To
The Members of the
Board of Studies in Mechanical Engineering
CBIT (A), Hyderabad.

Sir,

Sub: Board of Studies in Mechanical Engineering, CBIT (Autonomous) – convening the meeting of the Board of Studies in Mechanical Engineering on 18.07.2020 – Reg.

An online meeting of the Board of studies in Mechanical Engineering will be convened on Saturday, 18th July, 2020 at 10.30 a.m to discuss the following agenda.

AGENDA

1. To consider and approve the syllabus for B.E V, VI, VII & VIII Semester (Mechanical Engineering) under AICTE Model Curriculum (R-18).
2. To consider and approve the curriculum syllabus for M.E. (CAD/CAM) & M.E (Thermal Engg.,) III & IV Semester under AICTE model (R-19)
3. To consider and approve the syllabus of courses (a) CAD & Drafting (b)Workshop/ Manufacturing Practice for I and II semester (All programmes) under AICTE Model Curriculum (R-20).
4. To consider and approve the Mission, the Vision of the Department , PEOs and PSOs of the programmes B.E (Mechanical Engineering), M.E(CAD/CAM) and M.E (Thermal Engineering)
5. Any other item with the permission of the chair

All the members are requested to make it convenient to attend the on line meeting through zoom platform on Saturday, 18.07.2020 at 10.30 a.m. Link will be shared to the mails by 10 a.m on 18.07.2020.

Dr. P.V.R.Ravindra Reddy
Professor & Head, MED
Chairman – Board of Studies

DEPARTMENT OF MECHANICAL ENGINEERING

Minutes of the Meeting - Board of Studies in Mechanical Engineering

Date: 18.07.2020

Board of Studies meeting in Mechanical Engineering was conducted online by using Zoom platform on 18.07.2020 from 10.30 A.M to 2.30 P.M. The Minutes of the Meeting are as follows:

Members Present:

1. Prof. P. Ravinder Reddy, Principal & Professor
2. Prof. G. Chandra Mohan Reddy, Professor
3. Dr.MVSMurali Krishna, Professor
4. Prof. P.V.R. Ravindra Reddy, Professorand Head, Chairman- BOS
5. Dr. N.V. Srinivasulu, Professor
6. Prof. P. Prabhakar Reddy, Professor
7. Prof. G. Laxmaiah, Professor
8. Dr. T. Ratna Reddy, Associate Professor
9. Dr. K. Kishor, Assoc. Professor
10. Dr. R.P. Chowdary, Associate, Professor
11. Dr.L.Suresh Kumar, Assistant Professor
12. Dr.V.V.R. SeshagiriRao, Asst. Professor,Asst. Controllerof Examinations
13. Dr. P. Rama Lakshmi, Asst. Professor
14. Prof. P. Laxminarayana, Professor and Dean Academic Affairs, OUCE
15. Dr. S. Venkatesh, Professor, OUCE
16. Dr. N. Venkat Reddy, Professor, IITH
17. Dr. K. Ramesh Kumar, Sc.G, BRAHMOS, DRDL, Hyderabad
18. Dr. C. SatyanarayanaRaju, Sc.G, DRDL, Hyderabad
19. Dr.S.Satyanarayana, Director,A.P.LMEC systems, Hyderabad
20. Mr.M.Rajkiran, Director,Maathrusri Engineers Pvt. Ltd, Hyderabad

AgendaItem 1: Approval of B.E. Mechanical Engineering syllabus (V, VI, VII, VIII semesters) under R-18 Scheme,

1. It is advised to have a course on "**Industrial Safety and Maintenance**", for all B.E. programs. Chairman BoS has informed membersthat,as the scheme of R-18 was already fixed, The course on "**Industrial Safety and Maintenance**" may be introduced as one of the core elective in the upcoming revision i.e R-20. He further informed that the same will communicated in the upcoming academic council meeting
2. Regarding theOpen Electives, it is advised to add the courses appropriately from all the programmes so that thestudentsshould have atleast one such elective option in each semester offered by every department, rather than having all the elective offered by one department in only one semester. This modification enables the students in planning sequential opting of such courses as per their choice and interest. Chairman BoS informed the members that he will discuss the same in Academic Council meeting
3. Incorporation of "Object Oriented Programming with C++ course in B.E. VI semester was appreciated by the experts.
4. It is advised develop and add Virtual/Online labs with feasible experiments to be taught to students online, as such arrangements were incorporated by IIT Bombay. It is advised to develop assignments for the lab experiments so that students get the essence of experiment during Covidpandemic. BoS chairman informed the members that this will done if the classes are planned on line.
5. Add Case Studies in all relevant courses, like Renewable energy Sources and Entrepreneurship.
6. 18PE E01 - processing of elastomers is to be added in unit 5.
7. 18PE E02 – it is recommended to add some more topics of process planning in 4^{th} unit
8. 18ME E06 -Refer to some political science text books for the course.
9. 18ME E07 - change the title of the course to either Fuels & Combustion, or Combustion & Fuel Technology.
10. 18PE E08- flexible forming processes are to be included.
11. 18ME E14- contents of UNIT-I may be reduced
12. 18 ME E17- Manufacturing of PV cells should be included.

13. 18 ME C 17- Assembly modelling and constraints of assembly modelling is to be added.
14. 18 ME E24- the title may be changed to “Innovation and Intellectual Property Rights”.
15. 18PE E12- ABC analysis, VED analysis and FNSD analysis may be removed if it is there in IIFM
16. 18 ME O12- Powder bed fusion is to be elaborated.
17. In the case of newly added subject Blockchain Technology, add a topic related to Industry 4.0, and if available also add a related text book.
18. In the course 3D printing it is suggested to elaborate the syllabus by adding some more relevant topics.
19. At the end of the meeting, it was reaffirmed by the Chairman BoS, that recommendations of the BoS meeting would be brought to the notice of the members during the upcoming common BoS and academic council.

Agenda Item 2: Approval of M.E. (CAD/CAM and Thermal Engineering) syllabus under R-18 scheme,

1. 19ME E 14- The title “Heat pipes” may be changed appropriately.
2. 19ME O101- Safety standards for pandemic situations are to be included.
3. 19ME E212- Syllabus of Unit 1 appears to be heavy. “Limitations of simple carburettor and classification of automobile carburettor” may be removed from the syllabus.

Agenda Item 3: Approval of B.E. First year courses, syllabus under R-20 scheme

1. The members felt that the syllabus of CAD & Drafting and Workshop / Manufacturing Practice is appropriate.

Agenda Item 4: Approval of modified Department Mission, Vision, PEO’s and PSO’s statements

1. Suggestions given regarding the modification of PSO’s of B.E. Mechanical Engineering were done during the meeting.

Agenda Item 5: Any other item with the permission of the chair

1. The meeting was concluded as no other matter was raised by any member and Chairman BoS thanked all the members for attending the meeting and for giving suggestions.

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

AICTE MODEL CURRICULUM

B.E (Mechanical Engineering)

SEMESTER – I

S.No	Course Code	Title of the Course	Scheme of Instruction Hoursper week			Scheme of Examination			Credits
						Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
	THEORY								
1	18MT C01	Mathematics –I	3	1	-	3	30	70	4
2	18PY C03	Introduction To Mechanics and Electromagnetic Theory	3	1	-	3	30	70	4
3	18CS C01	Programming for Problem Solving	3	-	-	3	30	70	3
4	18EGC01	English	2	-	-	2	20	50	2
	PRACTICALS								
5	18PY C06	Mechanics and Electromagnetic Lab	-	-	3	3	25	50	1.5
6	18CS C02	Programming for Problem Solving Lab	-	-	4	3	25	50	2
7	18ME C02	Workshop/ Manufacturing Practice	1	-	4	3	25	50	3
8	18EG C02	English Lab	-	-	2	2	15	35	1
		Total	**12**	**02**	**13**	**-**	**200**	**445**	**20.5**

L:Lecture T:Tutorial D:Drawing P:Practical
CIE - ContinuousInternalEvaluation SEE - Semester EndExamination

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

AICTE MODEL CURRICULUM

B.E (Mechanical Engineering)

SEMESTER – II

S. No	Course Code	Title of the Course	Scheme of Instruction Hoursper week			Scheme of Examination			Credits
						Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
	THEORY								
1	18MTC03	Mathematics –II	3	1	-	3	30	70	4
2	18CYC01	Chemistry	3	1	-	3	30	70	4
3	18CEC01	Engineering Mechanics	3	1	-	3	30	70	4
4	18ME C01	Engineering Graphics and Design	1	-	4	3	30	70	3
5	18EE C01	Basic Electrical Engineering	3	1	-	3	30	70	4
	PRACTICALS								
6	18EE C02	Basic Electrical Engineering Lab	-	-	2	2	15	35	1
7	18CY C02	Chemistry Lab	-	-	3	3	25	50	1.5
		Total	**13**	**04**	**09**	**-**	**190**	**435**	**21.5**

L:Lecture T:Tutorial D:Drawing P:Practical

CIE - ContinuousInternalEvaluation SEE - Semester EndExamination

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

AICTE MODEL CURRICULUM

B.E (Mechanical Engineering)

SEMESTER – III

S. No.	Course Code	Title of the Course	Scheme of instruction			Scheme of examination			Credits
			Hours per week			Duration in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	18MT C05	Mathematics – III	3	1	--	3	30	70	4
2	18MB C01	Engineering Economics and Accountancy	3	--	--	3	30	70	3
3	18ME C03	Material Science and Metallurgy	3	--	--	3	30	70	3
4	18ME C04	Mechanics of Materials	3	1	--	3	30	70	4
5	18PE C01	Manufacturing Processes	3	--	--	3	30	70	3
6	18EG M01	Indian Constitution and Fundamental Principles	2	--	--	2	--	50*	Non-Credit
7	18EE A01	Indian Traditional Knowledge	2	--	--	2	--	50*	Non-Credit
PRACTICALS									
8	18ME C05	Material Science and Metallurgy Lab	--	--	2	2	15	35	1
9	18ME C06	Mechanics of Materials Lab	--	--	2	2	15	35	1
10	18PE C02	Manufacturing Processes Lab	--	--	2	2	15	35	1
		TOTAL	**19**	**02**	**06**	--	**195**	**455**	**20**

L:Lecture T:Tutorial D:Drawing P:Practical
CIE - ContinuousInternalEvaluation SEE - Semester EndExamination * Pass / Fail

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

AICTE MODEL CURRICULUM

B.E (Mechanical Engineering)

SEMESTER – IV

S. No.	Course Code	Title of the Course	Scheme of instruction			Scheme of examination			Credits
			Hours per week			Duration in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	18CS C05	Basics of Data Structures	2	--	--	2	20	50	2
2	18ME C07	Kinematics of Machines	3	1	--	3	30	70	4
3	18ME C08	Thermodynamics	3	1	--	3	30	70	4
4	18ME C09	Principles of Management	3	--	--	3	30	70	3
5	18ME C10	Fluid Principles and Hydraulic Machines	3	1	--	3	30	70	4
6	18CE M01	Environmental Science	2	--	--	2	--	50*	Non-Credit
PRACTICALS									
7	18CS C08	Basics of Data Structures Lab	--	--	2	2	15	35	1
8	18EG C03	Soft Skills Lab	--	--	2	2	15	35	1
9	18ME C11	Fluid Principles and Hydraulic Machines Lab	--	--	2	2	15	35	1
TOTAL			**16**	**03**	**06**	--	**185**	**435**	**20**

L: Lecture T: Tutorial D:Drawing P: Practical

CIE - ContinuousInternalEvaluation SEE – Semester EndExamination

* Pass /Fail

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)
AICTE MODEL CURRICULUM
B.E (Mechanical Engineering)

SEMESTER-V

S. No.	Course Code	Title of the Course	Scheme of instruction			Scheme of examination			Credits
			Hours per week			Duration in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	18ME C12	Dynamics of Machines	3	--	--	3	30	70	3
2	18ME C13	Applied Thermodynamics and Heat Transfer	3	--	--	3	30	70	3
3	18ME C14	Design of Machine Elements	3	--	--	3	30	70	3
4	18PE C07	Metal Cutting and Machine Tool Engineering	3	--	--	3	30	70	3
5		Core Elective – I	3	--	--	3	30	70	3
6		Core Elective – II	3	--	--	3	30	70	3
PRACTICALS									
7	18ME C15	Dynamics and Vibrations Lab	--	--	2	2	15	35	1
8	18ME C16	Applied Thermodynamics and Heat Transfer Lab	--	--	2	2	15	35	1
9	18PE C08	Metal Cutting and Machine Tool Engineering Lab	--	--	2	2	15	35	1
		TOTAL	**18**	--	**06**	--	**225**	**525**	**21**

L: Lecture T: Tutorial D: Drawing P: Practical CIE – Continuous Internal Evaluation SEE – Semester End Examination

Core Elective– I (3/3)			Core Elective– II (3/3)		
S.No	Subj.Code	Name of the Subject	S.No	Subj.Code	Name of the Subject
1	18ME E01	Refrigeration and Air Conditioning	1	18ME E04	Automobile Engineering
2	18ME E02	Values, Ethics and Society	2	18ME E05	Nano Science and Technology
3	18PE E01	Plastics, Ceramics and Composite Materials	3	18ME E06	Rights, Duties and Legislation
4	18PE E02	Product Design and Process Planning	4	18PE E04	Non Destructive Testing and Evaluation
5	18ME E03	Mechanical Vibrations	5	18ME E07	Fuels and Combustion

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AICTE MODEL CURRICULUM
B.E (Mechanical Engineering)

