasiliev, Y. Bayazitoğlu, Y. Yener, Springer.	2004
3	Nano/Micro-scale Heat Transfer, Zhuomin Zhang, McGraw-Hill	2007
4	Thermal Energy at the Nano-scale - Lessons from Nano science, A Lecture Notes Series, Timothy S Fisher.	2013
5	Micro fluidics and Nano fluidics - Theory and Selected Applications, Clement Kleinstreuer, Wiley.	2013
6	Introduction to Micro-fluidics, Patrick Tabeling, Oxford University Press	2010
7	Introduction to Bio-MEMS, Albert Folch, CRC press	2012

Course Name	**:**	**POWER PLANT ENGINEERING**
Course Code	**:**	**ME2032/ME3004/ME4032/ME6004**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:	
1	To understand different types of steam cycles and estimate efficiencies in a steam power plant.
2	To describe basic working principles of hydro, gas turbine, diesel engine and nuclear power plants.
3	To understand the power plant economics, depreciation and cost of producing power.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**STEAM POWER PLANT:** Introduction, configuration of steam power plant, basic cycles of operation, Reheat-regenerative cycle, binary cycle, topping and superimposed cycle. *Steam generators*: Modern generators, once through and fluidized bed boilers design. Consideration of modern steam generators, furnace, fuel firing methods, fuel and ash handling systems, various accessories of steam generators, steam pressure & temperature control. *Steam Turbines*: Details of construction, accessories, governing, turbine blades, power calculations, arrangement of turbines, industrial turbines. Condensers and Cooling Towers: Performance, heat transfer design, calculations, efficiencies, detail construction, cooling water circuit, environmental aspects.	12
2	**HYDEL POWER PLANT:** Hydrology, rainfall measurement hydrographs, flow duration curves, site selection, classification of hydro stations, capacity of hydro stations, selection of prime movers, governing of water turbines, operation of different components of hydro station reservoirs, dam, spillway, canals, penstock, water hammer surge tank, Draft-tubes, specific speeds of turbines, Advantages and disadvantages of HPP.	6
3	**DIESEL POWER PLANT:** Diesel plant elements, arrangements of diesel plant, diesel engine fuel injection system, air intake system, engine lubrication and engine cooling systems, supercharging and superchargers. Methods of starting and stopping the engines. Advantages and disadvantages of using diesel power plant, Economics of diesel plant over steam and hydro-electric plant.	6
4	**GAS TURBINE POWER PLANT:** General features and characteristics and their application power plants, Analysis of different cycles, components of gas turbine power plants, governing system of gas turbine plant, advantages of G. T. plant, Gas and steam turbines, combined cycles –Thermodynamic analysis for optimum design, advantages and performance of combined cycles, economics of combined cycle.	8
5	**NUCLEAR POWER PLANT:** Atomic structure, energy levels, binding energy. Radioactivity, decay laws, half-life, nuclear reaction. The fission chain reaction	7

	(Controlled and uncontrolled). Maintenance of chain reaction, heat removal, reactor fuels and materials. Some common types of power reactors. Pressurized water reactor, boiling water reactor and gas cooled reactor. Reactor system safety provisions, Fusion reaction, site selection, Economics of nuclear power plants, Air pollution, Power plant and the air pollution, Units of radiation dose, Control of internal and external hazards, Combined cycle with nuclear power plants.	
6	**POWER PLANT ECONOMICS:** Fluctuating load on power plants, load curves, various performance factors of power station. Effect of variable load power plant design and operation. Economic analysis of power plants, tariffs, load division, combined operation of different power plants, heat rate, incremental heat rate, selection of power plant and station equipment.	3

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	**Knowledge Level (Blooms Level)**
1	Understand, identify and interpret constructional features and working of various components of Steam power plant.	L1, L2, L3, L4
2	Classify various types of fuels used in thermal power plant and explain their handling, combustion etc. Explain ash handling and dust collection mechanism, principle of fluidized bed combustion	L1, L2, L3, L4
3	Understand, identify and interpret constructional features and working of various components of Hydel power plant.	L1, L2, L3, L4
4	Understand, identify and interpret constructional features and working of various components of Diesel and gas power plant.	L1, L2, L3, L4
5	Understand, identify and interpret constructional features and working of various components of Nuclear power plant.	L1, L2, L3, L4
6	Evaluate the Effect of variable load power plant design and operation and its economic analysis.	L1, L2, L3, L4,L5

CO-PO & PSO Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2	-	-	-	-	-	-	-	-	2	3	1
CO2	3	3	2	-	-	-	-	-	-	-	-	2	3	1
CO3	3	3	2	-	-	-	-	-	-	-	-	2	3	1
CO4	3	3	2	-	-	-	-	-	-	-	-	2	3	1
CO5	3	3	2	-	-	-	-	-	-	-	-	2	3	1
CO6	3	3	2	-	-	-	-	-	-	-	-	2	3	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Power Plant Engineering, T. Morse, Tata McGraw Hill.	2010
2	Power Station Engineering & Economy, Skrotzki, McGraw Hill.	2008
3	Steam Power Plants, Potter, Ronald Press co., New York	2011
4	Nuclear Power Plant, Taylor, Philosophical Library.	2010
5	Power Plant Engineering, Mahesh Verma, Metropolitan.	2012
6	Power Plant Engineering, Domkundwar, Dhanpat Rai and sons	2016

Open Elective Courses

Course Name	**:**	**MEMS AND MICRO SYSTEM DESIGN**
Course Code	**:**	**ME2033/ME3005/ME6005**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:	
1	To provide knowledge of semiconductors and solid mechanics to fabricate MEMS devices.
2	To educate on the rudiments of micro fabrication techniques.
3	To introduce various sensors and actuators.
4	To introduce different materials used in MEMS.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION TO MEMS:** Origin of Micro-electro-mechanical-systems (MEMS), Intrinsic characteristics of MEMS and their applications, scaling laws in miniaturization, Materials for MEMS, the multidisciplinary nature of micro-systems.	8
2	**MICROMACHINING TECHNOLOGIES**: Additive techniques, Oxidation & physical vapor deposition, Chemical vapor deposition, and other additive techniques.	6
3	**MECHANICS AND DESIGN OF MICRO-SYSTEMS:** Mechanics, Dynamics, electrostatics, Advanced MEMS operating, Principles for sensing and actuation including Piezo resistive, Piezoelectric, Thermo-mechanical, Magnetic, *Micro-fluidics*: Flow, heat and mass transfer at small scales, Electro kinetics.	8
4	**WORKING PRINCIPLE OF MICROSYSTEMS:** Micro-sensors, acoustic wave sensors, biomedical and nano-sensors, chemical sensors, optical sensors, pressure sensors, thermal sensors, micro-actuation through thermal forces, SMA-Piezo electric crystals, and electrostatic forces, magnetic actuation, *Micro devices*: Micro-grippers, Micro-motors, Micro-valves, Micro pumps, Micro-accelerometers.	8
5	**POLYMER MEMS:** Polymers in MEMS, Poymide, SU-8, Liquid Crystal Polymer (LCP), PDMS, PMMA, Parylene, Fluorocarbon, Application to Acceleration, Pressure, Flow and Tactile sensors.	6
6	**CASE STUDIES OF MEMS PRODUCTS:** Micro-fluidic devices, Micro/nano transducers, Blood pressure sensor, Microphone-acceleration sensors, Gyroscope, Magnetic actuation.	6

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Review the fundamentals of MEMS.	**L1**
2	Apply the basics of electro-magnetic fabrication techniques in mechanical engineering	**L3**
3	Analyze the mechanics and design of micro-systems.	**L4**
4	Understand the working principle of MEMS sensors and actuators.	**L2**
5	Choose the basic devices and techniques to be used in polymer MEMS.	**L5**
6	Prepare the case studies on MEMS for different industrial applications.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	2	1	1	-	-	-	-	-	-	-	1	3	1
CO2	1	2	2	1	-	-	-	-	-	-	-	1	2	1
CO3	2	3	3	1	-	-	-	-	-	-	-	1	2	1

CO4	2	2	2	1	-	-	-	-	-	-	-	1	2	1
CO5	2	3	2	3	-	-	-	-	-	-	-	1	3	2
CO6	1	1	2	3	-	-	-	-	2	2	-	1	3	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Foundation of MEMS, C Liu, Pearson Education.	2017
2	Micro sensors, MEMS and Smart devices, JW Gardner, VK Varadhan, John Wiley & Sons.	2001
3	Nano structure and Nano materials, synthesis, properties and applications, G Cao, Ying, World Scientific Publishing Co.	2011
4	MEMS and Micro system Design and Manufacturing, T R Hsu, Tata McGraw Hill.	2017
5	Nano Scale Science and Technology, Robert K, Ian W H, Mark Geoghegan.	2005

Course Name	**:**	**PRINCIPLES OF PRODUCT DESIGN**
Course Code	**:**	**ME2034/ME3006/ME6006**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: In this course, the student will be able to	
1	Learn the technologies and practical applications in the product design and development.
2	Learn how to manage a product over whole product lifecycle.
3	Understand the components and their functions in product design and development processes.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**OVERVIEW OF THE DESIGN PROCESS:** Philosophy of Engineering Design, Steps involved in the Design Process, S-curves, Challenges of Product Development.	3
2	**PROBLEM DEFINITION:** Identifying Customer needs and requirements, Establishing Engineering Characteristics, Quality Function Deployment (QFD), Product Design Specification.	6
3	**FUNCTIONAL DESIGN:** Functions in engineering Design, Basics of Function Structure, Functional analysis and its steps, Functional Basis, Functional decomposition and flow.	7
4	**PRODUCT CONCEPT:** Methods of concept generation, Theory of resolution of invention-related tasks (TRIZ), Concept selection and methods of evaluation.	8
5	**EMBODIMENT DESIGN:** Product architecture, configuration, parametric design, systems approach and other consideration, Introduction to product metrics, Product evaluation techniques.	8
6	**INDUSTRIAL DESIGN:** Aesthetics and ergonomic aspects of product design, Concepts of Value Engineering, Evaluation of function, cost, worth and value, Failure mode and effects analysis.	6
7	**LEGAL AND ETHICAL ISSUES IN INDUSTRY:** Origin of laws, Contracts, Product Liability, Tort Law, Codes of Ethics and solving ethical conflicts.	4

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand and analyze the product design and development processes.	**L2 & L4**
2	Apply and evaluate the methodologies for product design, development and management.	**L3 & L5**

3	Differentiate between embodiment and industrial design.	**L4**
4	Create and plan a methodical approach to the management of product development to satisfy customer needs.	**L6**
5	Interpret the legal and ethical issue in product development.	**L4**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	2	2	1	-	-	-	-	-	-	-	1	2	2
CO2	1	2	3	1	-	-	1	-	-	-	-	1	2	1
CO3	1	2	3	2	-	-	-	-	-	-	-	-	3	1
CO4	1	3	3	3	-	-	1	-	-	-	2	1	3	1
CO5	-	-	-	-	-	2	-	3	-	-	-	2	1	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Engineering Design, George E Dieter, 3rd ed., McGraw Hill.	2001
2	Engineering Design, Pahl, W Beitz J Feldhusun, K G Grote, 3rd ed., Springer.	2007
3	Product Design and Development, Karl T. Ulrich, Steven D. Eppinger, Tata McGraw Hill.	2007
4	The Mechanical Design Process, David G. Ullman, McGraw Hill.	2003

Course Name	**:**	**SYSTEM DYNAMICS AND CONTROL**
Course Code	**:**	**ME2035/ME3007/ME6007**
Credits	**:**	**4**
L T P	**:**	**3-1/2-2/2**

Course Objectives: In this course, the student will be able to understand	
1	Fundamental techniques for modeling of dynamic systems.
2	System models in the time and frequency domains.
3	Feedback control systems and parameters which influences the stability and performance.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Fourier and Laplace transforms description of systems, Mathematical Modeling of flow, heat transfer, electrical, pneumatic and vibration systems, Numerical computations and simulations using MATLAB.	6
2	**ANALYSIS OF LINEAR SYSTEMS:** Linearization, Linear system, Transfer function models, Block diagram representation, Signal flow graph, Transient response analysis using Laplace transform, First and second order systems and their characteristics, Higher order systems, Steady state error and error constants, Design and performance in time domain.	7
3	**LINEAR FEEDBACK CONTROL SYSTEMS:** *Characteristics of feedback control systems*: Disturbance rejection, sensitivity, *Standard feedback controllers*: On/off, Proportional, integral, derivative, PD and PID, Numerical computations using MATLAB.	6
4	**SENSORS AND ACTUATORS FOR CONTROL SYSTEMS:** Sensors for temperature, pressure, flow and motion control, accelerometers, gyroscope, encoders, solenoids, potentiometers, Tacho-generator, hydraulic amplifier, DC motor and stepper	4

	motors.	
5	**STABILITY OF CONTROL SYSTEMS:** Poles and zeros, complex plane, Routh's criterion, Delay and its influence on control system performance, Frequency response, Bode plots, Nyquist plot, Nyquist stability criterion.	6
6	**CONTROL SYSTEM DESIGN:** Root locus method of design, Lead and lag compensation, Control system design using Frequency response, Frequency domain specifications, Gain margin, Phase margin, Correlation of Frequency and time domain specifications, Frequency domain design, Lead and lag compensator design using Bode Plots.	7
7	**INTRODUCTION TO MODERN CONTROL:** State space representation, Pole placement, state observer, Control with state feedback.	6

List of experiments	**No of Hrs**
Students shall be performing modelling and simulation of different engineering problems of system dynamics and control using coding tools in the laboratory.	14

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	**Knowledge Level (Blooms Level)**
1	Recall the basics of Fourier and Laplace transformation.	**L1**
2	Apply transfer functions to analyze the mechanical systems.	**L3 & L4**
3	Understand and apply the feedback control techniques to optimize the working of mechanical systems.	**L2 & L3**
4	Understand the principles and methods of modeling the interfaces between rotational-mechanical, translational-mechanical, electrical, fluid, and thermal systems.	**L2**
5	Develop the control system to generate and analyze the time and frequency Domain characteristics.	**L4 & L6**
6	Evaluate the stability of control systems.	**L5**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	1	1	-	-	-	-	-	-	-	1	1	1
CO2	3	3	3	3	2	-	-	-	-	-	-	1	3	2
CO3	3	3	3	3	2	-	-	-	-	-	-	1	3	2
CO4	2	3	2	3	1	-	-	-	-	-	-	1	3	1
CO5	3	3	3	3	3	-	-	-	-	-	-	1	3	2
CO6	3	3	3	3	3	-	-	-	-	-	-	1	3	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Modern Control Engineering, Katsuhiko Ogata, Prentice Hall.	2010
2	Control Systems: Principles and Design, M. Gopal, Tata McGraw-Hill Education	2002
3	Feedback Control of Dynamic Systems, G. F. Franklin, 6 ed., Pearson.	2009
4	System Dynamics: An Introduction, Derek Rowell and David N. Wormley, Prentice Hall.	1997
5	Introduction to Dynamics and Control in Mechanical Engineering Systems, Cho W. S. To, Wiley-ASME Press Series	2016