SEMESTER-VI

S. No.	Course Code	Title of the Course	Scheme of instruction			Scheme of examination			Credits
			Hours per week			Duration in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	18ME C17	CAD/CAM	3	--	--	3	30	70	3
2	18ME C18	Machine Design	3	--	--	3	30	70	3
3	18ME C19	Thermal Turbo Machines	3	--	--	3	30	70	3
4		Core Elective – III	3	--	--	3	30	70	3
5		Core Elective – IV	3	--	--	3	30	70	3
6		Core Elective – V	3	--	--	3	30	70	3
PRACTICALS									
7	18ME C20	CAD/CAM Lab	--	--	2	2	15	35	1
8	18ME C21	Thermal Engineering Lab	--	--	2	2	15	35	1
TOTAL			**18**	--	**04**	--	**210**	**490**	**20**

L: Lecture T: Tutorial D: Drawing P: Practical

CIE – Continuous Internal Evaluation SEE – Semester End Examination

Core Elective – III (3/3)			**Core Elective – IV (3/3)**		
SNO	**Subj. Code**	**Name of the Subject**	**SNO**	**Subj. Code**	**Name of the Subject**
1	18ME E08	Object Oriented Programming with C++	1	18ME E12	Computational Fluid Dynamics
2	18ME E09	Mechanics of Composite Materials	2	18ME E13	Principles of Entrepreneurship
3	18ME E10	Robotic Engineering	3	18PE E08	Modern Machining and Forming Methods
4	18PE E06	Production and Operations Management	4	18ME E14	Heat and Mass Transfer
5	18ME E11	Advanced IC Engines	5	18ME E15	Blockchain Technology

Core Elective – V (3/3)		
SNO	**Subj. Code**	**Name of the Subject**
1	18ME E17	Renewable Energy Sources
2	18ME E18	Control Systems Theory
3	18ME E19	Artificial Intelligence
4	18ME E20	Industrial Administration and Financial Management
5	18PE E11	Principles and Applications of Additive Manufacturing

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SEMESTER – VII

S. No.	Course Code	Title of the Course	Scheme of instruction			Scheme of examination			Credits
			Hours per week			Duration in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	18ME C22	Metrology and Instrumentation	3	--	--	3	30	70	3
2	18ME C23	Operations Research	3	--	--	3	30	70	3
3	18ME C24	Finite Element Analysis	3	--	--	3	30	70	3
4		Core Elective – VI	3	--	--	3	30	70	3
5		Open Elective – I	3	--	--	3	30	70	3
PRACTICALS									
6	18ME C25	Metrology and Instrumentation Lab	--	--	3	3	25	50	1.5
7	18ME C26	Computer Aided Engineering Lab	--	--	3	3	25	50	1.5
8	18ME C27	Project: Part – 1	--	--	4	--	50	--	2
		TOTAL	**15**	--	**10**	--	**250**	**450**	**20**

L: Lecture T: Tutorial D:Drawing P: Practical

CIE – Continuous Internal Evaluation SEE – Semester End Examination

Core Elective– VI (3/3)			**Open Elective–I (3/3)**		
S NO	**Subj.Code**	**Name of the Subject**	**S NO**	**Subj.Code**	**Name of the Subject**
1	18ME E21	Power Plant Engineering	1	18IT O01	Object Oriented Programming using JAVA
2	18ME E22	Engineering Research Methodology	2	18PY O01	History of Science & Technology
3	18ME E23	Data Analytics	3	18EG O02	Gender Sensitization
4	18ME E24	Innovation and Intellectual Property Rights	4	18IT O03	Principles of Internet of Things
5	18PE E12	Supply Chain Management	5	18CS O09	Basics of Artificial Intelligence

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)
AICTE MODEL CURRICULUM
B.E (Mechanical Engineering)

SEMESTER – VIII

S. No.	Course Code	Title of the Course	Scheme of instruction			Scheme of examination			Credits
			Hours per week			Duration in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1		Open Elective – II	3	--	--	3	30	70	3
2		Open Elective – III	3	--	--	3	30	70	3
PRACTICALS									
3	18ME C28	Technical Seminar (On the latest trends and other than Project)	--	--	2	--	50	--	1
4	18ME C29	Project Part - 2	--	--	20	--	100	100	10
		TOTAL	**6**	--	**22**	--	**210**	**240**	**17**

L: Lecture T: Tutorial D: Drawing P: Practical
CIE - Continuous Internal Evaluation SEE – Semester End Examination

Open Elective – II (3/3)			**Open Elective – III (3/3)**		
S NO	**Subj. Code**	**Name of the Subject**	**S NO**	**Subj. Code**	**Name of the Subject**
1	18EC O01	Remote Sensing and GIS	1	18EG O01	Technical Writing Skills
2	18MT O01	Decision Theory	2	18BT O01	Basics of Biology
3	18EE O03	Energy Auditing	3	18CE O02	Disaster Mitigation and Management
4	18CS O04	Basics of Cyber Security	4	18EE O05	Waste Management
5	18EC O05	MEMS and its Applications	5	18EC O07	Systems Automation & Control

18ME C12

DYNAMICS OF MACHINES

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. To understand force analysis of single slider crank mechanism and turning moment Diagrams for Flywheels
2. To understand the Gyroscopic effect and the performances of Governors
3. To know the Balancing of rotating and reciprocating masses.
4. To determine natural frequencies of undamped, damped and forced vibrating systems of single degree freedom systems.
5. To understand the modes of vibrations, Two degree of Freedom and Torsional Vibrations

Outcomes: At the end of the course, the students are able to

1. Determine the fluctuation of energy and decide the cross section of flywheel. (BL-3)
2. Understand the gyroscopic effects in ships, aero planes and road vehicles. (BL-2)
3. Analyze the characteristics of various centrifugal governors. (BL-4)
4. Analyze balancing problems in rotating and reciprocating machinery. (BL-4)
5. Understand free and forced vibrations of single degree freedom systems and two-degree freedom linear systems. (BL-2)

UNIT- I

Force analysis: Dynamic force analysis of single slider crank mechanism, concept of dynamically equivalent link.

Flywheels: Working principle of flywheel, turning moment on the crank shaft, turning moment diagrams, maximum fluctuation of energy and its determination, coefficient of fluctuation of speed, design of flywheels, rim type flywheel versus solid type flywheel**.**

Gyroscope: Principle of gyroscope, roll, yaw and pitch motions, gyroscopic effect in a two-wheeler, car, ship and aeroplane, practical problems.

UNIT- II

Governors: Necessity of governor, different types of governors, working principle of centrifugal governors, characteristics of Watt governor, Porter governor, Proell governor, Hartnell governor, Hartung governor, hunting of governors, concept of control force, control force diagram, definition of stability of governor, condition for stability, concept of isochronism, sensitivity of governor, energy of governor.

UNIT- III

Balancing of Rotating masses: Balancing and its types, rotor balancing, single plane and two plane balancing, unbalanced forces and couples, static and dynamic balancing, balancing of rotors by analytical and graphical methods.

Balancing of reciprocating machines: Primary and secondary unbalanced forces, balancing of in line and radial engines.

UNIT - IV

Vibrations: Vibrations of single degree freedom system (axial, transverse and torsional), equivalent system of combination of springs, stepped shaft, whirling speed of shafts.

Damped Vibrations: Types of damping, vibrations with viscous damping,

Forced Vibrations: Vibrations with harmonically applied force with viscous damping, dynamic magnifier, resonance, vibration isolation and transmissibility.

UNIT –V

Two and three degree freedom systems: Natural frequencies of two degree freedom linear systems. Nodes in two and three rotor systems, modes of vibration, determining natural frequencies by Holzer's method for multi-rotor systems. Dunkerley's and Rayleigh's approximate methods.

Text Books:

1. S.S. Rattan, "Theory of Machines", Fourth edition ,Tata-Mc Graw Hill, ,2014
2. John.J.Vicker, Gordon R. Pennock, Joseph E. Shigley, "Theory of Machines & Mechanisms", Oxford University press, 2003. .
3. William T.Thomson "Theory of Vibration with Application", 5th edition, Pearson education 2008

Suggested Reading:

1. A. Ghosh and Mallick, "Theory of mechanisms and machines", Affiliated to E-W Press, 1988.
2. J.S. Rao and Gupta, "Theory and Practice of Mechanical Vibrations", PHI, 1984

18ME C13

APPLIED THERMODYNAMICS AND HEAT TRANSFER

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. The working principles of reciprocating air compressor and its applications in engineering
2. The working principle of diesel and petrol engine, their combustion phenomena and problems pertaining to abnormal combustion
3. Student will understand the features of IC engine like ignition system and injection system
4. The basic modes of heat transfer
5. The classification of heat exchanger, concepts of radiation heat transfer and phase heat transfer

Outcomes: At the end of the course, the students are able to

1. Estimate the power required for reciprocating air compressor using the basic principles of thermodynamics for many engineering applications. (BL-4)
2. Evaluate the performance of C.I. and S.I. engines with appropriate consideration for public health and safety. (BL-5)
3. Understand the functioning of components of I.C. engines and the concept of abnormal combustion with remedial measures. (BL-2)
4. Derive the expressions for the heat transfer in conduction and convection with the basic principles of thermodynamics. (BL-3)
5. Understand the basic principles of heat exchangers, boiling and condensation. (BL-2)

UNIT – I

Reciprocating Air Compressors: Classification of compressors, advantages of reciprocating compressors over rotary compressors, applications of compressed air, working principle of reciprocating compressors - single stage and multi stage compressors with and without clearance, concept of optimum pressure ratio, minimum work input, various efficiencies of multi stage compressors, simple problems on reciprocating compressors.

UNIT - II

Internal Combustion Engines: Classification, working principles of 2 stroke, 4 stroke SI and CI engines, valve and port timing diagrams, performance of IC engines, Morse test, various methods of determining frictional power, various efficiencies, heat balance sheet.

UNIT - III

Combustion Phenomena: Stages of combustion in SI and CI engines, octane and cetane number, factors affecting, normal and abnormal combustion phenomenon in SI and CI engines, methods to control the abnormal combustion, types of combustion chambers, cooling systems, lubrication systems, battery and magneto ignition systems of IC engines, working principle of simple carburetor and fuel injector.

UNIT - IV

Modes of Heat Transfer: General 3-D conduction equation in cartesian and cylindrical coordinates, one dimensional steady state conduction through slabs, hollow cylinders without heat generation, critical radius of insulation for cylinders.

Convection: Free and forced convection, dimensionless numbers and their physical significance.

UNIT - V

Radiation: Various laws of radiation, concept of black-body.

Heat Exchangers: Classification, concept of LMTD and simple problems.

Condensation and boiling: Types of condensation, heat transfer coefficient for laminar parallel flow condensation, pool boiling curve, simple problems on condensation and boiling.

Text Books:

1. Mahesh M. Rathore, "Thermal Engineering", TMH, New Delhi, 2010
2. V. Ganeshan, "Internal Combustion Engines", Tata Mcgraw Hill Publishing, New Delhi,2015
3. J.P. Holman, "Heat Transfer", McGraw Hill Publication, New Delhi,

Suggested Reading:

1 R.K. Rajput., "Thermal Engineering", Laxmi Publishers, New Delhi, 2014

2 D.S. Kumar, "Heat Transfer", S K Kataria Publishers, 2015

18ME C14

DESIGN OF MACHINE ELEMENTS

(Use of data book is permitted)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. To understand the principles of machine design and design considerations, types of loads, failure criteria.
2. To design machine members for static, fluctuating loads and impact loads
3. Learn the design principles of shafts, keys, couplings, belt drives and pulleys.
4. Understand the principles of design of permanent joints such as riveted and welded joints.
5. Understand the principles of design of bolted joints, power screws and gasket joints.

Outcomes: At the end of the course, the students are able to

1. Understand the standards, codes, various design considerations and failure criteria of members (BL-2)
2. Analyze and evaluate machine members subjected to static and dynamic loads (BL-4)
3. Recommend suitable shafts, couplings and belt drives for a given application (BL-5)
4. Design permanent joints for a given application (BL-6)
5. Design bolted joints, power screws and screw jack (BL-6)

UNIT – I

Introduction: Materials used in machine design and their specifications to Indian standards, codes and standards used in design. Reliability, principles of Ergonomics and Manufacturing considerations. Preferred numbers, analysis of stress and strain: Types of loading and stresses. Cotter and knuckle joints. Theories of elastic failure, stress concentration factor, factor of safety, Design of components for static loads.

UNIT – II

Design for Fatigue and Impact loads: Importance of fatigue in design, fluctuating stresses, fatigue strength and endurance limit. Factors affecting fatigue strength, S-N Diagram, Soderberg and Modified Goodman's diagrams for fatigue design. Cumulative fatigue, Miner's rule, Design of components for fatigue. Design of components for impact loading.

UNIT – III

Design of shafts, Keys & Couplings: Solid, hollow and splined shafts under torsion and bending loads, types & design of Keys, muff , split muff , flange, marine type and flexible type of couplings.
Design of Belt Drive Systems: selection of belts and design of pulleys.

UNIT – IV

Design of Permanent Joints: Types of Riveted joints, efficiency of the joint. Design of riveted joints subjected to direct and eccentric loads. Types and design of welded joints subjected to direct and eccentric loading.

UNIT – V

Design of Bolted Joints, Power Screws: Design of bolts and nuts, locking devices, bolt of uniform strength, design of gasket joints, design of power screws and screw jack.

Text Books:

1. V.B. Bhandari, "Design Machine Elements", Mc Graw Hill Publication, 2017.
2. J.E. Shigley, C.R. Mischne, "Mechanical Engineering Design", Tata Mc Graw Hill Publications, 2015.
3. R.S.Khurmi and J.K.Gupta, "Machine design", 34/e, S Chand publications, 2018.

Suggested Reading:

1. P. Kannaiah, "Machine Design", Sci-Tech Publications, 2010
2. M.F. Spotts, "Design of Machine Elements", Prentice Hall of India, 2013.

Machine Design Data Books:

1. K. Mahadevan, K. Balaveera Reddy., “Design Data Hand book for Mechanical Engineers”, 3/e, CBS Publisher, 2018
2. PSG College, “Design Data book”, 2012

18PE C07

METAL CUTTING AND MACHINE TOOL ENGINEERING

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Various cutting tool materials and tool geometry.
2. Factors effecting tool life and thermal aspects of metal cutting.
3. The working principles of various of types of lathes, drilling machine and milling machines ,
4. The working principles of boring machines, grinding machines and thread production
5. Working principles of non-conventional machines and jigs and fixtures

Outcomes: At the end of the course, the students are able to

1. Describe tool geometry, select tool material for machining of various materials and identify the types of chips. (BL-2)
2. Calculate cutting forces, MRR, power consumption under different cutting conditions. (BL-3)
3. Classify the mechanisms of tool wear, estimate tool life using Taylor's equation under various cutting conditions. (BL-4)
4. Identify the basic parts, specifications, operations of various machine tools and understand jigs & fixtures. (BL-2)
5. Classify methods of unconventional machining and identify suitable method for a given component. (BL-3)

UNIT - I

Cutting tool materials: High carbon steel, HSS, Stellite, Carbides, Coated carbides, Diamond.

Tool geometry: Nomenclature of single point cutting tool by ASA and ORS. Geometry of drills, Milling cutters and broaches. Recommended Tool angles. Chip formation: Types of chips, BUE, Chip breakers.

Machining: Orthogonal and oblique cutting, Mechanics of metal cutting, Merchant's analysis, Shear angle Solutions of Merchant and Lee & Shafer.

UNIT - II

Thermal Aspects of Metal Cutting: Sources of heat and heat distribution. Various methods of measurement oftemperature, cutting fluids and applications.

Tool Wear and Tool Life: Criteria for tool wear, flank and crater wear theories, criteria for tool life in roughingand finishing, Measurement of tool wear, Taylor's tool life equation, factors effecting tool life, Machiniability, Economics of machining: Tool life for maximum production, minimum cost.

UNIT-III

Constructional features and specifications of machine tools: Various operations on Lathe, Types of Lathes and special attachments on a Centre Lathe. Drilling, Milling operations. Indexing methods. Shaper, planer and slotter and their differences. Quick return mechanisms, Automatic feed devices. Jig Boring machines-Differences between horizontal and vertical jig boring machines.

UNIT- IV

Grinding machines: Types of grinding, Abrasives and bonds used for grinding wheels. Specification and selection of wheels. Principles of Broaching, Lapping, Honing, Polishing, Buffing, Super finishing and burnishing.

Screws and gear manufacturing: Screw making by tapping, chasers, thread rolling, thread milling, thread grinding. gear shaping, gear hobbing, gear shaving and grinding.

UNIT-V

Jigs and Fixtures: Design principles for location and clamping. Tool holding and work holding devices. Quick clamping devices. Types of Jigs and fixtures.

Unconventional machining: Principles of working and applications of USM, AJM, EDM, ECM, LBM andEBM.

Text Books:

1. P N Rao, “Manufacturing Technology – Metal Cutting & Machine Tools”, 3/e Tata McGraw-Hill Publishing Company Limited, 2013.
2. B L Juneja and G S Sekhon, “Fundamentals of metal cutting and machine Tools”, New Age International publishers, 2001.
3. Kalpakjian S. and Steven R. Schmid, “Manufacturing, Engineering & Technology”, Pearson, 2007

Suggested Reading:

1. David A. Stephenson, Johs S. Agapiou, “Metal Cutting Theory and Practice”, CRC Press, 3rd Edition, March 2016
2. Amitabha Ghosh and Ashok Kumar Mallik, “Manufacturing Science”, Affiliated East-West Press Pvt. Ltd. 2nd Edition, 2010

18ME E01

REFRIGERATION AND AIR CONDITIONING

(Core Elective-I)

(Use of data book is permitted)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Acquire the basic knowledge about the importance of refrigeration, its applications in aircraft refrigeration.
2. Demonstrate basic knowledge of vapor compression refrigeration system, cascade and compound refrigeration.
3. Understand various types of absorption refrigeration systems like ammonia, Electrolux and lithium bromide refrigeration systems.
4. Acquire the basic knowledge on various psychrometric processes and comfort air conditioning.
5. Acquire knowledge in estimating air conditioning loads.

Outcomes: At the end of the course, the students are able to

1. Evaluate COP of various air craft refrigeration systems using principles of thermodynamics along with necessity of eco-friendly refrigerants for public health and safety. (BL-4)
2. Analyze COP of vapor compression refrigeration system with the appropriate concern for environment. (BL-4)
3. Understand the Vapour absorption, steam jet refrigeration and non-conventional refrigeration in order to provide valid conclusions over simple vapor compression refrigeration system. (BL-2)
4. Understand the working principle of air conditioning system including human comfort and its importance over environment, society with balance of ecological system. (BL-2)
5. Apply the principles of engineering which are complex in nature, having lifelong learning to design air conditioning system for various environments. (BL-3)

UNIT – I

Introduction to Refrigeration: Application of Refrigeration, Definition of COP, Tonne of Refrigeration,Designation, Carnot cycle, Eco-friendly Refrigerants, Properties of Refrigerants.

Air Refrigeration Systems: Analysis of Bell-Coleman Cycle, Application to aircraft refrigeration, Simplecooling system, Bootstrap simple evaporating system, Regenerative cooling system and Reduced ambient cooling system.

UNIT - II

Vapour Compression System: Working principle and analysis of Simple vapor compression Refrigerationcycle. Effect of operating conditions like evaporating pressure, condenser pressure, Liquid sub-cooling and Vapor super heating, Performance of the system. Low temperature refrigeration system (with single load system), Compound compression with water inter cooler and Flash intercooler, Cascade refrigeration system-Analysis and advantages.

UNIT - III

Vapour Absorption Refrigeration System: Simple absorption systems, COP, Practical ammonia absorptionrefrigeration system, Lithium bromide absorption system, Electrolux refrigerator, Common refrigerants and absorbents properties, Comparison with vapor compression refrigeration system.

Steam Jet Refrigeration: Principle of working**,** Analysis of the system, Advantages, limitations andapplications.

Thermoelectric refrigeration systems: Seebeck effect, Peltier effect and Thompson effect, Analysis of the thermoelectric refrigeration systems using Peltier effect, Expression for COP, Vortex tube refrigeration – principle and working.

UNIT - IV

Psychrometry: Psychrometric properties, Psychrometric chart, construction, Representation of variousPsychrometric processes on the chart.

Introduction to Air Conditioning: Requirements of comfort air conditioning, Thermodynamics of humanbody, ASHRE comfort chart, Effective temperature.

UNIT - V

Cooling Load Calculations in Air Conditioning: Concept of bypass factor, Sensible heat factor, ApparatusDew Point, Various Heat Loads.

Design of air conditioning systems: Simple Problems on summer, winter and year Round Air conditioningsystems Energy conservation in air conditioned building.

Air Conditioning Systems: Components of air conditioner equipments, Humidifier, Dehumidifier, Filter.

Text Books:

1. C.P. Arora, “Refrigeration and Air conditioning”, Tata McGraw Hill, New Delhi, 2017.
2. Stoecker, W.F., and Jones, J.W., Refrigeration and Air-Conditioning, Mc.Graw Hill, New Delhi, 2014.
3. R.K. Rajput, “Refrigeration and Air Conditioning”, Laxmi Publications, New Delhi, 2013.

Suggested Reading:

1. V.K. Jain, “Refrigeration and Air Conditioning”, S Chand & Company, New Delhi, 2019.
2. Manohar Prasad, “Refrigeration and Air Conditioning”, New Age International, Allahabad, 2015.

Refrigeration and air conditioning data books:

1. Manohar Prasad, “Refrigeration and Airconditioning Data Book”, New Age International Publishers, 2010.

18ME E02

VALUES, ETHICS AND SOCIETY

(Core Elective - I)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Develop the critical ability among students to distinguish between what is of value and what is superficial in life
2. Understand the values, the need for value adoption and prepare them meet the challenges
3. Develop the potential to adopt values, develop a good character and personality and lead a happy life
4. Practice the values in life and contribute for the society around them and for the development of the institutions/organization.
5. Understand the professional ethics and their applications to engineering profession

Outcomes: At the end of the course, the students are able to

1. State basic values and the need for value education. (BL -2)
2. Differentiatebetween values and skills, happiness and accumulation of physical facilities, the Self and the Body, Intention and Competence of an individual. (BL-2)
3. Demonstrate the knowledge of ethics at their work place and apply different theoretical approaches to solve ethical dilemmas. (BL-3)
4. Apply risk and safety measures in the engineering practice. (BL-3)
5. Understand the role of a human being in ensuring harmony in society and nature. (BL-2)

UNIT- I

Concepts and Classification of Values –Need and Challenges for Value Adoption: Definition of Values**,** Concept of Values, Classification of Values, Hierarchy of Values, Types of Values, Espoused and Applied Values, Value judgement based on Culture, Value judgement based on Tradition, Interdependence of Values, Need for value education, Findings of Commissions and Committees, Corruption and illegal practices, Science and Technology without values, Exploitation of nature, Increasing use of violence and intoxicants, Lack of education in values, Implications of education in values, Vision for a better India, Challenges for Value adoption, Cultural, Social, Religious, Intellectual and Personal challenges.

UNIT -II

Process for Value Education: Right Understanding, Relationship and Physical Facilities,basicrequirements for fulfillment of aspirations of every human being with their correct priority, Understanding Happiness and prosperity correctly, a critical appraisal of the current scenario, Method to fulfill the above human aspirations; understanding and living in harmony at various levels.

UNIT-III

Basic Concepts of Professional Ethics: Ethics, Morals and Human life , Types of Ethics, Personal Ethics,Professional ethics, Ethical dilemmas, Indian and Global thoughts on ethics, Profession, Professional and Professionalism, Ethical role of a professional Basic ethical principles, Some basic ethical theories, use of ethical theories, Science, Religion Ethics, Genders and ethics, Media and ethics, Computer Ethics, Case Studies on Professional Ethics, Exemplary life sketches of prominent Indian personalities.

UNIT- IV

Ethics in Engineering Profession: Engineering profession-Technology and Society-Engineering as SocialExperimentation-Engineering ethics-Ethical obligations of Engineering Professionals, Role of Engineers-Engineers as Managers, Professional responsibilities of Engineers, Engineers Responsibility for Safety, A few Case Studies on Risk management, Conflicts of Interest, Occupational Crimes- Plagiarism-Self plagiarism-Ethics Audit-Consideration for ethics audit-Ethics Standards and Bench Marking.

UNIT - V

Understanding Harmony in the Family and Society: Understanding harmony in the family, the basic unit ofhuman interaction, Understanding values in human relationship; meaning of Nyaya and Program for its fulfillment to ensure Ubhay-tripti, Trust (Vishwas) and Respect (Samman) as the foundational values of relationship.

Text Books:

1. Subramanian R., “Professional Ethics”, Oxford University Press , 2017
2. Dinesh Babu S., “Professional Ethics and Human Values”, Laxmi Publications , 2016
3. Nagarajan R.S., “A Text Book on Human Values and Professional Ethics”, New Age Publications, 2007

Suggested Reading:

1. Santosh Ajmera and Nanda Kishore Reddy, “Ethics, Integrity and Aptitude”, Mc Graw Hill Education Private Limited , 2014
2. Govinda Rajan M., Natarajan S., Senthil Kumar V.S., “Professional Ethics and Human Values”, Prentice Hall India Private Limited, 2013.

18PE E01

PLASTICS, CERAMICS AND COMPOSITE MATERIALS

(Core Elective-I)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Understand various types of plastics, their properties and uses.
2. Understand various methods of manufacturing plastic components.
3. Understand types of ceramics, refractoriness, and their uses.
4. Understand the manufacturing processes of ceramics.
5. Understand composites and their uses.

Outcomes: At the end of the course, the students are able to

1. Recall the types of plastics, properties and applications. (BL-1)
2. Select the suitable method of manufacturing a plastic component. (BL-5)
3. Describe refractories, their manufacturing methods and applications. (BL-2)
4. Describe the properties, uses and Manufacturing methods of white wares, ceramic coatings and glass. (BL-2)
5. Understand the concept of composites, properties in engineering applications. (BL-2)

UNIT - I
Introduction to Polymers: Plastics and elastomers, polymerization, degree of polymerization, thermoplasticsand thermosetting plastics, properties and applications of various thermoplastic and thermosetting plastics, mechanical properties of plastics and their influencing parameters.

UNIT - II
Processing of Plastics and Elastomers: Constructional features, working principles, advantages, disadvantages and applications of Injection moulding, Extrusion, calendaring, thermoforming, Blowmoulding, compaction moulding, transfer moulding.

UNIT - III
Introduction to Ceramics, Classification of Ceramic Materials, Conventional and Advanced, Refractories:Classification of Refractories, Modern trends and developments, Basic raw materials, Elementary idea of manufacturing process technology, Flow diagram of steps necessary for manufacture, basic properties and areas of application.

UNIT - IV
White Wares: Classification and type of White wares, Elementary idea of manufacturing process technologyincluding body preparation, basic properties and application area.
Ceramic Coatings: Types of glazes and enamels, Elementary ideas on compositions, Process of enameling &glazing and their properties.
Glass: Definition of glass, Basic concepts of glass structure, glass manufacturing processes, Different types of glasses, Application of glasses.

UNIT - V
Fundamentals of Composites: Need for composites–enhancement of properties–classification of composites – Matrix-Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC) – Reinforcement–particle reinforced composites, Fiber reinforced composites, Applications of various types of composites, Production techniques for glass fiber, carbon fiber and ceramic fiber, manufacturing methods of composites.