Course Name	**:**	**SMART MATERIALS AND STRUCTURES**
Course Code	**:**	**ME2036/ME3008/ME6008**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: In this course, the student will be able to	
1	Learn about different types of smart materials and design smart structures.
2	Understand the techniques to develop solutions for industrial problems using smart structures and materials.
3	Learn the engineering principles in smart sensor, actuator and transducer technologies.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTELLIGENT MATERIALS:** Primitive functions of intelligent materials, Intelligence inherent in materials, Materials intelligently harmonizing with humanity, Intelligent biological materials.	4
2	**SMART MATERIALS AND STRUCTURAL SYSTEMS:** Actuator materials, Sensing technologies, Micro-sensors, Intelligent systems, Hybrid smart materials, Passive sensory smart structures, Reactive actuator based smart structures, Active sensing and reactive smart structures, Smart skins.	7
3	**ELECTRO-RHEOLOGICAL AND MAGNETO-RHEOLOGICAL FLUIDS:** Suspensions and electro & magneto-rheological fluids, Electro & Magneto-rheological phenomena and working principle, Charge migration mechanism for the dispersed phase, Electro & Magneto-rheological fluid actuators.	6
4	**PIEZOELECTRIC MATERIALS:** Background, Piezoelectricity, Industrial piezoelectric materials, Smart materials featuring piezoelectric elements.	5
5	**SHAPE MEMORY MATERIALS:** Background and Applications, *Continuum applications*: Structures and machine systems, Discrete applications, Impediments to applications of shape-memory-alloys, Shape-memory-plastics.	7
6	**FIBER-OPTICS:** Overview, Advantages of fiber-optics, Light propagation in an optical fiber, Embedding optical fibers in fibrous polymeric thermosets, Fiber-optic strain sensors.	6
7	**PIEZOELECTRIC VIBRATIONS ABSORBER SYSTEMS:** Introduction, Single mode absorber, theory, design solution, extension including viscous modal damping, electromechanical coupling coefficient, inductance, Multimode absorber, derivation of transfer function, design solution, self-tuning absorber, performance function and control scheme.	7

Sr. No.	**Course outcome** By the end of this course, the student will be able to	Knowledge Level (Blooms Level)
1	Understand the primitive functions of the smart materials and their implementation.	**L2**
2	Apply the principles of operation and methods of analyses employed in smart materials.	**L3**
3	Distinguish the materials for their properties and different applications.	**L4**
4	Evaluate piezoelectric materials; shape memory materials, electrorheological & magnetorheological fluids.	**L5**
5	Understand and analyze the principles of fiber optics for newer applications	**L2, L4**
6	Adapt alternative solution for vibration suppression, shape control and sizing of mechanical systems using smart materials	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	-	-	-	-	-	-	-	1	3	1
CO2	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO3	3	2	2	2	-	-	-	-	-	-	-	1	2	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	2	1
CO5	3	3	3	3	-	-	-	-	-	-	-	1	2	1
CO6	3	3	3	3	-	-	-	-	-	-	-	1	2	1

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Smart Materials and structures, M.V. Gandhi and B.S. Thompson, 2nd ed., Chapman & Hall.	1992
2	Smart Structures and Structuronic System, U. Gabbert and H.S. Tzou, Kluwer Academic Publishers.	2001
3	Smart Structures - Analysis and Design, A.V. Srinivasan and D. Michael McFarland, Cambridge University Press.	2001
4	Smart Material Structures: Modeling, Estimation and Control, H.T. Banks, R.C. Smith and Y.W. Qang, 6th ed., John Wiley & Sons.	1999

Course Name	**:**	**TRIBOLOGY AND LUBRICATION**
Course Code	**:**	**ME2037/ME3009/ME6009**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: This course is aimed to	
1	Give exposure to the students about the interaction between the three basic areas of engineering, i.e., friction, wear and lubrication.
2	Give exposure to complete range of industrial lubricants and their mechanical behavior.
3	Enable students to design sliding contact and rolling contact bearings.

Total No. of Lectures – 42

Sr. No.	Contents	
1	**SURFACE INTERACTION AND FRICTION:** Topography of surfaces, *Surface features*: properties and measurement, surface interaction, adhesive theory of sliding friction, rolling friction, friction properties of metallic and non-metallic materials, friction in extreme conditions, thermal considerations in sliding contact, concept on geometry for the performance analysis of bearing.	7
2	**WEAR AND SURFACE TREATMENT:** Types of wears, mechanism of various types of wear, laws of wear, theoretical wear models, wear of metals and non-metals, plastics and ceramics, surface treatments, surface modifications, surface topography measurements, laser methods, instrumentation, international standards in friction and wear measurements.	7
3	**LUBRICANTS AND LUBRICATION REGIMES:** Lubricants and their physical properties, viscosity and other properties of oils, additives and selection of lubricants, *Lubricants Standards*: ISO, SAE, AGMA, BIS standards, lubrication regimes, solid lubrication, dry and marginally lubricated contacts, boundary lubrication.	7
4	**SELECTION OF BEARINGS:** Selection criteria, dry and boundary lubrication bearings, hydrostatic and hydrodynamic bearings, electromagnetic bearings, dry bearings, rolling element bearings, bearings for precision applications, foil bearings, special bearings, selection of plain bearing materials, metallic and non-metallic bearings, tolerance on bearings.	6

5	**THEORY OF HYDROSTATIC AND HYDRODYNAMIC LUBRICATION:** Reynolds equation, assumptions and limitations, one and two dimensional Reynolds equation, Somerfield boundary conditions, pressure wave, flow, load capacity and friction calculations in hydrodynamic bearings, long and short bearings, pad bearings and journal bearings, squeeze film effects, thermal considerations, hydrostatic bearings & lubrication, design of foil bearings, air bearings.	8
6	**HIGH PRESSURE CONTACTS AND ELASTO HYDRODYNAMIC LUBRICATION:** Rolling contacts of elastic solids, contact stresses, Hertzian stress, spherical and cylindrical contacts, contact fatigue life, oil film effects, *Elasto Hydrodynamic Lubrication:* Theory of soft and hard elasto hydrodynamic lubrication, Reynolds equation for elasto hydrodynamic lubrication, film shape within and outside contact zones, film thickness and friction calculation, rolling bearings, stresses and deflections, traction drives, internal clearance, shaft and housing fit, mounting arrangements, materials for rolling bearings, manufacturing methods, ceramic bearings, rolling bearing cages bearing seals selection.	7

Sr. No.	**Course outcome** By the end of this course, the student will be able to	Knowledge Level (Blooms Level)
1	Recall and understand the basics of friction, wear and lubrication	**L1, L2**
2	Apply and evaluate wear mechanism principles to different kinds of materials.	**L3, L5**
3	Analyze the mechanical behavior of lubricants while working between rubbing surfaces under load without causing wear.	**L4**
4	Selection & design of Journal, Ball and Roller Bearings for different applications.	**L6**
5	Recall the various equations of fluid mechanics and conjecture these with hydrodynamic lubrication.	**L1, L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	1	1	-	-	-	-	-	-	-	1	3	1
CO2	3	3	3	2	-	-	-	-	-	-	-	1	3	2
CO3	3	3	2	2	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	3	2
CO5	3	3	3	3	-	-	-	-	-	-	-	1	3	2

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Friction and Wear of Materials, E. Rabinowicz, John Willey & Sons, UK.	1995
2	Basic Lubrication Theory, A. Cameron, Ellis Herward Ltd., UK.	1981
3	Principles of Tribology, J. Halling, Macmillian.	1984
4	Engineering Tribology, J. A. Williams, Oxford Univ. Press.	1994
5	Fundamentals of Tribology, S. K. Basu, S. N. Sengupta & B. B. Ahuja, Prentice-Hall of India Pvt. Ltd., New Delhi.	2005
6	Engineering Tribology, G. W. Stachowiak & A.W. Batchelor, Butterworth-Heinemann, UK.	2005
7	Tribology Hand Book, M.J. Neale, Butterworth Heinemann, UK.	2001

Course Name	**:**	**MODELING AND SIMULATION**
Course Code	**:**	**ME2038/ME30010/ME6010**

Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: In this course, the student will be able to
1. Understand modelling technique for analysis and synthesis of real-world problems. **2.** Understand the energy interaction of different components of a system. **3.** Learn different simulation techniques applied to mechanical systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** System, environment, input and output variables, State variables, Static and Dynamic systems, Hierarchy of knowledge about a system and modeling strategy, *Physical Modeling*: Similarity criteria and their application.	8
2	**MODELING OF SYSTEM:** Review of conservation laws and governing equations of heat, mass and momentum transfer, *Deterministic model*: Distributed parameter models in terms of partial identification and their solutions, Lumped parameter models in terms of differential and difference equations, state space model, transfer functions block diagram and sub systems, stability of transfer functions, modeling for control.	10
3	**SYSTEM SIMULATION:** Techniques of simulation, Monte Carlo method, Experimental nature of simulation, Numerical computation techniques, Continuous system models, Analog and Hybrid simulation, Feedback systems, Computers in simulation studies, Simulation software packages.	8
4	**SYSTEM DYNAMICS:** Growth and Decay models, Logistic curves, System dynamics diagrams, *Probability Concepts in Simulation*: Stochastic variables, discrete and continuous probability functions, Random numbers, Generation of Random numbers, Variance reduction techniques, Determination of length of simulation runs.	8
5	**SIMULATION OF MECHANICAL SYSTEMS:** Building of Simulation models, Simulation of translational and rotational mechanical systems, Simulation of hydraulic and pneumatic systems, Simulation of waiting line systems, Job shop with material handling and flexible manufacturing systems, Simulation software for manufacturing, Structure and development of expert systems.	8

Sr. No.	**Course outcome** By the end of this course, the student will be able to	Knowledge Level (Blooms Level)
1	Recall the conservation laws and governing equations of heat, mass and momentum transfer.	**L1**
2	Understand various systems and their input/output and state variables.	**L2**
3	Apply the concepts of physical and deterministic models for modelling of systems.	**L3**
4	Analyse and evaluate various system simulation techniques and feedback control systems.	**L4**
5	Generate and evaluate the system equations using different modelling techniques.	**L5 & L6**
6	Develop mechanical systems and perform its simulations.	**L3 & L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	1	1	1	-	-	-	-	-	-	-	1	1	1
CO2	2	3	3	2	-	-	-	-	-	-	-	1	3	1
CO3	3	3	3	3	1	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	3	1

CO5	3	3	3	3	1	-	-	-	-	-	-	1	3	1
CO6	3	3	3	3	2	-	-	-	-	-	-	1	3	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Principles of Modeling and Simulation: A Multidisciplinary Approach, John A. Sokolowski and Catherine M. Banks, Elsevier.	2009
2	Theory of Modeling and Simulation, Zeigler B.P. Praehofer and I.G. Kim, 2nd ed., Academic press.	2000
3	System Dynamics, Modeling and Simulation of Mechatronic Systems, D.C. Karnopp, D.L. Margolis and R.C. Rosenberg, John Wiley & Sons, NY.	2000

Course Name	**:**	**HYDRAULICS AND PNEUMATICS CONTROL DESIGN**
Course Code	**:**	**ME2039/ME30011/ME6011**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:	
1	To provide an insight into the capabilities of hydraulic and pneumatic fluid power.
2	To understand the concepts and relationships surrounding force, pressure, energy and power in fluid power systems.
3	To examine concepts centering on sources of hydraulic power, rotary and linear actuators, distribution systems, hydraulic flow in pipes, and control components in fluid power systems.
4	To provide the exposure to build and interpret hydraulic and pneumatic circuits related to industrial applications.
5	To familiarize with logic controls and trouble shooting.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**BASIC PNEUMATIC AND HYDRAULIC SYSTEMS:** Introduction and basic elements of fluid power system, their structure, advantages and limitation, Applications of fluid power, pneumatic vs hydraulics control systems, Properties of fluids for hydraulic systems and governing laws, review of pneumatics in distribution of fluid power, Structure and signal flow of hydraulic and pneumatic system, Basic types and constructions of hydraulic pumps, motors and compressors, Air generation and distribution, Processing elements, Power components.	5
2	**FLUID ACCESSORIES:** Air receiver, after-cooler, Air Dryer, Air Filter, Pressure Regulator, Air Lubricator, Air Service Unit, Pipeline layout, Seals, Hydraulic fluids, Hydraulic reservoir, Hydraulic filter, Hydraulic Accumulator, Intensifier, Pressure gauges and Volume Meters, Lines, Fitting and Connectors, Hydraulic seals.	5
3	**ACTUATORS AND OUTPUT DEVICES:** Cylinders, Classification of cylinders on the basis of construction, Single and Double acting cylinders, their types, *Classification of cylinders on the basis of working Medium*: hydraulic and Pneumatic, rod-less cylinders, Cylinder construction, mounting arrangement Construction and working of rotary actuators such as gear, vane, piston and hydraulic motors. Theoretical torque, power, flow-rate, hydraulic motor performance, Symbolic representation of actuators (cylinders and motors), Cylinder performance characteristics, Symbols of Motors, Classification of fluid motors.	5
4	**CONTROL ELEMENTS:** Classification of the valves, Direction Control valves, Poppet valves, Function of a 3/2-way NC and NO poppet valve, Manual and	8

	Mechanical operation of poppet valves, Mini poppet valves, 3/2-way and 5/2-way spool valves, Manual and mechanical operating devices for spool valves, Pneumatic operating devices for the valves , Directly operated solenoid valves , Servo solenoid valves with internal pilot and external pilot, Three-position valves, *Blocking valves*: Unidirectional, bidirectional, Signal processing valves, Nominal flow rate, Sizing of directional control distribution valves and connecting tubes, Interception valves, Non return, Flow and Pressure valves, Valve combination, Quick exhaust valve, Time delay Valve/Air Timer, Pneumatic Logic Valves, Twin Pressure valve, Shuttle Valve, Symbolic representation.	
6	**DESIGN OF HYDRAULIC CONTROL CIRCUIT:** Symbols and description of components, Rules for designing circuits, Control chain, design of circuit diagram, circuit layout, designation of individual elements, Single or semi-automatic cycle, Continuous or automatic cycle, Elementary circuits, Signals generated by limit switches, Hydraulic circuit for control of single acting and double acting cylinder, Speed control in hydraulic circuits, Bleed of circuit, Regenerative circuit, Sequencing circuit, hydraulic circuit for force multiplication, speed control of hydraulic cylinder-metering in, metering out and bleed off circuits, Pilot pressure operated circuits, Hydraulic circuit with accumulator, counter balance valve application, Memory valves, Timer, Cycle start command, Single and continuous cycle, Emergency commandpressure reduction circuit, problems in circuit design.	6
7	**DESIGN OF PNEUMATIC CONTROL CIRCUIT:** Pneumatic Circuits for control of single acting and double acting cylinder, *Simple Pneumatic Control*: Direct and indirect actuation pneumatic cylinders, speed control of cylinders, supply air and exhaust air throttling, Circuit with mechanical feedback, Use of flow control valve and Quick exhaust valve, Time delay circuit, Circuit with necessary conditions, Application of Twin pressure and Shuttle valve, *Signal Processing Elements*: Use of Logic gates, OR and AND gates in pneumatic application, Practical examples involving the use of logic gates, *Electro-Pneumatic Control*: Principles, signal input and output, pilot assisted solenoid control of directional control valves, use of relay and contactors, Control circuitry for simple signal cylinder application.	7
8	**CONTROL SYSTEMS:** Open and closed loop control system, Selection and comparison of working and control media, Control Theory, *Control system development*: Positional sketch, Displacement, step diagram, Control Chart, Function Diagram, Function chart, Circuit diagram, Cascade Design, Steps involved in cascade design, Sign Conventions, Development aspects, Emergency control.	6