Text Books:

1. Mikell P. Groover, "Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", Wiley publications, 6^{th} edition 2015.
2. Kalpakjian, "Manufacturing Engineering and Technology", Pearson publications, 7^{th} edition 2013.
3. P.N. Rao, "Manufacturing Technology", Vol.-1, McGraw Hills Publication, 4^{th} Edition 2016.

Suggested Reading:

1 R.K.Rajput, "A text book of Manufacturing Technology", Vol-I, Laxmi Pub., 2007.

2 P.C. Sharma, "A Text book of Production Technology", 8/e, S. Chand & Co., Pvt. Ltd., 2014.

18PE E02

PRODUCT DESIGN AND PROCESS PLANNING

(Core Elective-I)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. The essence of innovation in product development.
2. The Human Machine Interactions (ergonomics).
3. The various Intellectual Property Rights.
4. The interaction between Design, Manufacturing, Quality and Marketing.
5. The awareness about overall view of Process Planning.

Outcomes: At the end of the course, the students are able to

1. Define the needs of the customer while designing a new product or modifying existing product in the competitive environment. (BL-1)
2. Understand creativity, brainstorming and ergonomic concepts. (BL-2)
3. Apply the concept of design for manufacture, assembly, maintenance, reliability and product life cycle in developing a product. (BL-3)
4. Implement the Intellectual Property Rights to a new product or a process. (BL-3)
5. Evaluate and recommend an effective Process Plan and principles of value engineering to new product development. (BL-5)

UNIT - I

Product Design and Process Design: Functions, Essential factors of product design, Selection of right product,Systematic procedure of product innovation, function of design, value of appearance, colors and laws of appearance.

UNIT - II

Product Selection and Evaluation: Need for creativity and innovation. Techniques of innovation like brainstorming and Delphi techniques, collection of ideas. Selection criteria - screening ideas for new products using evaluation techniques. Principles of ergonomics, Anthropometry, Design with Human Machine Interaction (HMI).

UNIT - III

New Product Planning and Development: Interaction between the functions of design, manufacture, andmarketing, design and material selection, Steps for introducing new products after evaluation, Product life cycle, Research and new product development.

UNIT - IV

Intellectual Property Rights (IPR): Patents, definitions, Types of Patent, Patent search, Patent laws,International code for patents, Trademark, Trade Secret and Copy Rights.

Process Planning: Need and significance of process planning, Process capability studies, Process sheets, Benefits and Types of Computer Aided process planning.

UNIT - V

Process Selection and Planning: Selection of manufacturing process, estimation of machining time in various cutting operations, Estimation of costs for manufacture, value engineering in product design, Group technology, and concepts of concurrent engineering.

Text Books:

1. B.W. Niebel & A.B.Draper, "Production Design & Process Engg", McGraw Hill, 1974.
2. K. G. Swift & J. D. Booker, "Process Selection: From Design to Manufacture", Butterworth-Heinemann Ltd; Revised 2/e, 2003.
3. BhaskaranGopalakrishnan, "Product Design and Process Planning in CE (Design & Manufacturing", Chapman and Hall publishers, 1994.

Suggested Reading:

1. A.K. Chitale& R.C. Gupta, "Product Design & Manufacturing", PHI, 1997.
2. Karl T. Ulrich, Stephen Eppinger, "Product Design and Development", McGrawHill Publication, 2012.

18ME E03

MECHANICAL VIBRATIONS

(Core Elective-I)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. To analyze free vibration, damped and un-damped vibrations.
2. The principles of harmonically excited vibrations
3. The principle of damped and un-damped vibrations of two degrees of freedom system
4. To develop the equations of motion for a continuous system in elongation, bending and torsion to find the natural frequencies and mode shapes.
5. The working principles of vibration measurements

Outcomes: At the end of the course, the students are able to

1. Apply Newton's law of motion and energy method to get governing differential equations of vibrating systems. (BL-3)
2. Analyze response of machine members in forced vibration with different excitation frequencies. (BL-4)
3. Recommend suitable Vibration parameters for isolation and compute critical speeds. (BL-5)
4. Predict natural frequency and mode shape for all continuous systems. (BL-3)
5. Understand working principles of vibration measuring instruments. (BL-2)

UNIT - I

Single Degree of Freedom Systems: Undamped, Damped Translational and Torsional Systems**,** Different methods for equation of motion- Energy method, Rayleigh method, principle of virtual work, principal of conservation energy. Viscously damped free vibration, logarithmic decrement, coulomb damping,

UNIT - II

Harmonically Excited Vibration: Forced harmonic vibration, Rotating unbalance, whirling of rotating shafts, support motion, vibration isolation, energy dissipated by damping. Equivalent viscous damping, structural damping.

UNIT - III

Damped and Undamped Vibrations of Two Degree of Freedom System: Free and forced vibration analysis of two degree of freedom system-different methods for the formulation of equations of motion, natural frequencies, Normal mode vibration, Coordinate coupling and principal coordinates, semi definite systems, influence coefficients-flexibility, stiffness. Eigen values and Eigen vectors, orthogonal properties of Eigen vectors, repeated roots, modal matrix.

UNIT - IV

Vibrations of Continuous Systems: Vibrations of strings, bars and beams, formulation of equations of motion, characteristic equations, identification of nodes and mode shapes.

UNIT - V

Vibration Measurements and Applications: Vibration pickup, Vibrometer, accelerometer. Transducers, piezoelectric transducers, Electrodynamic transducers. Vibration exciters, mechanical and electro dynamic shakers. Frequency measuring instruments.

Text Books:

1. J.J. Thomson, “Theory of vibration with Application”, 5/e, 2014.
2. S.S. Rao, “Mechanical vibration”, 5/e, Pearson, 2011
3. G.S. Grover & Nigam, “Mechanical vibrations”, 8/e, New Chand & Bros, 2018

Suggested Reading:

1. V.P. Singh, “Mechanical vibration”, 3/e, Dhanpath Rai &Co., 2014.
2. S. Graham Kelley, “Mechanical vibration”, Schaums Outline Series, TMH, 2011.

18ME E04

AUTOMOBILE ENGINEERING

(Core Elective-II)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. The anatomy of the automobile in general.
2. The functioning of the engine and its accessories, gear box, clutch, brakes, steering, axles and wheels.
3. Suspension, frame, springs and other connections.
4. Ignition, controls, electrical systems and ventilation.
5. Emissions, pollution regulations, EURO and BHARATH stages

.**Outcomes:** At the end of the course, the students are able to

1. Understand the basic layout of automobiles. (BL-2)
2. Understand the various systems in an automobile like engine cooling, lubrication, ignition, electrical and air conditioning systems with the principles of thermodynamics. (BL-2)
3. Describe the principles of suspension and steering system using modern tool usage. (BL-2)
4. Explore therecent systems in Braking and Transmission. (BL-3)
5. Evaluate the effect of automobile pollution on environment and necessity of pollution norms along with trouble shooting (BL-5)

UNIT - I
Types of Automobiles: Normal, Hybrid and Hydrogen Fuel vehicles.
Engine: Engine location and its components, chassis layout - parts of the automobile body, terminology, automobile frames ; crank shaft, firing order, piston and piston rings, cylinder liners, valves and operation mechanism, inlet and exhaust manifolds, carburetion – Zenith carburettor, Fuel injection system, Mechanical Fuel Injection system- MPFI, Electronic Fuel Injection system.

UNIT - II
Lubricating Systems: Wet sump, dry sump and petroil systems
Cooling systems: Water pumps, radiators, thermostat control, anti-freezing compounds
Ignition Systems: Types of Ignition Systems, Modern Ignition systems, Types of Batteries and charging systems- Batteries used in Electric and Hybrid Vehicles, starting motors,
Electrical Systems : Main electrical circuits, generating & starting circuit, lighting system, indicating devices, warning lights, speedometer, automobile air-conditioning.

UNIT - III
Steering Systems: Linkage arrangements and its components, steering gear box types,recent trends, Davis Steering , Modified Ackerman linkage, Steering geometry: caster, camber, King Pin Inclination, Toe in, toe out.
Wheel and tyres: Tyre construction, specification. Tyre wear and causes, wheel balancing, wheel alignment
Suspension systems: Types of Suspension systems, Independent suspension, coil and leaf springs, torsion bar, shock absorbers

UNIT - IV
Power Train: Clutches gear and gearbox manual, semi-automatic and automatic gearboxes. Torque converter,propeller shaft, universal coupling differential, four-wheel drive system
Brakes Systems: Disc and drum types, leading and trailing shoe layout, Description and operation of hydraulic brake, hand brake linkage, Pneumatic, air and vacuum brakes

UNIT – V
Maintenance: Trouble shooting and servicing procedure overhauling, engine tune up, tools and equipment for repair and overhaul testing equipment
Pollution control: Pollution control techniques used for petrol and diesel engines, PCVS, EGR, SCRT, Thermal Reactors, Catalytic converters; Euro norms and Bharat Norms.

Text Books:

1. Crouse & Anglin, “Automotive Mechanics”, 10/e, TMH. Publishing Co. Ltd., New Delhi, 2006.
2. Kirpalsingh., “Automobile Engineering”, Vol. I & II Standard Publishers, Delhi, 2017.
3. Joseph Heitner, “Automotive Mechanics”, 2/e, Affiliated East West Pvt. Ltd. 2013.

Suggested Reading:

1. R.K. Rajput, “A Textbook of Automobile Engineering”, Laxmi Publications, New Delhi, 2012.
2. D S Kumar, “Automobile engineering”, S K Kataria Publications, New Delhi, 2015.

18ME E05

NANO SCIENCE AND TECHNOLOGY

(Core Elective –II)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Nanotechnology approach and challenges
2. Materials and characterization procedures
3. Zero and One dimensional Nano structures
4. Various Fabrication Techniques
5. Special nano materials and Nano biomaterials

Outcomes: At the end of the course, the students are able to

1. Understand the basic concepts, developments and challenges in Nano technology. (BL-2)
2. Describe the methods of evaluating magnetic and electronic properties, microstructure by SPM, atomic force microscopy, friction force microscopy. (BL-2)
3. Apply homogenous & heterogeneous methods and characterization techniques of Zero & One dimensional Nano structures. (BL-3)
4. Evaluate various Nano Material Fabrication Techniques. (BL-5)
5. Analyze Nano materials and Nano bio materials for obtaining solutions to societal problems. (BL-4)

UNIT - I
Introduction: Nanoscale, Properties at Nanoscale, advantages and disadvantages, importance ofNanotechnology, Bottom-up and Top-down approaches, challenges in nanotechnology, proximal probe technologies.

UNIT - II
Materials of Nanotechnology: Introduction, Si-based materials, Ge-based materials, Ferroelectric materials, Polymer materials, GaAs&InP (HI-V) group materials, Nanotribology and materials, characterization using Scanning Probe Microscope, AFM and Friction force microscopy.

UNIT - III
Nano Structures: Zero dimensional Nanostructure, synthesis procedure by heterogeneous method,characterization techniques, properties and applications particles
One dimensional Nanostructures: Nanowires, Nanotubes and its Synthesis procedure, characterization procedure and principles involved, properties and applications of Nano Wires

UNIT - IV
Nano Fabrication: Introduction, Basic fabrication techniques by Lithography, thin film deposition and doping,MEMS fabrication techniques, Nano fabrication techniques by E-beam, Nano-imprint fabrication, Epitaxy and strain engineering

UNIT - V
Special Nano Materials: Introduction, Synthesis procedure by metal-polymer, metal ceramic and polymerceramic, Characterization procedures, applications
Nano Biomaterials: Introduction, Biocompatibility, anti-bacterial activity, applications

Text Books:

1. Dieter Vollath, “Nanomaterials: An introduction to Synthesis, properties and applications”, Wiley, 2013
2. Guozhong Cao, “Nanostructures and Nano Materials, Synthesis properties and applications”, Imperial College Press, 2004
3. Carl C Koch, “Nano materials Synthesis, Properties and applications”, Jaico Publishing House, 2008

Suggested Reading:

1. Willia Tllsey Atkinson, “Nano Technology”, Jaico Publishing House, 2009
2. George W. Hanson, “Fundamentals of Nanoelectronics”, Pearson Education, 2009

18ME E06

RIGHTS, DUTIES AND LEGISLATION

(Core Elective - II)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Understand the value of human rights
2. Understand the Lawful rights available to him and others
3. Create understanding the rights of under privileged and respect them
4. Understand role of an individual in the Civil Society
5. Understand the safety aspects while using technology and to understand the role of NGO's in protecting human rights and environment.

Outcomes: At the end of the course, the students are able to

1. Recall the human rights in the global and national context. (BL-1)
2. Understand the overall view on working of Indian constitution. (BL-2)
3. Analyse the societal problems in the context of human rights. (BL-4)
4. Evaluate implementation of right to development and right to information. (BL-5)
5. Application of human rights for human safety and clean environment. (BL-3)

UNIT-I

Conceptual Background Of Human Rights And Duties: Rights, inherent, inalienable,universal, indivisible, Values, Dignity, liberty, equality, justice, unity in diversity, Need for balance between Rights and Duties, Freedom and Responsibility, Theories of human rights, History of human rights civilization, Human rights movements, Universal declaration of human rights 1948, classification and three generations of human rights and sarvodaya.

UNIT-II

Human Rights And Duties In India: Evolution, Independence movement, making of theConstitution, Indian Constitution, Fundamental Rights, Directive Principles, Fundamental duties, Their Interrelationship, Enforcement and protection mechanism of human rights in India, Judiciary, Article 32 and 226 of Indian Constitution, National Human Rights Commission and other Commissions and Committees, Non-governmental organizations, Information Media, Education.

UNIT-III

Societal Problems: Core Problems, Poverty, underdevelopment and illiteracy, Women, children andthe disadvantaged groups, National and state commissions of Women/children/minority/SC/ST.

UNIT-IV

Right to Development: Socio-Economic and Cultural Effects of Globalization, Right to Education,Transparency in Governance and Right to Information, Consumer Protection act.

UNIT-V

Environment Rights Such as Right to Clean Environment and Public Safety: Issues of Industrial Pollution,Prevention, and Rehabilitation, Safety aspects of New Technologies such as Chemical and Nuclear Technologies, Issues of Waste Disposal, Protection of Environment.

Text Books:

1. Mr. Ishay, “The history of Human rights”, Orient Longman, New Delhi, 2004.
2. S.N. Chaudhary, “Human Rights and Poverty in India: Theoretical Issues”, Delhi: Concepts, 2005.
3. Anuradha Kumar, “Encyclopedia of Human Rights Development of under Privilege”, New Delhi: Sarup, 2002.

Suggested Readings:

1. K.P. Saksena, “Human Rights and the Constitution: Vision and the Reality”, New Delhi: Gyan Pub., 2003.
2. Dr.J.N.Pandey, “Constitutional Law of India”, Central Law Agency; Central Law Agency; 37th Edition, 2001.

18PE E04

NON DESTRUCTIVE TESTING AND EVALUATION

(Core Elective-II)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Need, basic concepts and technologies of Non Destructive Testing (NDT).
2. Security precautions from Radiography, protection from radiation and measurement of radiation received by personnel.
3. Technologies like neutron radiography; laser induced ultrasonics, surface analysis and thermography.
4. Merits and demerits of the different NDT Technologies.
5. Latest research and developments in NDT.

Outcomes: At the end of the course, the students are able to

1. Understand Non Destructive Testing techniques of Dye penetrant inspection andMagnetic particle inspection. (BL-2)
2. Compareeddy current testing with other NDT methods. (BL-2)
3. Identify different types of defects using ultra sonic testing. (BL-2)
4. Analyze the radiograph to detect the defects by using principles of radiography. (BL-4)
5. Interpretlatest techniques of NDT with other methods. (BL-3)

UNIT - I

Dye Penetrant Inspection: Principles of penetrate inspection, characteristics of a penetrate, water washablesystem, post emulsification system, solvent removable system, surface preparation and cleaning, penetrate application, development, advantages limitations, and applications.

Magnetic Particle Inspection: Principle, magnetization methods, continuous and residual methods,sensitivities, demagnetization, magnetic particles, applications, advantages and limitations.

UNIT - II

Eddy Current Testing: Principle, lift-off factor, and edge effect, skin effect, inspection frequency, coilarrangements, inspection probes, types of circuit, reference pieces, phase analysis, display methods and applications.

UNIT - III

Ultrasonic Testing: Generation of ultra sound, characteristics of an ultrasonic beam, sound waves at interfaces,sound attenuation, display systems, probe construction, type of display, inspection techniques, identification of defects, Immersion testing , sensitivity and calibration, reference standards, surface condition, applications.

UNIT - IV

Radiography: Principle and uses of radiography, limitation principle, radiation sources, production of X-Rays,x-ray spectra, attenuation of radiation, radiographic equivalence, shadow formation enlargement and distortion, radio graphic film and paper, Xeroradiography, fluoroscopy, exposure factors, radiographic screens, identification markers and image quality indicators, inspection of simple shapes, inspection of complex shapes, viewing and interpretation of radiographs, radiation hazard, protection against radiation, measurement of radiation received by personnel.

UNIT - V

Acoustic Emission: Physical Principles, Sources of emission, instrumentation and applications, Other NDT Techniques: Neuron radiography, Laser induced ultrasonic, surface analysis, and thermography.

Text Books:

1. Barry Hull & Vernon John, "Non Destructive Testing", 1988
2. H J Frissell (Editorial Coordinator), "Non-Destructive Evaluation and quality control", ASM handbook-International Publication USA, 1989.
3. Don.E. Bray, Roderic K. Stanley: Nondestructive Evaluation- A Tool in Design, Manufacturing, and Service, Revised Ed, CRC Press, 1997.

Suggested Reading:

1. Paul E. Mix, "Introduction to Nondestructive Testing- A Training Guide", John Wiley & Sons, 2005.
2. J. Prasad and C. G. K. Nair, "Non-Destructive Test and Evaluation of Materials", Tata McGraw-Hill Education, 2nd edition, 2011.

18ME E07

FUELS AND COMBUSTION

(Core Elective-II)

(Use of combustion tables is permitted)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Different types of solid fuels and gaseous fuels with their properties.
2. The principles of refining liquid fuels, properties & their tests.
3. The thermodynamics of combustion and stoichiometric relations.
4. Features of different types of burners.
5. The importance of control of air pollutants and its effect on human being and environment.

Outcomes: At the end of the course, the students are able to

1. Analyse quality of fuels based on its properties with a special emphasis on environment with merits and demerits. (BL-4)
2. Understand the refining methods of various liquid fuels using the principles of engineering with a special focus on public health and safety and environmental considerations. (BL-2)
3. Estimate the theoretical air fuel ratio for different types of combustion processes using basic laws of thermodynamics in the context of environment. (BL-5)
4. Identify various techniques of utilizing fuels with different combustion appliances for cleaner environment and safety. (BL-3)
5. Understand the impact of pollutants on environment and to demonstrate the knowledge for sustainable development. (BL-2)

UNIT-I

Solid fuels: Origin of coal; analysis of coal-proximate analysis and ultimate analysis; tests on coal-calorific values, caking, fusibility, grindability; coal petrology; classification of coal; other solid fuels-wood, wood charcoal, coke, fuel briquettes.

Gaseous fuels: Natural gas, methane from coal mines, coal gas, blast furnace gas, liquefied petroleum gas (LPG); properties and testing of fuel gases; alcohols and biogas.

UNIT-II

Liquid Fuels: Origin of petroleum-deposition of organisms , reservoir rock; chemistry of petroleum-paraffins, olefins , napthenes, aromatics; refining of petroleum-fractional distillation, cracking, reforming, alkylation, polymerization, isomerisation; properties and tests for petroleum products; important petroleum products-motor gasoline, aviation gasoline, kerosene, jet fuels, diesel oils, fuel oils.

UNIT-III

Combustion of Fuels: Combustion Stoichiometry-- stoichiometric air, excess air, flue gas analysis, dew point of flue gases. Thermodynamics of Combustion--gross calorific value, net calorific value, enthalpy of combustion, enthalpy of formation; adiabatic flame temperature at constant pressure and constant volume.

UNIT-IV

Combustion Appliances: Classification; Coal burning equipment--over feed stokers, chain -grate stokers, under feed stokers, pulverized coal burners, cyclone furnaces. Oil burners--vaporized burners, rotary-cup oil burners, mechanical atomizing burners, high pressure and low pressure atomizing burners .Gas burners--non-aerated burners, aerated burners, surface combustion burners.

UNIT-V

Environmental Considerations: Air pollution types-grit and dust, smoke, gaseous pollutants; combustion generated air pollution and its control-air pollution from combustion of fossil fuels, air pollution from automobiles; effects on environment and human health; emission Standards.

Text Books:

1. Samir Sarkar, “Fuels & Combustion” Orient long man, 1996.
2. S.P. Sharma and Chander Mohan, "Fuels and Combustion", Tata McGraw Hill, 2004.
3. Roger A Strehlow, "Combustion Fundamentals ", Tata McGraw Hill, 1985.

Suggested Reading:

1. Shaha A K,"Combustion Engineering and Fuel Technology ", Oxford and IBH, 1974.
2. Stephen R. Turns,"An introduction to combustion", McGraw Hill International Edition, 2011.

Combustion Data Tables:

1. Combustion enthalpy tables from "Thermodynamics-An engineering approach" by Yunus A. Cengel, Michael A. Boles, McGraw Hill, 9th edition, 2019

18ME C15

DYNAMICS AND VIBRATIONS LAB

Instruction	2	Hours per week
Duration of SEE	2	Hours
SEE	35	Marks
CIE	15	Marks
Credits	1	

Objectives:

1. To demonstrate basic principle and exposure to evaluate CAM Follower Motion and Gyroscopic effects.
2. The importance of static and dynamic balancing.
3. The methods of controlling speeds of prime movers
4. To acquire the knowledge in evaluating the stability of vehicles
5. Frequency response of spring mass system with damping and without damping - Undamped torsional vibrations of single and double rotor systems

Outcomes: At the end of the course, the students are able to

1. Demonstrate the dynamic behavior of mechanical systems. (BL-3)
2. Analyze the cam profile for different motion characteristics. (BL-4)
3. Examine the performance of governors and the gyroscopic effect on vehicles. (BL-3)
4. Evaluate the static and dynamic balancing masses in a rotating mass system. (BL-5)
5. Determine the natural frequency of different single degree freedom vibrating systems. (BL-3)

List of the Experiments

1. To study the motion of follower with the given profile of the cam. To plot the follower displacement vs angle of rotation curves for different cam follower pairs.
2. To study the gyroscopic effect on a rotating disc.
3. Determination of the frequency of torsional vibrations.
4. Static and Dynamic balancing in a rotating mass system.
5. Study the effect of varying mass on the centre of sleeve in Porter governor.
6. Study the effect of varying the initial spring compression in Hartnell governor.
7. Undamped torsional vibrations of double rotor system.
8. To study the longitudinal vibrations of helical coiled spring.
9. To study the undamped forced vibration of spring mass system.
10. To study the force damped vibration of spring mass system.
11. Determination of critical speed of the given shaft with the given end conditions (Whirling of Shafts).
12. Frequency response of spring mass system with damping.
13. Determine the equivalent link parameters and centre of mass of connecting rod theoretically and validate the result by experiment by choosing suitable methods and devices.

NOTE: Students should complete a minimum of 10 experiments including experiment 13 which is compulsory.

Text Books:

1. S.S. Rattan, “Theory of Machines”, Fourth edition Tata-Mc Graw Hill, ,2014
2. John.J.Vicker, Gordon R. Pennock, Joseph E. Shigley, “Theory of Machines & Mechanisms”, Oxford University Press, 2003.
3. William T.Thomson “Theory of Vibration with Application”, 5th edition, Pearson education 2008

Suggested Reading:

1. Robert L. Norton, “Design of Machinery”, Tata Mc Graw Hill, 2005.
2. Benson H. Tangue, “Principles of Vibration”, 2/e, Oxford University Press, 2007

18ME C16

APPLIED THERMODYNAMICS AND HEAT TRANSFER LAB

Instruction	2	Hours per week
Duration of SEE	2	Hours
SEE	35	Marks
CIE	15	Marks
Credits	1	

Objectives:

1. To demonstrate basic knowledge and exposure to determine valve and port diagram and also to evaluate the performance of the petrol engine and diesel engine.
2. Student will determine the importance of heat balance sheet of IC engine.
3. Students will acquire knowledge in evaluating the performance of multi-stage reciprocating compressor.
4. To demonstrate knowledge in evaluating thermal conductivity and heat transfer coefficient under natural convection phenomena and forced convection phenomena.
5. Students will understand the basic concepts of radiation heat transfer.

Outcomes: At the end of the course, the students are able to

1. Evaluate the performance of petrol and diesel engines. (BL-5)
2. Evaluate the heat losses in heat balance sheet of IC engine. (BL-5)
3. Determine the performance of multi stage reciprocating air compressor and its importance over single stage air compressor. (BL-3)
4. Estimate the effect of insulation on conduction heat transfer and also estimate the value of convection heat transfer coefficients under different scenario. (BL-5)
5. Determine Stefan - Boltzmann constant, emissivity of grey plate and LMTD of heat exchanger. (BL-3)

List of the Experiments:

Applied Thermodynamics

1. Determination of Valve timing diagram and Port diagram of IC engine.
2. Determination of Performance characteristics of a multi-cylinder petrol engine.
3. To conduct Morse test on multi cylinder petrol engine.
4. To conduct performance test on a variable compression ratio petrol engine.
5. To conduct performance test on single cylinder diesel engine
6. To conduct heat balance test on single cylinder diesel engine.
7. To determine volumetric efficiency, isothermal efficiency of multi -stage reciprocating air compressor.

Heat Transfer

8. Determination of thermal conductivity of composite wall.
9. Determination of convective heat transfer coefficient under Natural and Forced convection phenomena using pin-fin apparatus.
10. Determination of Emissivity of a given plate.
11. Determination of the value of Stefan-Boltzmann constant.
12. Determination of Heat transfer coefficient in parallel and counter flow heat exchanger.
13. Evaluate the performance parameters of an alternative fuel on a vertical stroke single cylinder diesel engine.

Note: Students should complete a minimum of 10 experiments including experiment 13 which is compulsory.

Text Books:

1. Mahesh M. Rathore, “Thermal Engineering”, TMH, New Delhi, 2010
2. V. Ganeshan,“Internal Combustion Engines”, Tata Mcgraw Hill Publishing, New Delhi,2015
3. J.P. Holman, “Heat Transfer”, McGraw Hill Publication, New Delhi, 2009

Suggested Reading:

1. R.K. Rajput., “Thermal Engineering”, Laxmi Publishers, New Delhi, 2014
2. D.S. Kumar,” Heat Transfer”, S K Kataria Publishers, 2015

18PE C08

METAL CUTTING AND MACHINE TOOL ENGINEERING LAB

Instruction	2	Hours per week
Duration of SEE	2	Hours
SEE	35	Marks
CIE	15	Marks
Credits	1	

Objectives: Students will learn

1. To grind single point cutting tool using HSS as cutting tool
2. To do various operations like plain turning, step turning, knurling
3. Work shop practice on lathe drilling and milling machines
4. Measure cutting forces during machining on Lathe machine, milling
5. Unconventional machining operations like EDM & ECM

Outcomes: At the end of the course, the students are able to

1. Identify tool geometry and grind to a given tool signature. (BL-2)
2. Perform various machining operations to produce components of different shapes and also using jigs &fixtures. (BL-3)
3. Determine the shear angle at various cutting conditions. (BL-4)
4. Evaluate cutting forces using dynamometer, estimate MRR & power consumption under different cutting conditions. (BL-5)
5. Plan and create components of utility using various manufacturing facilities in the laboratory. (BL-6)

List of the Experiments

1. Facing and plain turning operations on lathe.
2. Step turning and knurling on lathe machine.
3. Taper turning on lathe.
4. Drilling and boring on lathe.
5. Thread cutting on lathe.
6. Influence of process parameters on MRR in turning operation.
7. Grinding of single point cutting tool.
8. Gear cutting using (a) Plain Indexing. (b) Compound indexing using universal dividing head.
9. Measurement of cutting forces during machining on lathe machine and milling machine.
10. Finding shear angle experimentally in turning operation.
11. Grinding flat surfaces using surface grinding machine and measurement of surface finish.
12. Process parameters of electro discharge machining (EDM).
13. Design utility component, prepare process sheet for the manufacturing of the same and produce the component in the lab. .