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recall basic elements of fluid mechanics and logic gates	**L1**
2	Identify and analyze the functional requirements of a fluid power transmission system for a given application.	**L2 & L4**
3	Understand the working of hydraulic/pneumatic circuit to accomplish the desired function.	**L2**
4	Design an appropriate hydraulic/pneumatic/combination circuit like electro-hydraulics, electro-pneumatics for a given application.	**L6**
5	Select and standardize the different components of the circuit.	**L5**
6	Apply the control systems development techniques in industrial applications.	**L3**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	1	1	1	-	-	-	-	-	-	-	1	2	1

CO2	2	3	3	2	-	-	-	-	-	-	-	1	3	1
CO3	3	3	2	3	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO5	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO6	3	3	3	3	-	-	-	-	-	-	-	1	3	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Fundamentals of Fluid Power Control, John Watton, Cambridge University press.	2012
2	Hydraulics and Pneumatics, Andrew Par, Jaico Publishing House.	2005
3	Fluid Power with Applications, Anthony Esposito, Pearson.	2000
4	Introduction to Fluid Power, Thomson, Prentice Hall.	2004
5	Pneumatic systems – Principles and Maintenance, Majumdar S.R., Tata Mc-Graw Hill, New Delhi.	2005
6	Oil Hydraulics, S. R. Majumdar, Tata Mc-Graw Hill.	2002

Course Name	**:**	**NON-CONVENTIONAL ENERGY RESOURCES**
Course Code	**:**	**ME2040/ME3012/ME6012**
Credits	**:**	**4**
L T P	**:**	**3 - 1 - 0**

Course Objectives: To understand the	
1	Solar energy, wind energy and biomass energy technologies.
2	Basic concepts of solar radiation, solar thermal systems and PV cells.
3	Wind-energy potential and get familiarize with different systems for its effective utilization.
4	Bio-energy generation from the bio-waste and waste management system.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Introduction to sustainable energy, energy and environment, energy scenario and role of renewable in India, human development index, conventional energy sources, limited fossil fuels, environmental impact of fossil fuels, energy alternatives, introduction to various sources of renewable energy.	4
2	**SOLAR RADIATION AND ITS MEASUREMENT:** Extra-terrestrial radiation, spectral distribution, solar constant, solar radiations on earth, measurement of solar radiations, solar radiation geometry, solar radiation on tilted surface.	4
3	**SOLAR ENERGY:** Solar flat plate collector, solar air heater, solar water heater, types of concentrating collectors, solar energy tracking systems, introduction to solar thermal energy storage systems, solar energy plants in India, Solar energy mission, environmental impact of solar energy, Solar photovoltaic systems and applications.	6
4	**WIND ENERGY:** Introduction, Wind resource assessment, wind data and energy estimation, energy pattern factor in wind power, Weibull probability density function, Beaufort wind scale, Wind power generation curve, Fundamentals and classification of wind turbines, aerodynamic design principles, Modern wind turbines and their characteristics, power extraction and control strategies, Modes of wind power generation, Wind energy farms, Wind energy power plants in India, Futuristic hybrid wind-solar system, Economic consideration and environmental impact.	12
5	**BIO-ENERGY:** Introduction, Photosynthesis, Constituents of biomass materials, *Analysis of biomass*: Biochemical, Proximate analysis, Ultimate analysis, *Primary*	12

	biomass as source of energy: Woody biomass, oilseed crops, energy plantation, *Secondary biomass as source of energy*: Residues and wastes, Processes of biomass separation and pelleting, *Thermochemical Processing*: Combustion, pyrolysis, gasification, hydrothermal processing, transesterification, producer gas, bio-diesel, *Biochemical Processing*: Anaerobic digestion, fermentation to produce ethanol, enzymatic conversion, *Bio-power generation systems*: Energy from urban waste, liquid waste, Power generation from landfill gas, biomass cogeneration, biomass resource development in India, environmental impact and future of bio-energy.	
6	**WASTE CYCLE MANAGEMENT:** Introduction, Common source of waste, Different types of waste, Waste management, Recycling processes and waste management, Advantages and disadvantages of recycling waste and Recycling plants.	4

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Introduction to energy and environment, energy scenario in India and role of renewable energy.	**L2**
2	Demonstrate various renewable energy systems based on solar, wind and bio-energy, and discuss their present status and future plans in India.	**L3**
3	Estimate the solar radiation, formulate heat transfer equations, and analyze modern energy conversion systems used in solar applications.	**L4** **L5**
4	Examine the wind energy potential and evaluate the performance of wind energy plants.	**L4** **L5**
5	Examine different methods of bio-energy sources, bio-energy harvesting, waste cycle management, and evaluate their economic and operational viability.	**L4** **L5**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	-	-	1	-	-	-	-	1	1	-
CO2	2	2	1	1	-	-	1	-	-	-	-	1	2	-
CO3	3	3	2	2	-	-	1	-	-	-	-	1	3	1
CO4	3	3	3	2	-	-	1	-	-	-	-	1	3	1
CO5	3	3	3	2	-	-	2	-	-	-	-	2	3	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Non-Conventional Energy Sources, G.D. Rai, Khanna Publishers, New Delhi	2014
2	Renewable Energy Resources, Twidell, J.W. & Weir, A., EFN Spon Ltd., UK	2005
3	Renewable Energy: Power for a Sustainable Future, Godfrey Boyle, Oxford University Press, U.K.	2012
4	Solar Energy: Principles of Thermal Collection and Storage, S.P. Sukhatme, Tata McGraw Hill Publishing Company Ltd., New Delhi.	2009
5	Solar Energy – Fundamentals Design, Modelling and applications, G.N. Tiwari, Alpha, Science Intl Ltd.	2015
6	Non-Conventional Energy Resources, B.H. Khan, McGraw Hill	2009
7	Wind Energy Explained-Theory, Design and Applications, J. F. Manwell, J. G. McGowan, and A. L. Rogers, 2nd ed. Wiley	2010
8	Renewable Energy Resources, J. Twidell and T. Weir, 3rd ed. Routledge	2015
9	Principles of Sustainable Energy Systems, F. Kreith, 2nd ed. CRC Press	2014

Course Name	**:**	**ADVANCED UNCONVENTIONAL ENERGY RESOURCES**
Course Code	**:**	**ME2041/ME3013/ME6013**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:	
1	To get an exposure of hydrogen energy, fuel cells, nuclear energy, tidal energy and geothermal energy technologies.
2	To understand the basic concepts and different systems involved in utilizing hydrogen as a fuel.
3	To understand the potential and applications of nuclear energy, tidal and wind energy and geothermal energy.
4	To understand the thermoelectric and thermionic convertors, MHD generator and small Hydel turbines.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**HYDROGEN ENERGY**: Hydrogen as a fuel, Properties and Sources of Hydrogen, Production, Storage and Transportation Methods, Controlled and Uncontrolled Hydrogen Combustion, Hydrogen as a Fuel in Automobiles, Hydrogen Management and Mitigation Strategies (including safety systems), Environmental Benefits.	8
2	**FUEL CELLS:** Introduction, difference between batteries and fuel cell, Working principle of Fuel Cell, Different components of fuel cells, Operating and Performance Characteristics of Fuel Cell, Types of fuel cell, Hydrogen Fuel Cell and Analysis, Fuel cell power plants, Fuel cell application in automobiles, Problems with Fuel Cells, Overview on ongoing research activities in India and World, Future potential of fuel cells.	8
3	**NUCLEAR ENERGY**: Nuclear energy scenario in India and World, India's three stage nuclear program, Introduction to nuclear fusion and fission reactions, Fissionable materials, *Nuclear Fission Power Plants*: Types of power plants (BWR, PWR, and PHWR), Basic components, construction and working of a nuclear reactors, *Nuclear reactor containment*: Purpose and basic construction, passive containment cooling concept, Introduction to various safety systems, 4^{th} generation Nuclear Power Plants, Radiation leakage and its effect on nearby habitants, Nuclear waste and its disposal, Nuclear fusion reactors.	8
4	**TIDAL AND WAVE ENERGY:** Origin of Tides, types of tidal power generation systems, important components, tidal power development in India, economics of tidal power, *Wave Energy*: Basic theory, Open and closed Ocean Thermal Energy Conversion Cycles (OTECs), global development of OTEC plants, OTEC development in India.	6
5	**GEOTHERMAL ENERGY:** Introduction, Sources, physics of deep geothermal resources, technologies for exploiting high enthalpy steam feeds, Geothermal power plants, geothermal preheat hybrid with conventional plants, Identification and utilization of geothermal energy in India, Recent advancement in geothermal energy, environmental impact of geothermal energy.	4
6	**OTHER ENERGY SYSTEMS**: *Thermo-Electric Power*: Basic principles, Thermo electric power generators, Applications and limitations, *Thermionic Power Generation*: Basic principles, Thermionic generators, Applications and limitations, *Magneto-Hydro-Dynamics (MHD) Generators*: Basics Principle of MHD generation system, MHD open and closed systems, Advantages and Disadvantages of MHD, *Small Hydro Power*: Resource assessment for small installations, Mini and micro hydel power plants, classification and operating range of different hydro turbines, Indian and global scenario of small hydro power, *Hybrid Energy Systems*, integrating renewable and	8

	conventional energy sources, Global impact of the unconventional energy sources.	

Sr. No.	Course outcome By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
	Introduction to advanced unconventional energy resources, such as hydrogen, nuclear, tidal & wave energy, geo-thermal and others.	**L2**
1	Discuss hydrogen, nuclear, tidal & wave energy, geo-thermal and other renewable energy systems, and their current status and future in India.	**L3**
2	Explore safe and effective use of hydrogen, analyze and evaluate the performance of different hydrogen fuel cells, and their implementation in Indian conditions.	**L4** **L5**
3	Examine the potential of nuclear energy from India's perspective, appraise different types of nuclear power plants and safety systems.	**L4** **L5**
4	Examine geothermal, tidal and wave energies from India's perspective and defend their operational viability.	**L4** **L5**
5	Distinguish and apply the various form of energies such as thermo-electric, thermionic, magneto hydrodynamic in practical applications.	**L2** **L3**

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	1	-	-	1	-	-	-	-	1	1	-
CO2	2	2	1	1	-	-	1	-	-	-	-	1	2	-
CO3	3	3	2	2	-	-	1	-	-	-	-	1	3	1
CO4	3	3	3	2	-	-	1	-	-	-	-	1	3	1
CO5	3	3	3	2	-	-	2	-	-	-	-	2	3	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Non-Conventional Energy Sources, G.D. Rai, Khanna Publishers, New Delhi.	2014
2	Renewable Energy Resources, Twidell, J.W. & Weir, A., EFN Spon Ltd., UK	2005
3	Renewable Energy, Power for a Sustainable Future, Godfrey Boyle, Oxford University Press, U.K.	2012
4	Non-Conventional Energy Resources, B.H. Khan, McGraw Hill.	2009
5	Renewable Energy Resources, J. Twidell and T. Weir, 3rd ed., Routledge.	2015
6	Principles of Sustainable Energy Systems, F. Kreith, 2nd ed., CRC Press.	2014

Course Name	**:**	**EXPERIMENTAL METHODS FOR ENGINEERS**
Course Code	**:**	**ME2042/ME3014/ME6014**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:	
1	To understand the measurement terminologies and the concept of measurement system.
2	To find the errors and uncertainty in the measurements.
3	To understand different sensors used for measurement.
4	To identify correct DAQ system for recording and analyzing the experimental results.

Total No. of Lectures – 42

Lecture wise breakup	**No. of**

		Lectures
1	**INTRODUCTION TO EXPERIMENTAL METHODS**: Measurement, Instrument, Measurement methods, Generalized measurement system and its functional elements, Classification of instruments, *Basic concepts*: accuracy, precision, Range, Resolution, Span, Experiment planning, *Analysis of experimental data*: Error Analysis, Evaluation of and propagation of uncertainties; Regression analysis, Calibration of instruments.	5
2	**INSTRUMENT CHARACTERISTICS:** Introduction, Static terms and characteristics, Dynamic terms and characteristics, Standard test-inputs, Zero, first and second order instruments, Response of first and second order system.	4
3	**FLOW MEASUREMENT AND VISUALIZATION**: Positive-displacement methods, Flow-obstruction methods, Sonic nozzle, Flow measurement by drag effects, Pressure probes, Hot-wire and hot-film anemometers, Magnetic flow meters, *Flow visualization methods*: Smoke methods, Shadowgraph, Schlieren photography, Laser Doppler anemometer, Laser-induced fluorescence, Particle image velocimetry.	10
4	**TEMPERATURE MEASUREMENT**: Temperature scales, Ideal-gas thermometer, Temperature measurement by mechanical and electrical effects, Temperature measurement by radiation, Transient response of thermal systems, Thermocouple compensation, Temperature measuring problems in flowing fluids, Dynamic compensation, Field temperature measurement using infrared camera.	10
5	**TRANSPORT-PROPERTY MEASUREMENT:** Measurement of thermal conductivity, Measurement of viscosity, Gas diffusion calorimetry, Convection heat transfer measurement, Humidity measurement, PH measurement, *Thermal-radiation measurements*: Emissivity measurement, Reflectivity and transmissivity measurement, Air pollution sampling and measurement, Gas sampling techniques, Combustion products measurement.	8
6	**DAQ AND SIGNAL ANALYSIS:** Systems for data acquisition and processing, Modules and computerized data system, Selection criteria for choosing a DAQ system, Digitization rate, Time and frequency domain representation of signals, Nyquist criterion, Techniques for signal analysis, *Signal conditioners:* Filters, low, high, band pass and amplifiers.	5

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Discuss different measurement systems and signal recording procedures.	**L2**
2	Interpret the error and minimize the uncertainty in the experimental data.	**L3**
3	Employ different measurement devices in real-time system to correctly measure the parameters of interest.	**L4**
4	Select the suitable DAQ system for recording of the experimental data.	**L5**
5	Design and implement the experimental measurement methodology to existing and new thermo-mechanical systems.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	1	1	1	-	-	-	-	-	-	-	1	1	1
CO2	3	2	2	1	-	-	-	-	-	-	-	1	2	1
CO3	3	2	3	2	1	-	-	-	1	-	-	2	3	2
CO4	3	2	3	3	2	-	-	-	2	-	-	2	3	3
CO5	3	3	3	3	3	-	-	-	3	-	-	2	3	3

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/**

		Reprint
1	Experimental Methods for Engineers (SIE), J. P. Holman, 7th ed., McGraw-Hill.	2017
2	Theory and Design for Mechanical Measurements, R. S. Figliola and D. Beasley, 7th ed., John Wiley & Sons.	2020
3	Measurement Systems, E. O. Doebelin, 7th ed., McGraw-Hill.	2019
4	An Introduction to Error Analysis, J. R. Taylor, 2nd ed., University Science Books.	1997
5	Theory and Design for Mechanical Measurements, Alex. C. Beasley, Intelliz Press.	2017