Note: Student should complete a minimum of 10 experiments including experiment number 13 which is compulsory.

Text Books:

1. P N Rao, “Manufacturing Technology – Metal Cutting & Machine Tools”, 3/e Tata McGraw-Hill Publishing Company Limited, 2013.
2. B L Juneja and G S Sekhon, “Fundamentals of Metal Cutting and Machine Tools”, New Age International publishers, 2001.
3. Kalpakjian S. and Steven R. Schmid, “Manufacturing, Engineering & Technology”, Pearson Education, 2007

Suggested Reading:

1. David A. Stephenson, Johs S. Agapiou, “Metal Cutting Theory and Practice”, CRC Press, 3rd Edition, March 2016
2. Amitabha Ghosh and Ashok Kumar Mallik, “Manufacturing Science”, Affiliated East-West Press Pvt. Ltd. 2nd Edition, 2010

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

AICTE MODEL CURRICULUM

B.E (Mechanical Engineering)

SEMESTER-VI

S. No.	Course Code	Title of the Course	Scheme of instruction			Scheme of examination			Credits
			Hours per week			Duration in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	18ME C17	CAD/CAM	3	--	--	3	30	70	3
2	18ME C18	Machine Design	3	--	--	3	30	70	3
3	18ME C19	Thermal Turbo Machines	3	--	--	3	30	70	3
4		Core Elective – III	3	--	--	3	30	70	3
5		Core Elective – IV	3	--	--	3	30	70	3
6		Core Elective – V	3	--	--	3	30	70	3
PRACTICALS									
7	18ME C20	CAD/CAM Lab	--	--	2	2	15	35	1
8	18ME C21	Thermal Engineering Lab	--	--	2	2	15	35	1
TOTAL			**18**	--	**04**	--	**210**	**490**	**20**

L: Lecture T: Tutorial D: Drawing P: Practical

CIE – Continuous Internal Evaluation SEE – Semester End Examination

Core Elective – III (3/3)			**Core Elective – IV (3/3)**		
SNO	**Subj. Code**	**Name of the Subject**	**SNO**	**Subj. Code**	**Name of the Subject**
1	18ME E08	Object Oriented Programming with C++	1	18ME E12	Computational Fluid Dynamics
2	18ME E09	Mechanics of Composite Materials	2	18ME E13	Principles of Entrepreneurship
3	18ME E10	Robotic Engineering	3	18PE E08	Modern Machining and Forming Methods
4	18PE E06	Production and Operations Management	4	18ME E14	Heat and Mass Transfer
5	18ME E11	Advanced IC Engines	5	18ME E15	Blockchain Technology

Core Elective – V (3/3)		
SNO	**Subj. Code**	**Name of the Subject**
1	18ME E17	Renewable Energy Sources
2	18ME E18	Control Systems Theory
3	18ME E19	Artificial Intelligence
4	18ME E20	Industrial Administration and Financial Management
5	18PE E11	Principles and Applications of Additive Manufacturing

18ME C17

CAD/CAM

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. To teach the basic design process and the importance and types of geometric modeling techniques
2. To teach the theory for modeling of surface and solid modeling techniques
3. To impart the basic skill in writing CNC part programming
4. To teach basic configurations of robot Manipulator
5. To teach concepts of part classification coding, computer aided process planning, automated inspection methods

Outcomes: At the end of the course, the students are able to

1. Understand the applications of computer in design, manufacturing, and geometric transformation techniques (BL-2)
2. Apply Wireframe, surface, and solid modeling techniques for the generating various parts. (BL-3)
3. Distinguish various NC systems and develop the CNC program. (BL-4)
4. Demonstrate the fundamentals knowledge of robotics (BL-2)
5. Understand automated manufacturing environment. (BL-2)

UNIT-I

Introduction: Introduction to CAD, Product life cycle, Design Process, Design criteria, Alternative solutions, Hardware integration and networking, Graphic Standards and Exchange Formats (IGES, STEP, STL)
Geometric Transformations: Introduction, Translation, Rotation, Scaling, Reflection Transformations, Homogenous Representation, Concatenated Transformation, Transformations about fixed point

UNIT-II

Wire frame Modeling: Wire frame entities and their definition, interpolation and approximation curves. concept of parametric and non-parametric representation of circle and helix curves, properties of splines, synthetic curves: parametric representation of cubic spline, Bezier and B-spline curves, continuity, properties and characteristics, Introduction to non-uniform rational B-splines.
Surface Modeling: Surface representation Analytic surfaces: definition of Plane surface, Ruled surface, Surface of revolution, Tabulated cylinder, Synthetic Surfaces- Hermite cubic and Bezier surfaces.
Solid Modeling: Solid entities, Boolean operations, B – rep and CSG approaches, feature based modeling, assembly modeling and mating conditions
UNIT-III

Numerical Control of Machine Tools: Features and elements of NC, Types of NC systems: PTP, straight Cut and Contouring. definition of axes, definition of interpolation, post-processor, preparatory and miscellaneous functions, canned cycles, tool length and cutter radius compensation. Manual part programming and computer aided part programming for simple components (APT).

UNIT-IV
CNC: Introduction to CNC, Typical configurations, Machining centers, Introduction to FANUC, SINUMERIC controllers
DNC: Typical configurations, CNC vs DNC.
Adaptive Control Systems: ACO and ACC.

Industrial Robots: Robot anatomy, configurations, control systems, drivers, accuracy and repeatability, end effectors, sensors in robotics, programming methods.Robot industrial applications: material handling, processing and assembly and inspection.

UNIT-V

GT: Part families, layout, part classification and coding system- OPITZ, MICLASS.

CAPP: Variant and Generative process planning.

FMS and CIM: FMS equipment, FMS layouts, benefits of FMS, Elements of CIM.

Computer Aided Inspection and QC: Automated inspection- Off-line, On-line, Contact (Co-ordinate measuring machine), Non-contact inspection (Machine Vision, Scanning LASER Beam, Photogrammetry).

Text Books:

1. Ibrahim Zeid, “CAD/ CAM Theory and Practice”, McGraw Hill Inc, New York, 2011.
2. Mikell P.Groover, “Automation, Production Systems and Computer-Integrated Manufacturing”, Pearson Publication, 4/e, 2016.
3. P.N. Rao, “CAD/CAM - Principles and Applications”, 2/e, Tata McGraw Hill, New Delhi, 2004.

Suggested Reading:

1. Yoram koren, “Computer Control of Manufacturing Systems”, McGraw Hill Int, New York, 1994.
2. C. Elanchezhian, T. Sunder Selwyn, G. Shanmuga Sunder, “Computer Aided manufacturing”, 2/e, Laxmi Publications (P) Ltd, New Delhi 2007.

18ME C18

MACHINE DESIGN

(Use of data book is permitted)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Design principles of helical coiled and leaf springs. types of materials used for springs
2. The design principles of gears
3. The design principles of sliding contact bearings
4. The Selection of rolling contact bearings and roller chains
5. Design principles of IC engine piston, connecting rod, crank shaft, C-clamp and crane hooks

Outcomes: At the end of the course, the students are able to

1. Understand the stresses in helical, leaf springs under static and fluctuating loads. (BL-2)
2. Design the spur, helical and bevel gears. (BL-6)
3. Demonstrate the ability in designing sliding contact bearings. (BL-3)
4. Selection of rolling contact bearings and roller chains. (BL-4)
5. Design of IC engine piston, connecting rod, crank shaft, C-clamp and crane hooks. (BL-6)

UNIT-I

Mechanical Springs: Introduction, types of springs, Materials used for springs.
Helical Springs: Wahl's factor, calculation of stresses, deflection and energy stored in spring. Design for staticand fluctuating loads.
Leaf Springs: Stresses and deflection, nipping of Leaf springs. Design for static loads.

UNIT-II

Gears: Introduction to gear drives, types of gears, materials used for gears, Standards and specification of gears,Design of Spur, Helical and Bevel gears. Lewis beam strength equation. Dynamic loads on gear tooth. Wear load and design for wear strength.

UNIT-III

Bearings: Introduction, classification of bearings, materials used for bearings, properties and types oflubricants.
Design of Sliding Contact Bearings: Hydrodynamic bearings: journal bearing and thrust bearings.
Selection of Rolling Contact Bearings: Types of rolling elements and their constructional details, Static anddynamic load carrying capacity, Load-life relationship, selection of bearing, for cyclic loads and speeds.

UNIT-IV

I.C. Engine Parts: Introduction, Materials used, Design of piston, connecting rod and overhang crank shaft.

UNIT-V

Design of Curved Beams: Introduction, stresses in curved beams, expression for radius of curvature of neutralaxis for rectangular, circular and trapezoidal sections, Design of C-clamp and crane Hook.
Selection of chain drives: Power rating of roller chains, Strength of roller chains.

Text Books:

1. V.B. Bhandari, "Design Machine Elements", Mc Graw Hill Publication, 2017.

2. J.E. Shigley, C.R. Mischne, "Mechanical Engineering Design", Tata Mc Graw Hill Publications, 2015.
3. R.S.Khurmi and J.K.Gupta, "Machine design", 34th edition, S Chand publications, 2018.

Suggested Reading:

1. P. Kannaiah, “Machine Design”, Sci-Tech Publications, 2010
2. M.F. Spotts, “Design of Machine Elements”, Prentice Hall of India, 2013.

Machine Design Data Books:

1. K.Mahadevan, K.BalaveeraReddy.,“Design Data Hand book for Mechanical Engineers”, 3/e, CBS Publisher, 2018
2. PSG College, “Design Data book”,2012

18ME C19

THERMAL TURBO MACHINES

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Student will acquire basic knowledge in designing of nozzles and diffusers used in rockets and aircrafts.
2. Student will come to know the design of ducts, combustion chambers and various types of shocks.
3. Student will come to know the working principles of various rotary compressors like centrifugal compressor and rotary compressor.
4. Student will understand the applications of various steam turbines and velocity triangles in order to calculate power developed by them.
5. Student will demonstrate the basic knowledge in gas turbines and various methods to improve efficiency of gas turbine cycles

Outcomes: At the end of the course, the students are able to

1. Design various configurations of nozzles and diffusers with the principles of Thermodynamics, Fluid mechanics and Heat transfer to meet specified needs. (BL-6)
2. Predict the compressible flow properties behavior with friction, heat transfer and shock waves for complex engineering problems (BL-3)
3. Estimate the power required for various types of rotary compressors using the principles of gas dynamics for engineering problems. (BL-5)
4. Understand the working principle of steam turbines, velocity triangles and performance parameters using principles of turbo machinery. (BL-2)
5. Discuss the working principle of gas turbine, jets and rocket propulsions incorporating methods for efficiency improvement in gas turbine cycles. (BL-2)

UNIT-I

Introduction to Compressible Flows: Speed of propagation of pressure waves, Mach number, Acousticvelocity and Mach cone, limits of compressibility, pressure field due to a moving source of disturbance, one dimensional compressible flow. Isentropic flow with variable area, Mach number variation, Area ratio as function of Mach number, flow through nozzles and diffusers Flow with Shock Waves-Development of Normal Shock waves, governing equations

UNIT-II

Flow in Constant Area Ducts with Friction-Fanno Flow: Variation of flow properties, variation of Machnumber with duct length, isothermal flow with friction, Prandtl – Meyer relation, Rankine-Hugoniot equations and Stagnation pressure ratio across shock.

UNIT-III

Rotodynamic Compressors: Introduction and general classification, Comparison of Reciprocating and Rotarycompressors, Positive displacement Rotary compressors, Flow through rotary compressors. Static and total head quantities. Thermodynamic cycles and work done, calculation of various efficiencies. Velocity diagrams and prewhirl. Euler equation for energy transfer between fluid and rotor, Analysis of Centrifugal compressors and analysis of axial flow compressors, Chocking, Surging and Stalling.

UNIT-IV

Steam Turbines: Introduction to steam nozzles, design for throat area, Classification of steam turbines, Impulseturbine, compounding of steam turbines, Pressure velocity variations across different compounding turbines, blade efficiency and work done by impulse turbine, degree of reaction of reaction turbine, blade efficiency and work done by reaction turbine, stage efficiency and nozzle efficiency and simple problems on impulse and reaction turbines.

UNIT-V

Gas Turbines: Applications and classification of Gas Turbines- constant pressure and constant volume gasturbines, Joule cycle-configuration diagram and temp-entropy diagram, Thermal efficiency of Joules cycle, maximum pressure ratio in terms of temperature ratio, optimum pressure ratio for maximum work output with and without considering machine efficiencies, Improvement of gas turbine plant performance- Inter-cooling, Reheating and Regeneration. Simple problems on Joule cycle.

Air Craft Propulsion: Air craft engine types, air craft propulsion theory, Turbo jet engines, Ramjet engines,Pulse jet engines.

Rocket Propulsion: Types of Propellants, types of Rocket engines, Rocket propulsion theory-Rocketapplications.