Course Name	**:**	**THERMAL MANAGEMENT OF ENGINEERING SYSTEM**
Course Code	**:**	**ME2043/ME3015/ME6015**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:	
1	To understand the basics concepts of thermal management system.
2	To understand the process of convective and conduction cooling for different engineering components.
3	To have in depth understanding of various cooling technologies and cooling of PCB Systems.
4	To impart the knowledge of advance cooling technologies and concept of cooling in micro-electric systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Need for Thermal Control, Reliability and Temperature, Fundamental of Convective and Boiling Heat Transfer, Key Components of Liquid Cooled System, Heat Transfer from Component to Coolant.	5
2	**CONDUCTION AND CONVECTION COOLING:** One-Dimensional Heat Conduction, Application to Single Plate, Parallel Plates, Straight Fin Arrays and Pin Fin Arrays, Thermal/Electrical Analogy, Lumped-System Transient Analysis and Heat Conduction with Phase Change.	8
3	**LIQUID COOING TECHNOLOGIES:** Natural Convection Liquid Cooling, Direct Immersion Pool Cooling, Forced Convection Liquid Cooling, Flow Boiling Cooling, Refrigerant Cooling, Micro channel Cooling, Jet Impingement and Spray Cooling, Forced Convection involving Phase Change Materials.	8
4	**COOLING OF MICRO-ELECTRIC EQUIPMENT:** Direct Immersion Cooled Chip Packages, Computing Systems; Other Types of Systems, Miniature, Small & Micro Scale Refrigeration Systems and Aerospace and Space Systems.	5
5	**COOLING OF PCB SYSTEMS:** Components of Printed Circuit Boards, Direct Air Cooling and Fans, Natural and Mixed Convection, Heat Exchanger and Cooling Plates, and Fans and Air-Handling Systems.	8
6	**ADVANCED COOLING TECHNOLOGY:** Single Phase Liquid Cooling, Two Phase Flow Cooling, Heat Pipe Operation Principle, Useful Characteristics, Operational Limits, Material Compatibility, Operating Temperatures, Operation Methods, Applications and Micro Heat Pipes, Thermoelectric Coolers, Operation Principle, System Configuration and Performance Analysis.	8

Sr. No.	**Course Outcome** By the end of this course, the student will be able to:	**Knowledge Level (Blooms Level)**
1	To understand the fluid dynamics of electronic cooling systems and heat transfer mechanisms	**L1, L2**
2	To understand and develop basic concept pertaining to thermal management of engineering system.	**L2, L3**
3	To have detailed idea of various convective and conduction cooling	**L5**

	techniques for different physical systems.	
4	To understand thermal energy conversion system and involve management practices for optimization of energy savings.	**L6**
5	To apply various cooling technologies for thermal management of PCB systems.	**L4**
6	To analyze advance cooling technologies and apply concepts of cooling in micro-electronic systems.	**L3, L4**
7	To design of electronic equipment which minimizes the thermal failures by having involving better technique cooling.	**L5, L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	2	3	-	-	-	-	-	-	-	-	-	1	-
CO2	-	1	2	3	-	-	-	-	-	-	-	-	2	-
CO3	-	-	-	1	2	3	-	-	-	-	-	-	2	-
CO4	-	-	-	-	-	1	2	3	-	-	2	1	2	1
CO5	-	-	-	-	-	-	-	2	3	1	-	-	1	1
CO6	-	1	2	1	-	3	-	-	-	-	-	-	1	1
CO7	-	-	-	1	-	-	-	1	2	2	1	1	1	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Thermal Design of Liquid Cooled Microelectronic Equipment, L T Yeh, ASME Press, New York.	2019
2	Thermal Management of Microelectronic Equipment, L T Yeh and R C Chu, ASME Press New York.	2002
3	Cooling of Electronic Systems, S. Kakaç H. YüncüK. Hijikata, Springer.	1993
4	Heat Transfer: Thermal Management of Electronics, Younes Shabany, CRC Press.	2010

Course Name	**:**	**SOLAR THERMAL ENERGY**
Course Code	**:**	**ME2044/ME3016/ME6016**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:	
1	To understand the basic principles of solar energy.
2	To understand the design and operation of solar thermal energy conversion devices.
3	To study the industrial and building applications of the solar energy.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**OVERVIEW:** Introduction, Space and Time, Solar Geometric Angles (Space), Earth's Tilted Axis and the Seasons, Solar Time, Extra-terrestrial Radiation and the Atmosphere, Micro-controller based solar energy measurement system, *Materials For Optocaloric Performance:* Introduction, Heat Transfer Considerations, Radiation Characteristics of Opaque Materials, Radiation in Cover-Absorber Systems.	8
2	**COLLECTOR SYSTEMS:** *Flat-Plate Collector Systems:* Introduction, Overview	14

	of Flat Plate Collectors, Energy Balance in Flat-Plate Collectors, Flat Plate Collector Performance and Characterization. *Concentrating Collector Systems*: Introduction, Overview of Concentrating Collectors, Non-Imaging Concentrators, Imaging Concentrators, Solar Energy Tracking Systems. *Performance Of Solar Thermal Collectors and Systems:* Introduction, Load of Solar Thermal Systems, Component and System Models. *Thermal Fluids:* Introduction, Overview of Solar Thermal Fluids, Applications of Various Fluids, Pumping Power Considerations.	
3	**SOLAR THERMAL POWER SYSTEMS:** Introduction, Overview of Solar Thermal Power Systems, Parabolic Trough Collector Systems, Central Receiver Systems - Power Tower, Solar Updraft Towers.	4
4	**INDUSTRIAL PROCESSING REQUIREMENTS:** Introduction, Overview of Solar Heat for Industrial Processes, Economic Aspects of Industrial Solar Heat, Industrial Process Applications and Requirements.	4
5	**APPLICATIONS OF SOLAR ENERGY:** Introduction, Active versus Passive, Energy storage considerations, f-Chart Method for Solar Heating Design, *Solar Cooling:* Introduction, Overview of Solar Cooling, Absorption Cooling, Psychrometrics and Desiccants, Solar Drying, Solar Desalination.	10
6	**CURRENT MARKET:** Introduction, Market Overview for Solar Thermal Energy, Identifying a Good Market for STE, Solar Heating and Cooling Status and Trends.	2

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	**Knowledge Level (Blooms Level)**
1	Identify the potential and scope of solar thermal energy in context to technological advancements and economics.	L5
2	Perform thermodynamic analysis of solar cooling and heating systems technologies.	L4
3	Develop the solar thermal conversion systems for low, medium and high temperature applications.	L6
4	Predict the productivity and performance of various solar thermal collectors.	L3
5	Compare performance and suitability of various solar thermo-mechanical household systems.	L5
6	Compare performance and suitability of various solar energy based industrial process heating systems.	L5

CO-PO & PSO Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	1	-	-	-	-	-	-	-	-	-	3	1
CO2	2	3	3	2	-	-	-	-	-	-	-	-	2	2
CO3	1	2	3	3	-	-	-	-	-	-	-	-	2	2
CO4	1	2	3	3	-	-	-	-	-	-	-	-	2	2
CO5	1	2	3	3	-	1	-	-	-	-	-	1	3	3
CO6	1	2	3	3	-	1	-	-	-	-	-	1	3	3

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**

1	*Solar Engineering of Thermal Processes*, John A. Duffie, William A. Beckman, John Wiley and Sons.	2013
2	Solar Energy - Principles of thermal collection and storage, SP Sukhatme, Tata McGraw-Hill, New Delhi.	1984
3	Principles of Solar Engineering, F Kreith, JF Kreider, McGraw-Hill.	1978
4	Solar Energy: Fundamentals and Applications, Garg, J Prakash, Tata McGraw Hill, New Delhi.	2007

Course Name	**:**	**NUMERICAL ANALYSIS TECHNIQUES**
Course Code	**:**	**ME2045/ME3017/ME6017**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:	
1	To understand the linkage between accuracy, stability, and convergence.
2	To perform error analysis for arithmetic operations.
3	To gain the basic understanding of numerical algorithms and its implementation.
4	To understand the propagation of errors through numerical algorithms.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** *Mathematical Preliminaries and Error Analysis:* Review of Calculus, Round-off Errors and Computer Arithmetic, Algorithms and Convergence, Numerical Software, *Solution of Equations in Single Variable:* Bisection Method, Fixed-Point Iteration, Newton's Method and its Extensions, Error Analysis for Iterative Methods, Accelerating Convergence, Zeros of Polynomials and Muller's Method, *Interpolation and Polynomial Approximation:* Interpolation and the Lagrange Polynomial, Data Approximation and Neville's Method, Divided Differences, Hermite Interpolation, Cubic Spline Interpolation, Parametric Curves.	10
2	**NUMERICAL DIFFERENTIATION AND INTEGRATION:** Numerical Differentiation, Richardson's Extrapolation, Elements of Numerical Integration, Composite Numerical Integration, Romberg Integration, Adaptive Quadrature Methods, Gaussian Quadrature, Multiple Integrals, Improper Integrals.	4
3	**INITIAL-VALUE PROBLEMS:** Euler's Method, Higher-Order Taylor Methods, Runge-Kutta Methods, Error Control and Runge-Kutta-Fehlberg Method, Multistep Methods, Variable Step-Size Multistep Methods, Extrapolation Methods, Higher-Order Equations and Systems of Differential Equations, Stability, *Direct and Iterative Methods:* Linear Systems of Equations, Pivoting Strategies, Linear Algebra and Matrix Inversion, Determinant of a Matrix, Matrix Factorization, Special Types of Matrices, Norms of Vectors and Matrices, Eigen values and Eigenvectors, Jacobi and Gauss-Siedel Iterative Techniques, Relaxation Techniques for Solving Linear Systems, Error Bounds and Iterative Refinement, Conjugate Gradient Method.	12
4	**APPROXIMATION THEORY:** Discrete Least Squares Approximation, Orthogonal Polynomials and Least Squares Approximation, Chebyshev Polynomials, Rational Function Approximation, Trigonometric Polynomial Approximation, Fast	8

	Fourier Transforms, *Approximating Eigen values:* Linear Algebra and Eigen values, Orthogonal Matrices and Similarity Transformations, Power Method, Householder's Method, QR Algorithm, Singular Value Decomposition.	
5	**NONLINEAR SYSTEM OF EQUATIONS:** Fixed Points for Functions of Several Variables, Newton's Method, Quasi-Newton Methods, Steepest Descent Techniques, Homotopy and Continuation Methods, *Boundary-Value Problems:* Shooting, Rayleigh-Ritz and Finite-Difference Methods for Linear and Nonlinear Equations, *Partial Differential Equations:* Elliptic, Parabolic and Hyperbolic Partial Differential Equations.	8

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the core ideas and concepts of numerical methods.	**L2**
2	Use the power of abstraction and generalization in the numerical analysis.	**L3**
3	Apply rigorous, analytic, highly numeric approach to solve engineering problems using numerical methods.	**L3**
4	Analyse problem solutions with correct mathematical terminology.	**L4**
5	Select and implement the appropriate numerical solution techniques for a given problem.	**L5**
6	Develop problem solution methodologies and optimal solutions.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	1	1	1	-	-	-	-	-	-	-	1	1	1
CO2	2	2	2	1	-	-	-	-	-	-	-	1	2	1
CO3	3	3	3	2	1	-	-	-	-	-	-	2	2	1
CO4	2	3	3	2	-	-	-	-	-	-	-	-	2	1
CO5	3	3	3	3	2	-	-	-	1	-	-	2	3	2
CO6	3	3	3	3	3	-	-	-	2	1	-	3	3	3

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Numerical Analysis, Richard L. Burden, J. Douglas Fair, 9th ed., Cengage Learning	2011
2	An Introduction to Numerical Analysis, K. E. Atkinson, 2nd ed., Wiley-India	1989
3	Numerical Analysis - An Algorithmic Approach, S. D. Conte, Carl de Boor, 3rd ed., McGraw-Hill.	1981
4	Numerical Analysis, Gautschi, Walter, 2nd ed., Birkhauser.	2012

Course Name	**:**	**THERMAL MANAGEMENT OF BUILDINGS**
Course Code	**:**	**ME2046/ME3018/ME6018**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:	
1	To understand the principles of energy flow diagram and energy auditing in buildings.
2	To understand the thermal performance and thermal comfort in buildings via simulations.
3	To understand the energy conservation buildings codes and rating systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Energy management concept in building, Energy auditing in buildings, Bio-climatic classification of India, Climate Analysis for Nat-Vent Buildings, Mixed Mode Buildings and Conditioned building, Passive design concepts for various climatic zones, Case studies on selected building designs.	6
2	**VERNACULAR ARCHITECTURE:** Vernacular architecture in Indian Context, Factors affecting architecture, building material and construction techniques, Case studies on vernacular architecture, Low cost buildings, climate responsive buildings, energy efficient buildings, green buildings, intelligent buildings, Building Integrated Photovoltaic's (BIPV), Green Buildings in India and Case studies.	8
3	**BUILDING CODES AND RATING SYSTEMS:** LEED, GRIHA, ECBC, Thermal properties and energy content of building materials, Building energy simulation, Simulation tool like Energy plus, ESP-r, Open studio, Building management systems and automation, Artificial and day lighting in buildings.	8
4	**THERMAL PERFORMANCE STUDIES:** Concept of comfort and neutral temperatures, Thermal comfort, PMV-PPD models, Thermal comfort models, Adaptive thermal comfort models, case studies.	6
5	**HEAT FLOW CALCULATIONS IN BUILDINGS:** Unsteady heat flows through walls, roof and windows, Concept of sol-air temperature and its significance, heat gain through building envelope, building orientation, shading and overhangs, Ventilation and Air-conditioning systems.	7
6	**PASSIVE HEATING CONCEPTS:** Passive and low energy concepts, Applications, Direct heat gain, indirect heat gain, isolated gain and sunspaces, *Passive cooling concepts*: Evaporative cooling, Radiative cooling, Application of wind, water and earth for cooling, Shading, paints and cavity walls for cooling, Roof radiation traps, Earth air-tunnel.	7

Experiments:	
Simulation of different building designs for effective thermal management will be performed using Energy plus, ESP-r, Open studio, etc.	28

Sr. No.	**Course outcome** By the end of this course, the student will be able to	**Knowledge Level (Blooms Level)**
1	Understand the basics of various types of energy interactions in a building	L1, L2
2	Apply simulation programs of buildings to perform energy calculations for indoor comfort.	L3
3	Evaluate and justify energy-saving measures in existing buildings.	L5
4	Categorize the energy efficient measures on grounds of engineering and economic feasibility.	L4
5	Identify environmental aspects of renovation and building's energy supply from a system perspective.	L4
6	Practice simulation of different building designs for effective thermal management using software	L5

CO-PO & PSO Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	-	-	-	-	-	-	-	-	-	-	2	-
CO2	2	3	2	-	-	-	-	-	-	-	-	-	-	2
CO3	1	2	2	3	3	-	-	-	-	-	-	-	3	1
CO4	1	3	2	1	1	1	-	-	-	-	-	-	2	-
CO5	1	1	1	1	2	-	3	-	-	-	-	-	2	-
CO6	1	1	2	2	3	-	-	-	-	-	-	-	2	3

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication Reprint**
1	Solar Passive Building, Science and Design, M.S. Sodha, N.K. Bansal, P. K. Kumar, M.A.S. Malik, Pergamon Press.	1986
2	Handbook on Energy Conscious Buildings, J.K. Nayak, J.A. Prajapati, Solar Energy Centre, New Delhi.	2006
3	Modelling Methods for Energy in Buildings, C.P. Underwood, F.W.H. Yik, Blackwell Publishing.	2004
4	Human Thermal Environments, K.C. Parsons, 2nd ed., Taylor and Francis.	2003
5	Energy Efficient Buildings, M. Majumder, TERI, New Delhi	2009
6	Comfort and Energy Use in Buildings - Getting Them Right, Nicol F., Elsevier	2007

Course Name	**:**	**THERMAL ENERGY STORAGE TECHNOLOGIES**
Course Code	**:**	**ME2047/ME3019/ME6019**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:	
1	To provide a basic background in the thermal energy storage (TES) techniques.
2	To study the sensible and latent heat storage methods.
3	To discuss different simulation techniques related to TES systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Concepts, Need and Applications of TES techniques, Classification, Active and Passive TES systems, Basic concepts of Thermodynamics and Heat-Transfer.	7
2	**TES MATERIALS:** Sensible heat storage materials, Latent heat storage materials, Thermo-chemical heat storage materials, selection of TES materials.	6
3	**SENSIBLE HEAT STORAGE:** Mechanism of sensible heat storage (SHS), Advantages and limitations of SHS, Thermal stratification and its importance, Techniques for thermal stratification enhancement.	7
4	**LATENT HEAT STORAGE:** Mechanism of latent heat storage (LHS), Advantages and limitations of LHS, Concept of melting and solidification, Techniques for optimizing melting and solidification process.	8
5	**THERMO-CHEMICAL HEAT STORAGE:** Mechanism of thermo-chemical heat storage (TCHS), Advantages and limitations of TCHS, Thermo-chemical reactions,	7

	adsorption and absorption heat storage, electro-chemical heat storage and Fuel cell.	
6	**SIMULATION OF TES SYSTEMS:** Mathematical modelling basics, Simulation of SHS, Simulation of melting and solidification, Case studies, Future trends and research problems.	7

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	**Knowledge Level (Blooms Level)**
1	Identify the suitable thermal energy storage systems for practical application.	L1, L2
2	Interpret and identify the storage materials	L3, L4
3	Summarize and understand the sensible heat storage system	L2, L3
4	Apply the knowledge to store thermal energy in optimum way.	L3, L5
5	Design and develop thermal energy storage systems via simulations.	L6

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	1	1	-	2	1	1	-	-	-	-	-	2	3
CO2	3	1	1	-	2	1	1	-	-	-	-	-	2	3
CO3	3	1	1	-	2	1	1	-	-	-	-	-	2	3
CO4	3	1	1	-	2	1	1	-	-	-	-	-	2	3
CO5	3	1	1	-	2	1	1	-	-	-	-	-	2	3

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Thermal Energy Storage Systems and Applications, Ibrahim Dincer and Marc A. Rosen, Wiley.	2011
2	Thermal Energy Storage: Basics, Design, Applications to Power Generation and Heat Supply, G. Beckmann, P.V. Gilli, Springer.	1984
3	Solar Thermal Energy Storage, H.P. Garg, S.C. Mullick, Vijay K. Bhargava, Springer.	1985
4	Advances in Thermal Energy Storage Systems: Methods and Applications, Luisa F. Cabeza, Elsevier.	2014
5	Latent Heat-Based Thermal Energy Storage Systems Materials, Applications, and the Energy Market, Amritanshu Shukla, Atul Sharma, Pascal Henry Biwolé, Apple Academic Press.	2020
6	Thermal Energy Storage Technologies for Sustainability by S. Kalaiselvam, R. Parameshwaran	2014

Course Name	**:**	**INDUSTRIAL ENGINEERING AND MANAGEMENT**
Course Code	**:**	**ME2048/ME3020/ME6020**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: In this course, the student should be able to understand the	
1.	Concept and significance of Industrial engineering & Management and focus on financial management.
2.	Plant location & layout and applications of inventory control systems.
3.	Applications of Time & Motion study and Value Engineering.

4.	Marketing and Strategic Management.

Total No. of Lectures – 42

Lecture wise breakup		**No. of lectures**
1	**INTRODUCTION:** Concept, nature and significance of Industrial Management, economic, social, political forces affecting business operations & growth. Social responsibility of business.	4
2	**FINANCIAL MANAGEMENT:** Scope and functions of financial management, sources of finance, Balance sheets and financial ratios, Capital Budgeting Decisions, Nature of investment decisions, Cost of capital and its measurement, Capital Budgeting process, technique of capital budgeting, Investment criteria: payback period, Accounting rate of return method, Discount cash flow method, Net present value method and internal rate of return method, Management of working capital, factors affecting requirement of working capital, capital structure decisions.	6
3	**PRODUCTION MANAGEMENT:** Plant location, Weber's Theory of location of industries, Layout and assembly line balancing- process and product layout, Government policies on industrial location, Production control charts, Route & process charts, Operation charts, Machine load charts, Process charts, Mechanical and Bar charts.	6
4	**MATERIALS AND STORE CONTROL**: Introduction, significance and scope. Materials requirement planning, Inventory control- deterministic and probabilistic models, ABC analysis, EOQ model, LIFO and FIFO in inventory system, Types of purchasing, Centralized and De-centralized purchasing.	6
5	**TIME AND MOTION STUDY:** Time and motion study, Job design, job standards, work measurement time study, work sampling, job evaluation, merit rating, method studies, Pre-determined motion time standards (PMTS).	7
6	**VALUE ENGINEERING**: Introduction, applications and types of values, concepts of value engineering, phases of value engineering studies, value analysis.	5
7	**MARKETING MANAGEMENT**: Nature, scope & importance of Marketing management, Modern marketing concepts, Consumer vs Industrial marketing, marketing mix meaning, nature and scope of international marketing, rural marketing, advertising, sales and distribution management, channel management.	4
8	**STRATEGIC MANAGEMENT AND NEW TRENDS:** Strategic management, industry matrix plus EFAS, IFAS and SFAS tables. DMAIC – Six Sigma.	4

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	**Knowledge Level (Blooms Level)**
1	Understand and illustrate the plant location & layouts concepts of the manufacturing plant	**L2**
2	Apply the concepts of Industrial and Financial Management in industries.	**L3**
3	Analyze the process involved in various inventory models in industries.	**L4**
4	Explain and evaluate the Time and motion study concepts in the design the workplace layout design.	**L5**
5	Apply the concepts of Value engineering and Value analysis.	**L3**
6	Analyze the principles of Marketing & Strategic management.	**L4**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	1	-	1	1	1	1	-	-	-	1	-	1	1
CO2	2	1	1	1	3	-	2	-	-	-	1	-	1	1
CO3	2	1	1	-	2	-	2	-	1	-	1	-	1	2
CO4	2	1	1	2	2	-	2	-	1	-	-	-	1	1

CO5	2	1	1	1	2	1	2	-	1	-	-	-	1	1
CO6	1	2	1	-	3	-	1	-	-	1	3	-	1	2

	Name of Book/ Authors/ Publisher	**Year of Publication/ Reprint**
1.	Industrial Engineering and Management, Hicks, Tata McGraw Hill, New Delhi	2003
2.	Industrial Management, W.R. Spreigel, 4th ed., John Wiley & Sons: NY	1947
3.	Financial Management, Pandey, Vikas Publishing House, New Delhi	2016
4.	Estimating and Costing for Metal Manufacturing Industries, Creese, Adihan and Pabla, Marcel Dekker Inc., New York	1992
5.	Motion and Time Study, R. Barnes, John Wiley & Sons.	2017

Course Name	**:**	**RELIABILITY AND MAINTENANCE ENGINEERING**
Course Code	**:**	**ME2049/ME3021/ME6021**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: To impart the knowledge

1. On the role and contribution of maintenance towards achieving competitive advantage in the industries.
2. About the key concepts and issues of maintenance in both manufacturing and service organization.
3. About the various strategies, philosophy, scheme and schedules of maintenance engineering and it applications in the industry.
4. About the safety, housekeeping, breakdown, availability and reliability indices of engineering system.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Concept, classification and types of maintenance, preventive, corrective, renovative, planned, breakdown and quality maintenance; objectives and characteristics of maintenance function, organizational set-up and record keeping, Organizational hierarchy, position and responsibilities of maintenance department, control and coordination in maintenance, benefits and effects of maintenance.	6
2	**MAINTENANCE PLANNING AND SPARE PARTS MANAGEMENT**: Long and short term planning and scheduling; man power planning, training and allocation, requirement planning of raw materials and spare parts, inventory control of spare parts, ABC analysis, FSN Approach, XYZ approach, VED approach, Estimation of maintenance work and monitoring.	5
3	**HOUSEKEEPING AND SAFETY IN MAINTENANCE**: Factors governing housekeeping, illumination, layout and equipment, air distribution, pollution and ventilation, training and awareness in housekeeping; *Safety:* Classification and types of hazards, important factors and measurement of hazards, minimize hazards and control of accidents, fault tree analysis, safety devices and cheek list.	5
4	**RELIABILITY AND AVAILABILITY OF ENGINEERING SYSTEMS:** Reliability and maintainability, failure, Bathtub hazard rate concept; *Reliability structures*: series, parallel, combination of series and parallel, redundancy; Quantitative estimation of reliability of parts, mean time to failure (MTTF), mean time between failure (MTBF), mean time to repair (MTTR), accuracy and confidence of reliability estimation, statistical estimation of reliability indices, machine failure pattern: breakdown time distribution, machine failure patter.	6
5	**MAINTENANCE OF DRIVES AND EQUIPMENTS:** *Mechanical drives and equipment's:* belts, chains, gears, couplings, brakes and their drives; pumps, compressors, blowers, air-conditioners; *Electrical circuits and equipment's:* power cable, line and circuit connection, switchboard, fuse, relays, interlocks, contactors, measuring	5

	equipment's, motors, generators; essential care and maintenance; *Lubrication:* manual, forced and oil bath lubrication, testing, additives used, rectification and re-use of lubricants; *Corrosion:* factors influencing and effect of pH value on corrosion, testing, prevention, application of inhibitors and control techniques;	
6	**INSPECTION, TESTING, QUALITY CONTROL AND AUDIT IN MAINTENANCE**: *Inspection:* objectives, interval, card history and report; *Testing:* non-destructive, destructive and semi-destructive testing; liquid penetration test, magnetic particle test, ultrasound test, vibration analysis, oil analysis, eddy current testing; *Quality Control:* importance, application of statistical quality control tools and techniques; *Performance and audit:* Maintenance performance indices-BPI, EQBI, MEI, BAI, MUI, EURRI, BEI; function and operational audit, plan and programme audit.	5
7	**FAULT DIAGNOSIS AND CONDITION MONITORING**: Objectives, methods and purpose of faults diagnosis and condition monitoring, non-vibration and vibration based monitoring; periodic and continuous monitoring methods and equipment's used; fault diagnosis and condition monitoring of bearings; computerized trouble shooting and condition Monitoring;	5
8	**BUDGET AND COST ESTINATION OF MAIANTENANCE**: *Cost estimation:* life cycle cost, machine breakdown cost, repair cost; spare parts and labour cost; impact of maintenance cost, *Incentive Payment:* objectives, financial, non-financial and semi financial incentive of maintenance staff, different types of incentive plans for maintenance staff; *Budget:* objectives and functions of budget in maintenance.	5

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the philosophies of maintenance of plant, machineries and equipment's.	**L2**
2	Plan and apply the concept of maintenance on repair and renovation of machine, plant and equipment's	**L3**
3	Analyse the hazards, fault and control of failure using theories, housekeeping and safety in maintenance	**L4**
4	Ability to conduct inspection and tests on machines and equipment's to assess their condition and availability.	**L4**
5	Estimation of reliability of part, system, machine and equipment using different theories of maintenance	**L5**
6	Adapt computerized trouble shooting in maintenance	**L6**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	2	-	2	-	-	-	-	-	2	3	1
CO2	3	3	3	2	-	-	-	-	-	-	-	2	3	1
CO3	3	2	2	2	1	2	3	3	-	-	-	3	3	1
CO4	2	3	2	3	1	2	-	-	-	-	-	2	3	1
CO5	2	3	3	2	-	1	-	-	-	-	-	1	3	1
CO6	1	1	1	3	2	1	-	-	-	-	-	1	2	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/Reprint**
1	A text Book of Reliability and Maintenance Engineering, Alakesh Manna, I. K. International Publishing House Pvt. Ltd, New Delhi.	2020
2	Preventive Maintenance, Terry Weriman, Reston Publishing Company.	1984
3	Principle of planned maintenance, Clifton R. H, McGraw Hill.	1983

4	Maintenance Planning and Control, Enthory Kelly, EWP, New Delhi.	1984

Course Name	**:**	**OPERATION RESEARCH AND SIMULATION TECHNIQUES**
Course Code	**:**	**ME2050/ME3022/ME6022**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: To impart the knowledge of

1.Optimization using calculus and dynamic programming.
2.Linear programming, transportation and assignment problems.
3.Evolutionary algorithms for optimization and search, Taguchi, Grey-relational analysis, Response surface methodology, Genetic algorithm based optimization and simulations.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION AND BASIC CONCEPTS:** Historical Development, Art of Modeling and simulation, Objective function, Formulation of design problems as mathematical programming problems, Classical and advanced techniques, Basics of operations research, OR models and applications.	5
2	**OPTIMIZATION USING CALCULUS:** Stationary points, Functions of single and two variables, Global Optimum, Convexity and concavity of functions of one and two variables, Optimization of function of one variable and multiple variables, Gradient vectors, Lagrangian function, Hessian matrix formulation, Eigen values, Kuhn-Tucker Conditions, Optimization problems.	8
3	**LINEAR PROGRAMMING:** Standard and Canonical form of linear programming, Assumptions in LP Models, Elementary operations, problem formulation, Graphical method, Simplex method, Big-M method, Two-phase method, Revised simplex method, Duality in LP, Dual Simplex method, Sensitivity or post optimality analysis, Other algorithms for solving LP problems, Karmarkar's projective scaling method, Use of software for solving linear optimization problems.	8
4	**TRANSPORTATION AND ASSIGNMENT PROBLEMS:** North west corner rule, Least cost method, Vogel's method, Stepping stone method, MODI method, *Assignment problem formulation*: Optimal solution, Hungarian algorithm, Variants of assignment problems, Travelling salesman problem.	6
5	**DYNAMIC PROGRAMMING:** Representation of multistage decision process, Types of multistage decision problems, Concept of sub-optimization and optimality, Recursive equations, Forward and backward recursions, Computational procedure in dynamic programming, Discrete versus continuous dynamic programming, Multiple state variables, curse of dimensionality, Problem formulation and application of dynamic programming in design of continuous beam and optimal geometric layout of a truss, water allocation as a sequential process, Capacity expansion and Reservoir operation.	7
6	**ADVANCED TECHNIQUES IN OPTIMIZATION & SIMULATION:** Concept and object of simulation, Multi objective optimization, Direct and indirect search methods, Taguchi, Grey-relational analysis, Response surface methodology, Genetic algorithm based optimization, applications in engineering problems, Algorithms and software for simulations.	6

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understanding the basic concept of optimization, modelling and simulation.	**L2**

2	Apply scientific methods and mathematical techniques to solve various engineering problems.	**L3**
3	Analysis of the various optimization techniques for engineering problems.	**L4**
4	Recommend the various software tools for modelling and simulations of real-time industrial problems.	**L5**
5	Development and formulation of new models for better decision making in the organization.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	1	2	-	-	-	-	1	2	1	2	1
CO2	3	3	3	3	2	-	2	-	-	-	1	1	3	1
CO3	3	3	3	3	2	-	-	-	-	-	3	1	3	2
CO4	3	3	3	3	3	-	1	-	-	1	2	2	2	2
CO5	3	3	3	1	2	-	1	-	3	2	3	2	3	3

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Engineering Optimization: Theory and Practice, S.S. Rao, New Age International Pvt. Ltd., New Delhi.	2000
2	Linear programming, G. Hadley, Narosa Publishing House, New Delhi.	1990
3	Operations Research: An Introduction, H.A. Taha, 5th ed., Macmillan, New York.	1992
4	Optimization for Engineering Design Algorithms and Examples, K. Deb, Prentice-Hall of India Pvt. Ltd., New Delhi.	1993
5	Multi-criterion Analysis in Engineering and Management, K. Srinivasa Raju, D. Nagesh Kumar, PHI Learning Pvt. Ltd., New Delhi.	2010