Text Books:

1. S M Yahya, "Fundamentals of Compressible Flow", New Age International Publishers, 2014.
2. Mahesh M. Rathore, "Thermal Engineering", TMH, New Delhi, 2010
3. M L Mathur & F S Mehta, "Thermal Engineering", Jain Brothers, New Delhi, 2014

Suggested Reading:

1. V. Ganeshan, "Gas Turbines", Tata Mc Graw Hills, New Delhi, 2010.
2. R Yadav, "Steam and Gas Turbines", Central Publishing House Ltd, Allahabad, 2003.

18ME E08

OBJECT ORIENTED PROGRAMMING WITH C++

(Core Elective-III)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. To understand difference between OOP and structured programming
2. To know classes, objects, constructors and destructors.
3. How to overload operators.
4. To understand inheritance and polymorphism
5. Knowledge about templates and exception handling.

Outcomes: At the end of the course, the students are able to

1. Identify fundamental object oriented concepts of C++ programming Language. (BL-1)
2. Distinguish between object oriented program and structured programming (BL-2)
3. Use operator overloading to give comfort in the programming. (BL-3)
4. Illustrate Exception handling and templates (BL-4)
5. Solve basic mechanical engineering problems by developing programs using object oriented features (BL-5)

UNIT - I
Principles of Object Oriented Programming: Procedure Vs Object Oriented, Paradigm, Basic concepts,benefits, Applications and Object Oriented Languages.
Introduction: Program structure, Creating, Compiling and Linking of C++ program.
Token, Expression and Control Structures: Tokens, Keywords, Identifiers and Constants, Data Types,Operators, Precedence, Type Compatibility, Control Structures, New Features of C++.
Functions: Function Prototype and Parameter Passing, Inline Functions, Default, Constant Arguments,Recursion, Function Overloading

UNIT - II
Classes and Objects: Defining classes and Member functions, creating objects, objects and arrays, objects andfunctions, const with classes, friends to a class, nesting static members of a class.
Constructors and Destructors: Type of Constructors, Dynamic Initialization of Objects, Destructors.

UNIT - III
C++ Operator Overloading and Type Conversions: Fundamentals, restrictions, overloading unary / binaryoperators, overloading ++ and —, overloading special operators, overloading by member functions and friend functions, type conversions.

UNIT - IV
C++ Inheritance: Defining derived classes, Types of Inheritance, Virtual Base class Abstract Class, functionoverriding and containership.
Pointers and Polymorphism: Pointers and Generic pointer, Pointer to Objects and Derived Classes, thispointer, Virtual Functions, Virtual Destructors

UNIT - V
C++ Templates: Introduction, function templates and class templates.
C++ Exception Handling: Conventional error handling mechanism, C++ error handling mechanism, Try,throw, catch, exception handling in classes.

Text Books:

1. Rohit Khurana, “Object oriented programming with C++”, Vikas publications. 2/e, 2014.
2. Ashok Kamtani, “Object Oriented Programming with ANSI and Turbo C++”, Pearson Education, 2017.
3. Somshekara, “Object Oriented Programming with C++”, Eastern Economy Edition, 2/e, 2012.

Suggested Reading:

1. E. Balagurusamy, “Object Oriented Programming with C++”, McGraw-Hill Education (India), 6/e, 2018.
2. Robert Lafore, “Object-Oriented Programming in C++”, 4/e, Sams Publishing, 2016.

18ME E09

MECHANICS OF COMPOSITE MATERIALS

(Core Elective - III)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Application and use of composite materials in industry.
2. Types of fibers and matrix materials used in commercial composites.
3. Prediction of the properties of UD lamina based on the constituent materials.
4. Analysis of composite laminates based on classical lamination theory.
5. Method of predicting failure in composite lamina using different theories.

Outcomes: At the end of the course, the students are able to

1. Differentiate between composite materials and conventional materials using basic concepts. (BL-2)
2. Analyze macro and micro mechanical behaviour of a lamina. (BL-4)
3. Determine role of constituent materials in defining the average properties and response of composite materials on macroscopic level. (BL-3)
4. Analyze the laminates for stresses and strains using Classical lamination theory (BL-4)
5. Summarize the various fabrication methods of composite materials and measurements of properties through tests. (BL-2)

UNIT-I
Introduction: Definition, characteristics, overview of advantages and limitations of Composite materials. classification, significance, objectives of composite materials and applications.

UNIT-II
Basic concepts and characteristics: Scale of analysis; Micromechanics, Macromechanics, Macro and micro mechanical behaviour of a lamina: Stress strain relations for anisotropic materials, Restrictions on engineering constants, transformation of stress, Strain and elastic parameters.

UNIT-III
Elastic behaviour of UD Lamina: Elastic constants of a lamina using MOM approach, relations between engineering constants and reduced stiffness and compliances, variation of lamina properties with orientation. Tensile and compressive strength of unidirectional fibre composites, Macromechanical failure theories, applicability of various failure theories. Max stress theory, max strain criteria, maximum work (Tsai-Hill) criterion, quadratic interaction criteria.

UNIT-IV
Elastic Behaviour of Laminate: Basic assumptions, Strain-displacement relations, classical Lamination Theory [CLT], Stress-strain relation of layer within a laminate, Force and moment resultant, classification of laminates. Analysis of different types of laminates.

UNIT-V
Manufacturing Processes& Testing: Hand lay-up, bag molding, autoclave processing, RTM, pultrusion, filament winding, gel time test for resins, curing cycle, Testing: Fiber and matrix tests, tensile test, compressive test, in-plane shear test, inter-laminar shear test, flexure test.

Text Books:

1. R. M. Jones, “Mechanics of Composite Materials”, Mc Graw Hill Co., 2006.
2. B. D. Agarwal, “Analysis and performance of fiber composites”, Wiley & Sons 3/e, 2013.
3. Ronald F Gibson, “Principles of composite material mechanics”, CRC press. 4/e, 2016.

Suggested Reading:

1. Isaac M. Daniels and Ori Ishai, “Engineering Mechaincs of Composite Materials”, Oxford University Press, 1994.
2. M.W.Hyer, “Stress Analysis of Fibre Reinforced Composite Materials”, McGraw Hill Co., 1998.

18ME E10

ROBOTIC ENGINEERING

(Core Elective–III)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Principle of working of a robot, types and specifications,configuration, work envelop and motion controls and applications
2. Transformations, kinematics and dynamics of robots
3. Singularities, Jacobian and trajectory planning of a robot to prepare the robot for various tasks
4. Design of end effectors, drives, working of sensors and controllers for finding position and orientation.
5. Robot vision for image acquisition and processing and plan for various tasks and various Languages and Programming methods of robot.

Outcomes: At the end of the course, the students are able to

1. Understand the basic components and specifications of the Robots (BL-2)
2. Solve the problems of transformations, direct and inverse kinematics of robots (BL-3)
3. Analyze forces in links and joints of a robot and find the singularities, Jacobian and trajectory planning of a robot for various tasks (BL-4)
4. Recommend sensors and controllers for finding position and orientation to take corrective action based on feedback (BL-5)
5. Design an intelligent robot using machine vision and sensors (BL-6)

UNIT - I
Overview of Robots and Subsystems: Brief History, Types of robots, resolution, repeatability and accuracy,degrees of freedom of robots, Robot configurations, Workspace, Mechanisms and transmission, End effectors and Different types of grippers, vacuum and other methods of gripping, Pneumatic, hydraulic and electrical actuators, applications of robots, specifications of different industrial robots.

UNIT – II
Direct Kinematics: Rotation matrices, Euler angle and RPY representation, Homogeneous transformationmatrices, Denavit-Hartenberg notation, representation of absolute position and orientation in terms of joint parameters, direct kinematics.

UNIT - III
Inverse Kinematics: inverse orientation, inverse locations, Singularities, Jacobian, Trajectory Planning: jointinterpolation, task space interpolation, executing user specified tasks, sensor based motion planning.

UNIT - IV
Analysis of RP and RR Type Robots: Static force analysis of RP type and RR type planar robots, Dynamicanalysis using Lagrangean and Newton-Euler formulations of RR and RP type planar robots. Independent joint control, PD and PID feedback, actuator models, nonlinearity of manipulator models, force feedback, hybrid control

UNIT - V

Sensors and Controllers: Internal and external sensors, position, velocity and acceleration sensors, proximitysensors, force sensors, laser range finder. Robot vision: image processing fundamentals for robotic applications, image acquisition and preprocessing. Object recognition by image matching and based on features

Text Books:

1. Nagrath and Mittal, "Robotics and Control", Tata McGraw-Hill, 2003.
2. Spong and Vidyasagar, "Robot Dynamics and Control", John Wiley and sons, 2008.
3. Mikell P. Groover " Industrial Robotics", McGraw-Hill, 2008.

Suggested Reading:

1. Fu. K.S, Gonzalez, R.C., Lee, C.S.G, "Robotics, control, sensing, Vision and Intelligence", McGraw Hill International, 1987
2. Steve LaValle, "Planning Algorithms", Cambridge Univ. Press, New York, 2006.

18PE E06

PRODUCTION AND OPERATIONS MANAGEMENT

(Core Elective-III)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Understand plant layout design to facilitate material flow and processing of a product in the most efficient manner
2. Gain some ability to recognize situations in a production system environment that suggests the use of certain quantitative methods to assist in decision making on operations management and strategy.
3. Understand how Materials Requirement Planning and MRPII systems are used in managing operations
4. Recognize the importance of Inventory control to ensure their availability with minimum capital lock up.
5. Evaluate the quality processes in manufacturing and service sector to improve the operational performance

Outcomes: At the end of the course, the students are able to

1. Understand the role of production system and its design in Production and Operations Management. (BL-2)
2. Apply forecasting techniques for predicting demand. (BL-3)
3. Use Aggregate Planning, Master Scheduling and Materials Requirement Planning in a production system. (BL-3)
4. Compare various inventory control techniques used in production system. (BL- 4)
5. Apply the quality control tools to improve performance of production system. (BL- 3)

UNIT-I

Introduction: Production systems classification and characterization

Plant Location and Layout: Factors affecting plant location, Objectives of Plant layout, different types of layouts, merits and demerits.

Work Study: Productivity, Introduction to method study and work measurement, standard time calculations, work sampling, wages and incentive plans.

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UNIT-II

Forecasting: Introduction, forecasting objectives and uses, demand patterns, qualitative models, market survey,Delphi method, quantitative models, moving average, weighted moving average, simple exponential smoothing, trend adjusted exponential smoothing, simple regression.

Forecast Errors: Mean Absolute Deviation (MAD), Mean Square Error (MSE), Mean Forecast Error (MFE),Mean Absolute Percentage Error (MAPE)

UNIT-III

Aggregate Planning and Master Scheduling: Introduction, objectives of aggregate planning, cost in aggregateplanning, strategies in aggregate planning, master production scheduling

Materials Requirement Planning (MRP): Importance of MRP, MRP system inputs and outputs, bill ofmaterials (BOM).

UNIT-IV

Inventory Control: Importance of Inventory control, Inventory control systems, Types of Inventories, Inventory costs, Deterministic Inventory models - Basic Purchase model, Purchase model with Instantaneous replenishment and with shortages, Basic Production model, Production model with shortages, Inventory model with price breaks.

UNIT-V

Quality Control: Introduction, quality gurus and their contributions, quality tools, process capability, qualitycontrol by control charts, control charts for variables and attributes, sampling plans, operating characteristic curve, introduction to total quality management (TQM).

Text Books:

1. William J. Stevenson, “Operations Management”, 8/e, Tata Mc Graw Hill Edition, 2005.
2. Joseph G. Monks, “Operations Management: Theory and Problems”, 3/e, McGraw Hill International Edition, 1987.
3. ElwoodS. Buffa, “Modern Production/Operations Management”, 5/e, John Wiley Publishers, Singapore, 2002.

Suggested Reading:

1. Everrete E. Adama & Ronald J. Ebert, “Production & Operations Management”, 5/e, Prentice Hall of India, 2005.
2. R. Panneerselvam, “Production and Operations Management,” 2/e, PHI Learning Pvt. Ltd., New Delhi, 2006.

18ME E11

ADVANCED IC ENGINES

(Core Elective-III)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Fundamental working principles of diesel/petrol engines.
2. Importance of combustion phenomena in I.C. Engines.
3. Importance of control of pollutants and their remedies and working principles of analyzers for measurements of pollutants.
4. Concept of alternative fuel technology to improve the performance of the engine.
5. Concepts of recent trends in IC engines.

.**Outcomes:** At the end of the course, the students are able to

1. Evaluate the performance of SI/ CI engines with emphasis on environment (BL-5)
2. Understand the combustion phenomenon in IC engines with remedial methods for controlling abnormal combustion. (BL-2)
3. Discuss the need and control of I.C Engine emissions in the context of human health and environment. (BL-2)
4. Understand the need for professional and engineering practices required for identifying alternative fuels in the context of fossil fuels depletion to address health, safety and societal issues. (BL-2)
5. Choose appropriate technologies to improve engine performance with alternative power sources for automobiles. (BL-5)

UNIT - I
Fundamentals of IC Engines: Classification, working principles of 2 stroke, 4 stroke SI and CI engines, performance of IC Engines, heat balance sheet; cooling, lubrication systems, battery and magneto ignition systems of IC engines.working principle of simple carburetor, Zenith carburetor and fuel Injector, injection systems-MPFI and CRDI systems.

UNIT - II
Combustion Phenomena: Stages of combustion in SI and CI engines, normal and abnormal combustion phenomenon in SI and CI engines, remedies. combustion chambers for SI & CI engines; supercharging of IC engines: need of supercharging, advantages, limitations and configurations of supercharging**.**

UNIT - III
Pollutant Formation And Control: Pollutant– sources – formation of carbon monoxide, unburnthydrocarbon, aldehydes, NOx, smoke and particulate matter – methods of controlling Emissions – thermal and catalytic converters, particulate traps, chemical methods and EGR, SCRT- various methods of measurements like flame ionization detector, Infrared gas analyzer, chemiluminescence method and opacity meters; emission norms.