Course Name	**:**	**TOTAL QUALITY MANAGEMENT**
Course Code	**:**	**ME2051/ME3023/ME6023**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: To imparts the knowledge of	
1	Basic concepts in Quality, Quality planning & Control and Process capabilities.
2	Statistical Process Control and use of Quality Control charts in manufacturing and service sectors.
3	Total Quality Management concepts and Quality Standard (ISO) systems.
4	Reliability and Six Sigma and applications in industries.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Introduction to quality (Services and manufacturing), Quality planning and control, Quality cost, Economics of quality control, Phases of quality evolution	4
2	**PROCESS CAPABILITY & MEASUREMENTS:** Specification, tolerances and process capability studies, precision reproducibility and accuracy of method measurement, Taguchi method.	4
3	**STATISTICAL QUALITY CONTROL:** Inspection and quality control, statistical quality control, statistical process control, sampling plans and control charts for variables and	8

	attributes, economics of sampling charts.	
4	**QUALITY CONCEPTS:** Quality Assurance, Total Quality Control, Total quality concept, Deming's 14 points.	4
5	**TOTAL QUALITY MANAGEMENT**: Concept, quality planning and improvement, quality team and circles, just in time (JIT).	6
6	**QUALITY STANDARDS:** Definition, applications, implementation procedure and requirements of Quality, ISO 9001, ISO 9002, ISO 9003, ISO 9004, ISO 14000, ISO 27000, ISO 31000, Quality standards.	6
7	**QUALITY & RELIABILITY:** Product quality and reliability, failure data analysis and life testing, redundancy in design.	6
8	**SIX SIGMA:** Concept, definition, procedure and applications, TQM and six sigma, Indian industries, certification, process capabilities and case studies.	4

Sr. No.	**Course outcome** By the end of this course, the students will be able to:	**Knowledge Level (Blooms Level)**
1	Understand the concepts of concepts of Quality & Quality standards in industries.	**L2**
2	Remember the capabilities of various processes in industries and service sectors.	**L1**
3	Apply the concepts of sampling plans and control charts for process improvement in various organizations.	**L3**
4	Apply the concepts of TQM, Quality Assurance and JIT in industries.	**L3**
5	Analyze the ISO Quality standards; used in various organizations.	**L4**
6	Estimate the reliability of various systems and Apply the Six Sigma concepts in industries and service sectors.	**L5**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	1	1	1	2	1	-	-	-	2	-	1	2
CO2	2	1	2	1	2	-	2	-	-	-	1	-	1	1
CO3	3	2	1	-	2	-	2	-	1	-	1	-	1	2
CO4	3	1	1	2	1	2	2	-	1	-	2	-	1	2
CO5	1	2	1	1	2	1	2	-	1	1	-	-	1	2
CO6	2	2	2	-	2	1	1	-	-	2	2	-	1	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Statistical Quality Control, E. L. Grant, 6th ed., McGraw-Hill	2017
2	Statistical Quality Control, M. Mahajan, Dhanpat Rai & Co. (P) Limited	2016
3	Statistical Quality Control, J. M. Juran, 5th ed., McGraw-Hill	1990
4	Quality Control, Hansen & Ghare, PHI	2005
5	Statistical Quality Control, R.C. Gupta, 9th ed., Khanna Publishers	2016

Course Name	**:**	**MICRO AND NANO MANUFACTURING**
Course Code	**:**	**ME2052/ME3024/ME6024**
Credits	**:**	**4**

L T P	:	3-0-2

Course Objectives:
1.To give awareness of different techniques used in micro and nano manufacturing 2.To give in-depth idea about the measurement and metrology tools used in micro and nano manufacturing 3.To impart the knowledge about non-conventional micro and nano domain finishing approaches 4.To impart the knowledge about micro mechatronics and micro joining.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**CONCEPT OF MICRO ENGINEERING*:*** Introduction to precision engineering, macro milling, micro drilling, Micro-electromechanical systems, merits and applications, Micro phenomenon in electro-photography, applications; Introduction to bulk micromachining, Surface micromachining steps, Micro instrumentation and applications, Micro mechatronics, Concept of Nano finishing and nano-level finishing techniques.	6
2	**MICRO-ENERGY AND CHEMICAL SYSTEM (MECS):** Introduction, Space micro-propulsion, *e-Beam nanolithography:* important techniques and applications, Introduction to nanotechnology, Carbon nano-tubes: properties and structures, Molecular logic gates and Nano level Biosensors, applications,	5
3	**MECHANICAL MICROMACHINING**: Principle, Micro drilling-process, tools and applications, Diamond micro turning process, tools and applications, *Micro milling and grinding*: principle, process characteristics, tools and applications, *Micro extrusion*: process and applications, micro bending with Laser, Nano plastic forming and Roller imprinting.	5
4	**NON-CONVENTIONAL MICRO-NANO MANUFACTURING**: Different processes, principle and applications, Abrasive jet micro machining, WAJMM, Micro EDM, Micro WEDM, Micro EBM: process principle, description and applications, Micro ECM, Micro LBM: process principle, description and applications, principle of Focused ion beams and applications, hybrid techniques applied to nano-domain non-conventional manufacturing.	6
5	**MICRO AND NANO FINISHING*:*** Different processes, Magneto rheological finishing, Magneto rheological abrasive flow finishing, process principle and applications, Force analysis of MRAFF process, Magneto rheological jet finishing processes, Working principle and polishing performance of MR jet machine, Elastic emission machining (EEM), machine description, applications, *Ion Beam Machining (IBM)*: principle, mechanism of material removal, applications, *Chemical Mechanical Polishing (CMP)*: Schematic diagram, principle and applications.	4
6	**MICRO FABRICATION*:*** Techniques, flowchart, Introduction to Nanofabrication, Top-down and top-up approach, dry and wet itching, micro-deposition and surface modification, *Nanofabrication using soft lithography*: principle, applications, Examples (Field Effect Transistor, Elastic Stamp), *Manipulative techniques*: process principle, applications, *Carbon nano materials*: CN Tubes, properties and applications, *CN Tube Transistors:* Description only, Diamond properties and applications, CVD Diamond Technology, LIGA Process.	8
7	**MICRO WELDING AND ANALYSIS**: Laser welding, description and applications, Defects, *Electron Beam Micro-welding*: Description and applications, Introduction to micro and nano measurement, defining the scale, uncertainty, SEM and XRD of micro-welded joints, Scanning White-light Interferometry, Optical Microscopy, Scanning Probe Microscopy, Scanning Tunneling Microscopy and Confocal Microscopy as applied to micro-welding analysis, Introduction to Online-Machine Metrology.	8

List of practical's / mini-projects	**Hours**

1	Experiments on Micro EDM and analysis of accuracy & precision of the machined surface.	6
2	Mini project on MEMS.	10
3	Micro gear cutting and analysis of accuracy-clamping & setting errors.	6
4	Grinding- analysis of thermal effects.	6

Sr. No.	**Course outcome** By the end of this course, the students will be able to:	Knowledge Level (Blooms Level)
1	Understand the traditional and advance manufacturing processes and techniques	**L2**
2	Identify the need and suitable applications for traditional and advanced micromachining, forming joining, and deposition processes.	**L3**
3	Analyze metal removal mechanisms and metal removal rate in ultra-precision machining.	**L4**
4	Design the fabricate MEMS devices use in micro machining and other applications.	**L6**
5	Explain and judge the modern micro manufacturing methods, varies from basic concept to advanced mathematical modelling to estimate the process capabilities/ responses.	**L5**
6	Solve problem through experimental studies to investigate the behavior of the process on micro/precision high-speed machining centers to analyze the process capability.	**L3**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	3	2	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	3	1	1	-	-	-	-	-	-	1	2	1
CO3	3	2	3	1	-	-	-	-	-	-	-	1	3	1
CO4	2	3	2	3	-	-	-	-	-	-	-	1	2	1
CO5	2	3	3	1	-	-	-	-	-	-	-	1	2	1
CO6	3	2	2	3	-	-	-	-	-	-	-	1	2	1

Text Books:		
Sr. No.	**Name of the Book/ Authors/Publisher**	**Year of Publication/ Reprint**
1	Micro and Nano-manufacturing, Mark. J. Jackson, Springer,	2006
2	Micro-fabrication and Nano-manufacturing - Pulsed water drop micromachining, Mark. J. Jackson, CRC Press	2006
3	Micro-manufacturing and Nanotechnology, Nitaigour Premchand Mahalik, Springer	2006
4	Micro-manufacturing Processes, V. K. Jain, CRC Press	2012

Course Name	**:**	**INDUSTRIAL AUTOMATION**
Course Code	**:**	**ME2053/ME3025/ME6025**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:	
1	To understand the principles, strategies and advantages of industrial automation.
2	To impart the knowledge about PLC programming for a given task.

3	To demonstrates problem-solving skills in automation with circuits design.
4	To impart the knowledge about the practical methods of automatic control of advance machines, critical processes and systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**AUTOMATION:** Concepts, Need and Demand of automation, Current and future Trends, Components of Industrial Automation System and their functionalities, Levels and Types of Automation, Mechanization vs Automation, strategies of automation, Current emphasis in automation.	6
2	**AUTOMATION CONTROLLERS:** Introduction of Industrial Controllers, *Programmable Logic Controller*: Constructions, Types, Programming Units, Memory, I/O Modules, Programming methodology, Ladder Logic programming and diagrams, timers, internal relays and counters, data handling, analogue input and output. Application on real time industrial automation systems.	6
3	**LOGIC CONTROL CIRCUITS FOR HYDRAULICS AND PNEUMATICS:** Basic elements of hydraulics and pneumatics, fluid power control elements and standard graphical symbols, hydraulic & pneumatic cylinders and valves for pressure, flow & direction control, Circuit design approach and real time examples, sequence operation of two and more than two cylinders, Hydraulic and pneumatic safety and their applications in clamping, traversing and releasing operations.	6
4	**INDUSTRIAL CONTROL SYSTEM:** Process versus discrete manufacturing, continuous versus discrete control, computer process control, forms of computer process control, closed loop versus open loop control, design of control systems, levels of automation in industries, variables and parameters in industries.	6
5	**ELECTRICAL AND ELECTRONIC CONTROL:** Sensor Terminology, classification of sensor and transducer, their selection, temperature, light, position, piezoelectric, pressure and vision sensors, acoustic emission sensing techniques, microprocessor, microcontroller.	6
6	**FACTORY AUTOMATION:** Fundamentals of production lines, types of assembly lines , reasons for using automated assembly lines, transfer systems in assembly lines, automatic machines, transfer devices and machines, selection of transfer devices, linear and rotary transfer mechanism, classification, conveyors, *Feeders*: classification, selection criterion, feeding devices, *Types of feeders*: reciprocating, vibratory, screw, rotary, centrifugal , flexible, Automated guided vehicles.	6
7	**MATERIAL HANDLING SYSTEMS AND DESIGN**: Introduction to Material Handling, Material Transport Equipment, analysis of Material Transport Systems, Storage systems, Storage System Performance and Location Strategies, Conventional Storage Methods and Equipment, Automation Storage Systems, Engineering Analysis of Storage Systems.	6

Sr. No.	**Experiments**	**Hours**
1	Students in a group will carry out projects on design and implementation of an automatic modular system which can be useful in contemporary automation industries. The methodologies will be followed the design and simulation of automated systems using software and implementation via pneumatic controls, electro-pneumatic controls, PLC and motion controls in Simens CoE Labs, PEC, Chandigarh.	28

Sr. No.	**Course Outcomes** By the end of this course, the student will be able to:	**Knowledge Level (Blooms Level)**
1	Understand the concept, need and demand of automation.	**L2**

2	Apply the principles, strategies and advantages of automation.	**L3**
3	Select the level and types of factory automation.	**L3**
4	Categories the material handling system for modern automated industry.	**L4**
5	Justify the uses of various automation controllers in real life time industrial application.	**L5**
6	Design the logic control circuits for hydraulics and pneumatics operated automation systems.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	-	-	1	-	-	-	-	1	2	1
CO2	3	3	2	2	-	-	2	-	-	-	-	1	3	1
CO3	3	2	2	1	-	-	2	-	-	-	-	1	3	2
CO4	2	3	2	3	2	-	2	-	-	-	2	1	3	3
CO5	1	2	2	3	2	1	-	-	-	-	1	1	1	2
CO6	1	2	3	2	2	1	1	-	-	-	-	1	2	3

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Automation production Systems and Computer Integrated Manufacturing, Groover, M.P., Pearson Education	2009
2	Computer Based Industrial Control, Krishna Kant, Prentice Hall of India, New Delhi.	2000
3	Mechatronics, W. Bolton, 5th ed., Addison Wesley Longman Ltd	2010
4	An Introduction to Automated Process planning Systems, Tiess Chiu Chang and Richard A.W., Tata McGraw-Hill Publishing company, New Delhi	2000
5	Automated Manufacturing Systems, Morriss, S. B., McGraw Hill.	2006

Course Name	**:**	**COMPUTER INTEGRATED DESIGN AND MANUFACTURING**
Course Code	**:**	**ME2054/ME3026/ME6026**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: To impart the knowledge of	
1	Various phases of design and manufacturing of products considering different aspects of manufacturability, ease of assembly and environment issues.
2	Computer integrated environment in Industries.
3	Smart factories with a concept of Industry 4.0.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**PRODUCT DESIGN**: Introduction, Essential factors of product design, Phases and approaches of design, Robust product design, parameter and tolerance design, Aesthetic and ergonomics in product design.	8
2	**COMPUTER INTEGRATED ENVIRONMENT:** Integrating CAD/CAM/CAE tools, objectives, product development cycle integrated with CAD/CAM tools, Concept development and modelling, Introduction to finite element analysis and rapid prototyping, product data management, Computer aided process planning, Flexible	8

	manufacturing system, Concept of group technology, Rapid tooling.	
3	**NUMERICAL CONTROL IN MACHINING PROCESSES:** Introduction to NC, CNC and DNC Machines, Components of CNC machines, Control systems in CNC, CNC tooling and fixtures, *CNC part programming*: G-Codes and M-Codes, Canned cycles, Manual part programming, Computer aided part programming.	8
4	**DESIGN FOR MANUFACTURING AND ENVIRONMENT:** Design for manufacturing (DFM), Design for assembly (DFA), guidelines and principles of DFM and DFA, General design principles for manufacturability, Strength and mechanical factors, Material selection, Process capability, Feature tolerances, Geometric tolerances, Assembly processes, *Design for environment*: Introduction, objectives and issues, guidelines, Lifecycle assessment, Basic method, Design to minimize material usage, Design for recyclability, Design for Energy efficiency, Design for sustainability	8
5	**INDUSTRY 4.0:** Introduction, Chronological development of Industry 4.0, Today's factory, Globalization, Basic principles and technologies of a Smart Factory, Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services, Cloud Computing and Manufacturing, Security issues within Industry 4.0 networks, Human-Robot Collaboration in Industry.	10

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand about the essential factors and phases of product design.	**L2**
2	Apply the CAD/CAM tools in manufacturing, service and environmental aspects.	**L3**
3	Apply the CNC and DNC machining processes in manufacturing.	**L3**
4	Design for manufacturability and recyclability of product.	**L6**
5	Estimate the energy efficiency in manufacturing.	**L5**
6	Analyse and adapt of industry 4.0 in manufacturing.	**L4**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	2	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	3	1	1	-	-	-	-	-	1	1	3	1
CO3	3	3	3	2	2	-	-	-	-	-	2	2	3	2
CO4	3	3	3	3	1	-	2	-	-	-	1	2	3	2
CO5	3	2	3	2	1	-	-	-	-	-	-	1	3	2
CO6	2	2	2	1	1	-	-	-	-	-	-	1	2	1

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Product Design and Development, Karl T. Ulrich and Steven D. Eppinger, McGraw Hill	1999
2	CAD/CAM Principles and Applications, P N Rao, Tata McGraw-Hill.	2010
3	CAD/CAM, H P Groover and E W Zimmers, Prentice Hall.	1984
4	Engineering Design and Design for Manufacture and Structural Approach, Dickson, John. R and Corroda Poly, Field Stone Publisher, USA.	1995

5	Computer Aided Design and Manufacturing, Sadhu Singh, Khanna Publishers	1998
6	Industry 4.0: The Industrial Internet of Things, Alasdair Gilchrist, Apress, Springer Nature	2017
7	The Fourth Industrial Revolution, Klaus Schwab, Penguin Random House	2017

Minor Specialization in Mechanical Engineering - Course Basket

(Student is required to opt minimum one course each from below mentioned groups)

Minor Specialization in Mechanical Engineering - Course Basket (Student is required to opt minimum one course each from below mentioned groups)				
S. No.	**Course Name**	**Course Code**	**Credit**	**L T P**
GROUP A				
1	Manufacturing Technology-I	ME5001	4	3-0-2
2	Manufacturing Technology-II	ME5002	4	3-1-0
GROUP B				
3	Fundamentals of Thermo-Fluidics	ME5003	4	3-1/2-2/2
4	Fundamentals of Heat Transfer	ME5004	4	3-0-2
GROUP C				
5	Strength of Materials and Concepts of Design	ME5005	4	3-1/2-2/2
6	Kinematics and Dynamics of Machines	ME5006	4	3-1/2-2/2

GROUP-A

Course Name	**:**	**MANUFACTURING TECHNOLOGY-I**
Course Code	**:**	**ME5001**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

1.To familiarize the students with the basic tools and equipment's used in manufacturing.
2.To introduce the practical knowledge on different aspects of manufacturing processes.
3.To familiarize with basic manufacturing processes, techniques, use of machine & tools etc.
4.To familiarize with the production of basic raw materials and secondary processes like joining, forming, assembly.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**MANUFACTURING**: Definition, Classification, Concept of product design and development, Plant and shop layout, Manufacturing activities inside and outside the factory, Industrial safety, Selection of raw materials, Storing, Process planning.	6
2	**FOUNDRY:** *Raw materials*: fuels, fluxes, refractory and related materials, patterns, mould, core; *Furnaces*: Cupola, induction and resistance heating furnaces, core furnace, open hearth furnace, pit furnace, Sand casting, Mechanics of solidifications; *Design:* Gating system, runner and riser; Pouring time calculation, Degassing, Fettling; *Special Castings*: Centrifugal, carbon dioxide, plaster, shell and permanent moulding, precision casting, investment casting, die casting, Continuous casting;*Casting of composites:* Casting Al/SiC, Al/ZrO2, Al/Al2O3 and hybrid MMCs, properties and applications. *Casting defects:* Causes and their remedial actions.	10
3	**METAL FORMING**: Classification, hot and cold working processes, Types: coining, embossing, punching, blanking, rolling, forging, fullering, edging extrusion, drawing, *Special forming processes:* rotary swaging, ring rolling, gear forming, tandem rolling, thread rolling, bearing cup, spline shaft rolling, electro, hydraulic, magneto-electro and hybrid forming; *Forming defects*: Causes and remedial actions.	8
4	**WELDING:** Definition, classification, mechanism of welding, weldability. *Arc welding*: principle, types, Carbon, submerged, electro-slag, MIG, TIG and plasma arc welding. *Electrodes:* Types, classification and codification, selection and specific applications. *Resistance welding*: Principle, types, Spot-welding machines. *Solid state welding*: Cold, diffusion, ultrasonic, explosive, friction and forge welding. *Thermochemical welding:* Principle, types, applications. *Gas welding*: Types, different zone and temperature of flames, applications. Oxy-flame cutting: Principle, types, applications. *Brazing and soldering*: Principle, types, materials, application in macro and micro domain, *Welding defects*: Causes and remedial actions.	10
5	**HEAT TREATMENT:** Definition, classification, annealing, normalizing, hardening and tempering; Iron-carbon and TTT diagram, *Surface hardening processes*: carburizing, nitiriding, cyaniding and flame hardening, heat treatment processes for non-ferrous metals.	8

List of Experiments:	
1	Carpentry section: (i) half lap T & L-joint, (ii) pattern of hexagonal nut.
2	Fitting section: (i) leveling & surface marking, (ii) square hole making.
3	Foundry section: (i) mould making, (ii) casting hexagonal nut.
4	Smithy section: (i) round bar to cube, (ii) round bar to V-block.

5	Welding section: (i) arc welding: V, L,T joints, (ii) spot welding on sheet metal.
6	Machine section: (i) turning & tapering, (ii) thread cutting.
7	Assembly and electrical basic connection: (i) study automobile engine, (ii) wiring & electrical connection.
8	Sheet metal & Electroplating: (i) bending & joining, (ii) buffing and electroplating on sheet metal

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the concept of manufacturing, product design, selection of raw materials, storing, and process planning.	**L2**
2	Plan and apply the different manufacturing processes to generate the ferrous, nonferrous and composite materials.	**L3**
3	Analyse the possible defects of manufacturing processes and ability to rectify the defects.	**L4**
4	Ability to select and apply the suitable manufacturing processes to make desire feature of products.	**L3**
5	Estimation of pouring time and solidification of metal casting	**L5**
6	Design and adapt different gating system, runner and riser	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	3	3	-	1	-	-	-	-	-	1	2	2	1
CO2	3	2	3	1	2	-	-	-	-	-	2	1	3	2
CO3	1	3	1	3	1	-	-	-	-	-	2	2	3	1
CO4	3	3	1	1	2	-	-	-	-	-	2	2	3	2
CO5	3	1	1	3	2	-	-	-	-	-	1	1	3	1
CO6	2	2	3	3	3	-	-	-	-	-	1	1	3	2

Suggested Books		
Sr. No.	**Name of the Book/ Authors/Publisher**	**Year of Publication/ Reprint**
1	Manufacturing Engineering and Technology; Serope Kalpakjian and Steven R. Schmid, 4th ed., Pearson.	2007
2	Principles of Manufacturing Materials and Processes; Campbell-Tata McGraw Hill.	1999
3.	Fundamentals of Modern Manufacturing, Mikell P. Groover, 5th ed., Wiley	2013
4.	Material and Processes in Manufacturing, E.P. Degarmo, Ronald A. Kohser, and J. T. Black; Prentice Hall of India	2008
5.	Manufacturing Processes, P.C. Sharma, S. Chand Publication.	2008

Course Name	**:**	**MANUFACTURING TECHNOLOGY-II**
Course Code	**:**	**ME5002**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

1.To impart the knowledge of tools and tooling system used for fabrication of metal powder, plastic and ceramics parts.
2.To impart the knowledge about various machine tools and their applications in the conventional and non-conventional machining processes used in metal cutting.
3.To impart the knowledge of advanced non-conventional machining techniques and their applications for processing of conductive and non-conductive materials.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**MACHINE TOOLS:** Classification, Specifications, Working principle and Applications of Lathe, Milling, Drilling, Boring, Broaching, Slotting, Sawing, Shaping, Planning, Grinding machines.	6
2	**PRINCIPLE OF METAL CUTTING AND MACHINING OPERATIONS:** Single, Double and Multipoint point cutting tools; Advanced cutting tool materials; Oblique cutting, Orthogonal cutting; Mechanics of chip formation; Types of chips; Merchant Force diagram; Tool life; Machinability; Machining parameters and their influence on machining performance, taper turning, thread cutting, knurling, indexing, hexagonal head, spline shaft and gear cutting.	10
3	**POWDER METALLURGY AND PROCESSING OF CERAMICS:** Principles, Advantages and limitations, Methods of producing powders. Applications of powder metallurgy parts, properties, Machining and Joining of ceramic metal powder components.	6
4	**PROCESSING OF PLASTICS:** Polymerization, Types of plastics, Fabrication and Processing of Plastics, Calendering's, Rotational molding, Injection and Blow molding, Helmet manufacturing, Machining and Welding of plastics.	6
5	**ADVANCED MACHINING PROCESSES:** Need and objective of non-conventional machining methods. ECM, EDM, WEDM, USM, EBM, LBM, AJM: Working principle, Process parameters, Effect of process parameters on machining responses, Applications, Introduction to rapid prototyping.	8
6	**METROLOGY& INSPECTION:** Limits, fits and tolerances, standard and limit gauges, design of gauges, steps of inspection, introduction to coordinate measuring machine and automated inspection technique, elements and relationship of surface finish related to production methods and measurement; measuring devices used in inspection and quality control.	6

List of Experiments:		**No. of Hours**
1	Gear cutting on milling machine	6
2	EDM of hard materials and study the effect of process parameters	4
3	Micro drilling using EDM process	4
4	Fabrication of plastic components using Injection molding setup	4
5	Product Development using 3D printing	4
6	Design and Fabrication for production of metal powder set-up	4
7	Measurement of angle using Sine Centre / Sine bar / bevel protractor	2

Sr. No.	**Course Outcomes** By the end of this course, the student will be able to:	**Knowledge Level (Blooms Level)**
1	Understand the principle and description of different machine tools.	**L2**
2	Understand the principle of metal cutting.	**L2**
3	Analyze the effects of machining parameters on machining performance.	**L4**
4	Apply advanced non-conventional machining processes for manufacturing of	**L3**

	different industrial products.	
5	Apply principle and processes of powder metallurgy for processing of ceramics.	**L3**
6	Compile information of the quality of product through knowledge of inspection, measurement and quality control.	**L6**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	2	2	-	-	1	-	-	-	-	1	3	1
CO3	3	2	2	1	-	-	2	-	-	-	-	1	3	2
CO4	2	3	2	3	2	-	2	-	-	-	2	1	3	3
CO5	1	2	2	2	2	1	1	-	-	-	-	1	3	3
CO6	2	1	1	2	2	1	-	-	-	-	-	1	2	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Manufacturing Engineering and Technology, Serope Kalpakjian and Steven R.Schmid-4thed., Pearson Edition.	2013
2	Manufacturing Science, Amitava Ghosh and Asok Kumar Mallik, East-West Press Pvt Ltd., New Delhi.	1993
3	Advance Machining Processes, V K Jain; Allied publishers, New Delhi.	2002

GROUIP-B

Course Name	**:**	**FUNDAMENTALS OF THERMO-FLUIDICS**
Course Code	**:**	**ME5003**
Credits	**:**	**4**
L T P	**:**	**3-1/2-2/2**

Course Objectives:	
1	To understand the importance of thermodynamics and fluid mechanics.
2	To understand the basics of thermodynamic systems and their applications.
3	To understand statics, dynamics and various approaches to fluid mechanics.
4	To correlate fundamentals of fluid mechanics with various mechanical systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**Basics and First Law of Thermodynamics:** Concept of Continuum, Thermodynamic System, Surrounding and Boundary, Thermodynamic Equilibrium, State, Path, Process, cycle, Quasi-static Process, Reversible and Irreversible Process, Working Substance, Thermodynamic Properties, Zeroth Law, Temperature Scales, Concept of Heat and work, First Law thermodynamics for closed and open systems, Enthalpy, Energy of an isolated System, Control Volume, Work and Energy Equations,	9
2	**Second Law of Thermodynamics:** Energy Analysis of Heat Engine, Refrigerator and Heat Pump, Reversibility and Irreversibility, Carnot Theorem and Carnot cycle, Equality of Ideal Gas Temperature and Kelvin Temperature. *Entropy:* Clausius Theorem and Clausius Inequality Principle of Entropy Increase, Applications to closed and open System, Entropy and disorder.	7
3	**Power Cycles:** *Air Standard Cycles*: Equation of state of a gas, Properties of Mixture of gases, Otto, Diesel, Dual, and Brayton Cycles, Comparison of cycles. *P-v, T-s, h-s,* diagram for a Pure Substances (with special reference to water), Use of Steam Table and Mollier Diagram, *Vapor Cycles*: Carnot and Rankine Steam Power Cycle, Actual Vapour cycle Processes, Comparison of Carnot and Rankine cycle, Mean Temperature of Heat Addition.	5
4	**Fluid Statics and Kinematics:** *Basics:* Properties of Fluid, Viscosity, Capillarity, Surface Tension, Compressibility, Normal and Shear Stresses in Fluid Flows. *Fluid Static:* Mechanics of Fluid at Rest and in Rigid Body Motion, Manometry, Hydrostatic Forces on Fully and Partially Submerged Bodies, Stability of a Floating Body, *Fluid Kinematics*: Langrangian and Eulerian Methods, Local and Convective Acceleration, Streamlines, Path Lines, Streak Lines, Acceleration and Rotation of a Fluid Particle, Vorticity and Circulation, Stream Function, Frictionless and Irrotational Flow, Velocity Potential Function.	9
5	**Dynamics of Fluid Flow:** Reynolds Transport Theorem, Equation of Conservation of Mass, Differential Form of Continuity Equation, Navier-Stokes Equations, Euler's Equation of Motion, Frictionless Flow - Bernoulli's Equation, Angular Momentum Theorem, Applications to Flow Measurement and other Real Flow Problems.	7
6	**Viscous Flow:** Regimes of Flow, Pressure Gradient in Steady Uniform Flow, Qualitative Aspects of Viscous Flows, Exact solutions of Navier-Stokes Equations, Laminar Flow Through a Pipe - Hagen-Poiseulli's Flow, Transition from Laminar to Turbulent Flow, Turbulent Flow Through a Pipe, Friction Factor, Applications to Pipe Networks. *Flow Past Immersed Bodies:* Reynolds Number and Geometry Effects, Momentum Integral Estimates, Boundary Layer Equations, Flow Over a Flat-Plate Boundary Layer, Boundary Layers with Pressure Gradients.	5

List of Experiments:		**No. of Turns**
1	To determine the metacentric height of a given vessel under unloaded condition.	1

2	Verification of Bernoulli's theorem.	1
3	To measure the velocity of flow using Pitot tube.	1
4	To determine the Coefficient of discharge through Venturi meter.	1
5	To determine the Coefficient of discharge through Orifice meter.	1
6	To determine the different types of flow Patterns by Reynolds's experiment.	1
7	To determine the Friction factor and loss coefficients for the different pipes.	1

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand basic laws and concepts of engineering thermodynamics and fluid mechanics.	**L2**
2	Apply the thermo-fluidic concepts to systems used in day-to-day activities and various engineering applications.	**L3**
3	Examine the thermo-hydrodynamic systems by using the basic concepts.	**L4**
4	Select the appropriate theoretically feasible system and out rightly rejects the proposed Perpetual Motion Machines of any kind.	**L5**
5	Analyze the performance of air-standard and vapor cycles.	**L4**
6	Implement the fundamentals of fluid flow in various mechanical systems.	**L3**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	-	-	-	-	-	-	-	1	1	1
CO2	2	2	1	1	-	-	-	-	-	-	-	1	2	1
CO3	3	3	2	2	-	-	-	-	-	-	-	2	2	1
CO4	3	3	3	2	-	-	-	-	1	-	-	1	2	1
CO5	3	3	3	2	-	-	-	-	1	-	-	2	2	1
CO6	3	3	3	2	1	-	-	-	2	-	-	2	2	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Thermodynamics, Yunus A. Cengel and Mike Boles, 9th ed., McGraw Hill	2019
2	Engineering Thermodynamics, P.K. Nag, McGraw Hill	2005
3	Thermodynamics, D.S. Kumar, S.K. Kataria & Sons	2013
4	Fluid Mechanics by Frank .M. White, McGraw Hill Publishing Company Ltd.	2017
5	Fluid Mechanics and Hydraulic Machines by R.K. Bansal, Laxmi Publications	2018
6	Fluid Mechanics: Fundamentals and Applications, Yunus A. Cengel, John M. Cimbala, McGraw Hill Education; 4th edition	2019

Course Name	**:**	**FUNDAMENTALS OF HEAT TRANSFER**
Course Code	**:**	**ME5004**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:	
1	To understand the fundamental principles and laws of heat transfer and explore the implications of these principles.
2	To formulate the models necessary to study, analyze and design heat transfer systems through the application of these principles.

3	To develop the problem-solving skills and practice of heat transfer in real-world applications.

Total No. of Lectures –42

Lecture wise breakup		**No. of Lectures**
1	**CONDUCTION HEAT TRANSFER:** Conduction, Convection, and Radiation Heat Transfer, Steady-State one, two and multi-Dimensional heat Conduction: Plane Wall, Insulation and R values, Radial Systems, Heat-Transfer Coefficient, Critical Thickness of Insulation, Heat-Source Systems, Thermal Contact Resistance, Mathematical Analysis of Two-Dimensional Heat Conduction, Graphical Analysis, Shape Factor, Numerical Analysis of Resistance Elements, Gauss-Seidel Iteration, Accuracy Consideration, Conduction-Convection System Fins with uniform cross-sections, Lumped-Heat-Capacity System, Transient Heat Flow in a Semi-Infinite Solid.	10
2	**PRINCIPLES OF CONVECTION:** Viscous Flow, Inviscid Flow, Laminar Boundary Layer on a Flat Plate, Energy Equation of the Boundary Layer, Thermal Boundary Layer, Relation between Fluid Friction and Heat Transfer, Turbulent-Boundary-Layer Heat Transfer, Turbulent Flow in a Tube, Empirical and Practical Relations for Forced-Convection Heat Transfer. Empirical Relations for Pipe and Tube Flow, Flow Across Cylinders, Spheres and Tube banks, Liquid-Metal Heat Transfer.	10
3	**NATURAL CONVECTION SYSTEMS:** *Free-Convection*: Heat Transfer on a Vertical Flat Plate, Empirical Relations, Vertical planes and Cylinders, Horizontal Cylinders, Plates, Inclined Surfaces, Spheres, Empirical co-relation and analogy for turbulent flow forced convection over extension surface.	5
4	**RADIATION HEAT TRANSFER:** Physical Mechanism, Radiation Properties/laws, Shape Factor and their relations, Heat exchange between non-black bodies, Infinite Parallel Planes, cylinders, spheres, Radiation shields. Solar radiation, Effect of Radiation on Temperature Measurement.	8
5	**BOILING AND CONDENSATION:** Boiling types, mechanism, Pool Boiling: Nucleate Boiling, CHF Flow Boiling: Plug/Slug flow, types, Mechanism Film-wise / Drop wise Condensation	3
6	**HEAT EXCHANGERS:** Introduction, Analysis of Heat Exchangers: LMTD for parallel flow HX, LMTD for counter Flow HX, Effectiveness for parallel Flow /Counter Flow HX, Design of HX, Compact Heat Exchangers, Cross flow Heat Exchangers, Some Important Topics from current research.	6

List of Experiments:		**No. of Turns**
1	To determine thermal conductivity of metal rod (Al, Brass and Steel)	1
2	To determine thermal conductivity of insulting metal.	1
3	To determine thermal conductivity of composite wall	1
4	To determine thermal conductance of heat pipe & compare it with other metal rods.	1
5	To determine thermal conductivity of insulator specimen by guarded hot plate method	1
6	To determine heat- transfer coefficient in natural convection	1
7	To study heat transfer from a pin-fin in natural & forced convection mode	1
8	To determine heat - transfer coefficient in forced convection.	1
9	To find heat transfer coefficient for drop-wise and film-wise condensation process	1
10	To determine overall heat transfer coefficient & compare it with value obtained from standard correlation	1
11	Study of CHF & pool-boiling	1
12	To determine effectiveness of parallel/counter flow heat exchange	1
13	To determine Stefan Boltzmann constant of radiation heat transfer.	1
14	To determine the emissivity of a non-black surface	1

Sr.	**Course Outcomes**	**Knowledge Level**

No.	By the end of this course, the student will be able to:	(Bloom Level)
1.	Understand basic concepts of heat transfer through different modes.	L2
2.	Apply the concepts of heat transfer to different devices, e.g., cooling fins, heat sink, radiation shields, etc.	L3
3.	Analyze, examine, and design the thermal systems based on the phase-change heat transfer, e.g., condensers, boilers, power plant equipment, etc.	L4, L5 & L6
4.	Solve real time problems applicable to heat conduction, heat convection, and heat radiation.	L4
5.	Examine the performance of heat exchangers, and optimize and design the heat transfer systems.	L5 & L6

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	1	-	-	-	-	-	-	-	-	1	1
CO2	3	2	3	2	-	-	1	-	-	-	-	-	3	1
CO3	3	2	2	2	-	-	1	1	-	-	-	1	2	1
CO4	3	2	3	2	-	-	1	-	-	-	-	-	2	1
CO5	3	2	2	1	-	2	1	1	-	-	-	1	3	1

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Heat and Mass Transfer: Fundamentals and Applications (SIE), Yunus A Cengel; Afshin J. Ghajar, McGraw Hill Education; 5th edition	2017
2	Fundamentals of Heat and Mass Transfer, Incropera, Dewitt, Wiley India Edition.	2018
3	Engineering Heat Transfer, R.C. Sachdeva, New Age	2012
4	Heat Transfer, J.P. Holman, Mc Graw Hill	2014
5	Engineering Heat and Mass Transfer, M.M. Rathor, University Science Press	2015
6	Fundamentals of Heat & Mass Transfer, C. P. Kothandaraman, New Age	2012

GROUIP-C

Course Name	**:**	**STRENGTH OF MATERIALS & CONCEPTS OF DESIGN**
Course Code	**:**	**ME5005**
Credits	**:**	**4**
L T P	**:**	**3-1/2-2/2**

Course Objectives:
At the end of this course, the student should be able to understand the basic philosophies of strength of material and designing of a system. The course will prepare the students to apply these to engineering and applied sciences problems.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION:** Equations of static equilibrium, Concept of various forces/loads, stresses and strains developed due to these forces/loads, Uniaxial tensile test, Stress-strain diagrams for various types of ferrous and non-ferrous materials, isotropic and anisotropic materials, Compression test, impact test, fatigue test, hardness test, torsion and bending test as per ASTM standards.	**4**
2	**SIMPLE & COMPOUND STRESSES:** Concept of stresses and strains, relationship between elastic constants, stresses produced in compound and simple bars due to axial loading, Generalized 2-D state of stress, stresses on an arbitrary plane under Generalized 2-D state of stress, principal stresses and principal planes, Mohr's stress circle and ellipse of stress	**6**
3	**SHEAR FORCE AND BENDING MOMENT IN BEAMS:** Shear force (SF), Bending moment (BM), Relation between rate of loading (w) with shear force (SF) and bending moment (BM). SF and BM diagrams of cantilevers, simply sported beams with or without overhang under different types of loading e.g. concentrate loads, uniformly distributed load, uniformly varying load, moment or its combinations	**5**
4	**BENDING AND SHEAR STRESSES IN BEAMS**: Theory of pure bending, Bending equation, Bending stresses in various cross-sectional beams under different loads, shear stresses in beams, variation of shear stresses in different cross-sectional beams	**6**
5	**GENERAL DESIGN CONSIDERATION:** Scope and meaning of design with special reference to machine design, design process, Concept of tearing, bearing, shearing, crushing, bending, Selection of materials, Factors of safety under different loading conditions, stress-concentration factors, Design stresses for variable and repeated loads. Endurance limit, fatigue. Fits and tolerances and finish	**5**
6	**FASTENERS:** Cotters and cotter joints, pin fasteners knuckle joints, Screws, bolts, preloaded bolts, bolts subjected to shear, tension and torque, eccentrically loaded bolted joints, Welded and riveted connection, eccentrically loaded, welded and riveted connections.	**8**
7	**SHAFTS AND AXLES:** Torsion and its equation for circular shafts, determination of principal stresses and maximum shear stresses in circular hallow and solid shaft due to combined bending and torsion, application of torsional concepts in Shafts & Axles, Keys, Design of Rigid & flexible Coupling	**8**

List of Experiments:		**Number of Turns**
1	To perform Tensile Test on a given material and to determine its various mechanical properties under tensile loading.	1
2	To perform Compressive and shear test on a given material and to determine its various mechanical properties under compression loading.	1
3	To perform Torsion test on a given material and to determine various mechanical properties under torsional load.	1
4	To perform Bending test and to determine the Young's Modulus of Elasticity of the beam via deflection formulae.	1
5	To determine Rockwell hardness of a given material.	1
6	To perform Impact test on a given material and to determine its resilience.	1

7	To study and perform Fatigue test on a given material and to determine endurance strength and limit of the material.	1

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recall the basic concepts of Mechanics, forces, stresses and understand the basic causes of failure	**L1 & L2**
2	Understand simple and complex stresses.	**L2**
3	Beam analysis on the basis of shear force and bending moment & their corresponding stresses.	**L4**
4	Select the suitable materials, fits, tolerances and surface finish considering manufacturing aspects.	**L5**
5	Apply the causes of failure in designing/sizing of mechanical components under various types of loading.	**L3, L6**
6	Ability to conduct various tests on materials to assess their mechanical properties.	**L4**

CO-PO & PSO course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	2	2	2	-	-	-	-	-	-	-	1	2	1
CO3	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO5	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO6	2	2	2	3	-	-	-	-	2	3	-	1	2	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Strength of Material - G. H. Ryder (MacMillan)	1969
2	An Introduction to the Mechanics of Solids – Crandall & Dahl (Mc-Graw Hill)	2012
3	Engg. Mechanics of Solids - E. P. Popav (Pearson Education)	2003
4	Strength of Material: D S Bedi, Khanna Publishing, 6th edition	2019
5	Strength of Material by R K Rajput, S Chand	2012

Course Name	**:**	**KINEMATICS AND DYNAMICS OF MACHINES**
Course Code	**:**	**ME5006**
Credits	**:**	**4**
L T P	**:**	**3 -1/2- 2/2**

Course Objectives: In this course, the student should be able to

1. Understand the basics of machines and mechanism.
2. Understand the concepts of kinematic diagrams, kinematic chains & mobility, mechanisms and Kinematic analysis.
3. Understand various components used in power transmission devices.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**BASIC CONCEPTS:** Kinematics and Dynamics of Machines, Mechanisms, Pairs, kinematic chain, four bar chain, Inversions of single and double slider crank chains, Degrees of freedom, Kutzbach's equation. Grubler's criterion, Joints..	4

2	**VELOCITY AND ACCELERATION:** Relative motion, displacement, velocity, acceleration diagrams of different types of mechanisms, Relative velocity method, instantaneous center method; Kennedy theorem, Klien's construction, Coriolis component, Numerical problems.	6
3	**CAMS:** Type of cams and followers, definition-basic circle & least radius, angle of ascent. Dwell, Descent & Action; Displacement, Velocity and Acceleration diagrams of followers, Simple harmonic motion, Uniform and maximum velocity, acceleration and retardation, cycloidal motion.	5
4	**GEARS AND GEAR TRAINS:** ***Toothed gears:*** types, definitions and terminology, pressure angle, path contact, arc of contact and approach, law of gearing, gear tooth profiles, involute and cycloidal gear systems, interference in involute gears; ***Gear Trains*****:** Types, simple and compound, epicyclic and reverted gear trains; Sun and planet gear, differential; Velocity ratio of worm and worm wheel, Helical and spiral gears; spiral angle and efficiency; Numerical problems.	8
5	**GYROSCOPE:** Definition, axis of spin and precision, gyroscopic couple and effect on movement of ships and vehicles, stability of two and four wheel automobile; Numerical problems.	4
6	**FLYWHEEL AND GOVERNORS:** Turning moment and crank movement diagrams, dynamics of simple horizontal and vertical engine. Fluctuation of speed, co-efficient of fluctuation of speed and energy, Punching press. Simple problems; *Governors*: Functions, types and characteristics of governors, Sensitivity, stability, isochronism and hunting of governors, governor effort and controlling force curve, effect of sleeve friction. Numerical problems.	8
7	**BALANCING:** Classification, static and dynamic balancing, Primary and secondary balancing of rotary and reciprocating masses, swaying couple and variation of tractive effort, hammer blow, partial balancing of locomotive, multi cylinder in line engines, balancing of V-engines.	7

List of Experiments:		**No. of Hrs**
1	To find displacement, velocity and acceleration of slider in a single slider crank mechanism for different crank angles and draw various graphs.	2
2	Verify experimentally the gyroscopic couple is given by $T = I.\omega.\omega_p$	2
3	Draw experimentally the approximate straight line be watts mechanism.	2
4	Find out the positions of the four weights, so that the system becomes statically & dynamically balanced.	2
5	Find the moment of inertia of a given body about an axis passing through C.G. and perpendicular to the plane of the body also calculate the minimum oscillation of the point of suspension.	2
6	Balance experimentally as far as possible the known unbalanced force due to a rotating weight by introducing two balancing weights in two different planes (a) Balancing planes on either side of unbalanced force (b) Balancing planes on the same side of unbalanced force.	2
7	Determination of characteristics curve of the Watt, Porter, Proell and Hartnell Governors using universal governor set up.	2

Sr. No.	**Course outcome** By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand and apply concepts of kinematics and dynamics on the mechanism & machines.	**L2 & L3**
2	Develop various cam profiles for engines and machines.	**L6**
3	Analyze and develop gear trains required for various applications.	**L4**
4	Understand the working of gyroscope, flywheel and governors.	**L2**
5	Ability to conduct various tests on machine & mechanism to assess their output	**L4**

	characteristics.	

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	-	-	-	-	-	-	-	1	3	1
CO2	2	2	2	1	-	-	-	-	-	-	-	1	2	1
CO3	2	3	2	1	-	-	-	-	-	-	-	1	2	1
CO4	1	1	2	1	-	-	-	-	-	-	-	1	2	1
CO5	1	1	1	3	-	-	-	-	2	2	-	1	3	2

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Theory of Machines, V.P. Singh, Dhanpat Rai & Co. Pvt. Ltd, New Delhi	2014
2	Theory of Machines, P.L. Ballaney, Khanna publishers, New Delhi	1994
3	Theory of Machines, Shigley, Tata McGraw Hill.	1981
4	Mechanism & Machine Theory, J.S. Rao & R.V. Dukhipati, Wiley Eastren Ltd.	1992
5	Theory of Mechanisms, Amitabh Gosh & A.K. Mallik, East West Press Machines Private Ltd.	2006
6	Theory of Machines, S. S. Rattan, McGraw Hill Education (India)	2014