UNIT - IV
Alternative Fuels: Alcohols, vegetable oils, bio diesel, Hydrogen, natural gas, liquefied petroleum gas and bio gas properties, suitability, merits and demerits as fuels.

UNIT - V
Technological Advances in Vehicles: Lean burn engines, stratified charge engines, homogeneous charge compression ignition (HCCI) engines and GDI concepts.
Electric vehicles: Introduction, limitations of IC engines as prime mover, history of EVs, EV system, components of EV-DC and AC electric machines, Introduction and basic structure, electric vehicle drive train, advantages and limitations.

Text Books:

1. Ganeshan, V., “Internal Combustion engines”, Tata Mc Graw Hills Publishing Co.Ltd, New Delhi 2015.
2. Gill, P.W. and Smith (Jr), J.H, “Fundamentals of Internal combustion Engines”, Oxford & IBH publishing Co.New Delhi, 2007
3. Heywood, J.B, “Internal Combustion engine fundamentals”, McGrave Hills, Book Co, New York, 1988

Suggested Reading:

1. M.L. Mathur and R.P. Sharma, “Internal Combustion Engine”, DhanpatRai&Sons,New Delhi, 2010.
2. Seth Leitman and Bob Brant “Build your own electric vehicle” McGraw Hill Co. 2nd edition, 2009.

18ME E12

COMPUTATIONAL FLUID DYNAMICS

(Core Elective - IV)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. To understand governing equations of fluid flow
2. To understand turbulence and how to model them.
3. To know how to descretize governing equations of fluid flow by FDM and their stability.
4. To learn various iterative methods to solve N-S equation.
5. To understand FVM to solve fluid flow equations.

.**Outcomes:** At the end of the course, the students are able to

1. Describe and develop mathematical models for flow phenomena. (BL-1)
2. Classify PDE for fluid flow and heat transfer applications. (BL-2)
3. Apply Finite Difference Method for fluid flow and heat transfer problems (BL-3)
4. Test the discretized equations for stability and solve the system of linear equations (BL-4)
5. Formulate numerical equations by Finite Volume Method for fluid flow and heat transfer problems (BL-6)

UNIT-I

Basic Equations: Continuity, momentum and energy equations, Navier-Stokes equations, Heat transferconduction equations for steady and unsteady flows, steady convection-diffusion equation

UNIT-II

Models: Reynolds and Favre averaged N-S equations, mixing length model, k-epsilon turbulence model. **Classifications of Partial Differential Equations:** Elliptic, parabolic and hyperbolic equations, Initial andboundary value problems.

UNIT-III

Finite Difference Method: Forward, backward and central difference.

Parabolic partial differential equations: Euler, implicit and crank Nicholson methods, ADI models, Errors,consistency, stability analysis, Vonnumen analysis, Convergence criteria

UNIT-IV

Elliptic Partial Differential Equations: Jacobi, Gauss Seidel methods, TDMA, Viscous incompressible flow,Vorticity Stream function method.

UNIT-V

Finite Volume Method: Finite volume formulation for diffusion equation, convection diffusion equation,Solution algorithm for pressure velocity coupling in steady flows, staggered grid, SIMPLE algorithm.

Text Books:

1. P.S. Ghoshdastidar, “Computational Fluid Dynamics & Heat Transfer”, Cengage Pub., 2018.
2. J.D. Anderson, Jr., “Computational Fluid Dynamics: The Basic with Applications”, McGraw Hill, Inc., 2012.
3. H. Versteeg and W. Malalasekra, “An Introduction to Computational Fluid Dynamics : The Finite Volume Method”, 3/e ,Pearson, , 2016

Suggested Reading:

1. F. John Wendt (Editor), "Computational Fluid Dynamics - An Introduction", Springer – Verlag, Berlin, 1992.
2. Charles Hirsch, "Numerical Computation of Internal and External Flows", Vols. I and II. John Wiley & Sons, New York, 1988.

18ME E13

PRINCIPLES OF ENTREPRENEURSHIP

(Core Elective - IV)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Concept and procedure of idea generation
2. The nature of industry and related opportunities and challenges
3. Elements of business plan and its procedure
4. Project management and its techniques
5. Behavioral issues and Time management

.**Outcomes:** At the end of the course, the students are able to

1. Understand the concept and essence of entrepreneurship. (BL-2)
2. Identify business opportunities and nature of enterprise. (BL-3)
3. Analyze the feasibility of new business plan. (BL-4)
4. Apply project management techniques like PERT and CPM for effective planning and execution of projects. (BL-3)
5. Use behavioral, leadership and time management aspects in entrepreneurial journey. (BL-3)

UNIT-I
Entrepreneurship: Definition, functions of entrepreneurship, qualities of entrepreneurs, Entrepreneur vs intrapreneur, First generation entrepreneurs, women entrepreneurs, innovation and Intellectual property in entrepreneurial journey, conception and evaluation of ideas and their sources, need and importance of startups and incubation centers.

UNIT-II
Indian Industrial Environment: Competence, opportunities and challenges, Entrepreneurship and Economic growth, Entrepreneurship and Engineering, Small Scale Industry in India, objectives, Linkage among small, medium and large scale industries, Types of enterprises**,** corporate social responsibility.

UNIT-III
Formulation of Business Plan: Introduction, Elements of Business Plan and its salient features, Business model canvas, Technical Analysis, Profitability and Financial Analysis, Marketing Analysis, Feasibility studies, Executive Summary. Choice of Technology and Collaborative interactions, Sources of finance and Incentives for entrepreneurs.

UNIT-IV
Project Management: During construction phase, project organization, project planning, execution and control using CPM, PERT techniques, Human aspects of project management, Assessment of tax burden, environmental issues.

UNIT-V
Behavioral Aspects of Entrepreneurs: Personality, determinants, Maslow’s Hierarchy of needs, Leadership concepts and models, Values and attitudes, Motivation aspects, Change behavior Time Management: Approaches of time management, their strengths and weaknesses. Time management matrix and the urgency addiction

Text Books:

1. Vasant Desai, “Dynamics of Entrepreneurial Development and Management”, Himalaya Publishing House, 1997.
2. Prasanna Chandra, “Project-Planning, Analysis, Selection, Implementation and Review”, Tata Mcgraw-Hill Publishing Company Ltd. 1995.
3. S.S. Khanka, “Entrepreneurial Development”, S. Chand & Co. Pvt. Ltd., New Delhi, 2012

Suggested Reading:

1. Robert D. Hisrich, Michael P. Peters, “Entrepreneurship”, 5/e, Tata Me Graw Hill Publishing Company Ltd., 2005
2. Stephen R. Covey and A. Roger Merrill, “First Things First”, Simon and Schuster Publication, 1994.

18PE E08

MODERN MACHINING AND FORMING METHODS

(Core Elective - IV)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Various non-conventional machining processes and their process parameters.
2. The relative merits, limitations and applications of various non-conventional machining processes.
3. The knowledge regarding working media and its functions of non-conventional machining processes.
4. The concepts of non-conventional forming processes such as rubber pad forming, hydro forming, stretch forming, etc.
5. The concepts of HERF and to provide the description of HERF process

Outcomes: At the end of the course, the students are able to

1. Compare the Traditional and Non Traditional Machining process and recognize the need for Non traditional Machining process. (BL-2)
2. Illustrate constructional features, performance parameters, process characteristics, applications, advantages and limitations of Non Traditional Machining process. (BL-3)
3. Classify mechanisms of material removal of various non traditional machining processes. (BL-4)
4. Describe the principles, characteristics, advantages, limitations and applications of various unconventional methods of forming, HERF. (BL-1)
5. Compare the principles, constructional features and applications among explosive forming, EHF and EMF. i. (BL-4)

UNIT-I

Ultrasonic Machining (USM):Introduction, Process description, abrasive slurry, Abrasive materials and theircharacteristics, Functions of liquid medium in slurry, Types of transducers, effect of process parameters, applications and limitations.

Abrasive Jet Machining (AJM): Principle of operation, process details, process variables and their effect onMRR and accuracy, advantages, disadvantages and applications

Water Jet Machining (WJM): Schematic diagram, equipment used, advantages and applications.

Abrasive Water Jet Machining (AWJM): Process, advantages, limitations and applications

UNIT-II

Electro Discharge Machining (EDM): Process description with schematic diagram, process parameters,functions and characteristics of dielectric medium, dielectric fluids, flushing, mechanism of metal removal, types of power supply circuits, mathematical analysis of metal removal rate (MRR), equations for surface finish, characteristics of spark eroded surfaces, advantages, disadvantages and applications.

Wire EDM: Process description and applications.

Laser Beam Machining (LBM): Principle of LASER beam production, materials used, process parameters,advantages, limitations and applications.

Plasma Arc Machining (PAM): Introduction, equipment used, process description and parameters, types of plasma arc: transferred arc and non transferred arc and process applications.

Electron Beam Machining (EBM): Schematic of the process, process parameters, principle of production ofelectron beam, equipment used, advantages, disadvantages and applications.

UNIT-III

Electro-chemical machining (ECM): Schematic of processparameters, function and characteristics of electrolyte, MRR for pure metal and alloys, electrode feed rate (EFR), advantages, limitations and applications.

Chemical Machining : Chemical blanking and chemical milling, advantages, limitations and applications.**ION Etching**: Process description, merits, limitations and applications.

UNIT-IV

High Energy Rate Forming Processes (HERF): Introduction, applications, advantages
Explosive Forming: Principles, explosive materials, Equipment, types of explosive forming, standoffoperation and contact operation.
Electro Hydraulic Forming (EHF): Schematic of process, description and its applications
Electro Magnetic Forming (EMF): Process description, merits, limitations and applications.

UNIT-V

Flexible Forming: Principle of the process, process details and its types, Guerin, wheelon, Mar formingand Hydro forming processes and applications
Stretch Forming: Introduction, types of stretch forming, stretch draw forming, rotary stretch forming or stretchwrapping, compression forming, radial draw forming.
Tube spinning: Introduction, methods of tube spinning, backward spinning, forward spinning.

Text Books:

1. P.C. Pandey and H.S. Shah, "Modern Machining Process", Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1980.
2. J Paulo Davim, "Modern Machining Technology - A Practical Guide", 1/e, Woodhead Publishing in Mechanical Engineering, 1980.
3. Hassan Abdel-Gawad El-Hofy, "Advanced Machining Processes, Nontraditional and Hybrid Machining Processes", McGraw Hill Publishing Co. Ltd., 1984.

Suggested Reading:

1. Davies and Austin, "Developments in High Speed Metal Forming", The Machinery Publishing Co. Ltd., 1985.
2. "Production Technology", HMT, 1984.

18ME E14

HEAT AND MASS TRANSFER

(Core Elective - IV)

(Use of data book is permitted)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. To demonstrate basic knowledge by understanding conduction heat Transfer.
2. Students will acquire the basic knowledge in understanding the principles of convection heat transfer.
3. Student will come to know basic principles of radiation heat transfer.
4. Student will come to know the difference of condensation phenomena and boiling phenomena and understand the working principle of heat exchanger and their effectiveness.
5. Student will come to know mass transfer phenomena in gases and liquids.

Outcomes: At the end of the course, the students are able to

1. Apply various laws pertaining to conduction heat transfer using basic principles of thermodynamics.(BL-3)
2. Determine heat transfer coefficient for free and forced convection phenomena along with boundary layer for various complex engineering problems. (BL-5)
3. Understand the concept of radiation phenomena of heat transfer. (BL-2)
4. Design of heat exchangers using the principles of engineering sciences. (BL-6)
5. Understand the concept of mass transfer and co-relate with heat transfer and provide valid conclusions. (BL-2)

UNIT-I

General Heat Conduction Equation: Derivation of the equation in Cartesian and Polar Co-ordinate systems.
Steady-state one-dimensional heat conduction problems in Cartesian and Polar System: Steady-state 1-D heat conduction problems with and without heat generation and varying thermal conductivity for different boundary conditions, Thermal Resistances in Series and in Parallel. Critical thickness of insulation
Fins: Classification, Rectangular Fins, Fin Efficiency and Fin Effectiveness, Applications,
Transient heat conduction: Lumped heat analysis, Semi-infinite Body, use of Heisler and Grober charts,

UNIT-II

Convection: Boundary Layer Theory, Velocity and Thermal Boundary Layers over a flat plate and through pipes.
Forced convection: Flow over flat plates, cylinders, internal flows -laminar and turbulent flow, Empirical solutions.
Free convection: Flow over vertical Plates, Internal flows-Vertical Tubes and Horizontal Tubes- Laminar and Turbulent flows, Empirical solutions. Dimensional analysis, Buckingham π theorem, Physical significance of different dimensionless numbers.

UNIT-III

Basic Relations: Definition of absorptivity, reflectivity and transmissivity, Concept of black-body and emissivity. Kirchoff's law, Planck's black body spectral distribution, Wien's and Steffan Boltzmann law.
Radiation Heat Exchange between Surfaces: Radiation shape factor, Concept of surface, space resistances, Heat exchange between non-black bodies, Radiation shields.

UNIT-IV

Heat Exchangers: Definition, Classification, LMTD method, Effectiveness - NTU method, chart Solution for Heat Exchanger Problem, correction factor charts and Effectiveness-NTU charts.

Boiling: Boiling Heat Transfer Phenomena, Pool boiling Curve

Condensation: Laminar film wise condensation on a vertical plate.

UNIT-V:

Mass Transfer: Applications, concentrations, velocities and fluxes, Fick's law of diffusion, General three dimensional equation for mass transfer in stationary media, diffusion coefficient, steady state molecular diffusion through a plain membrane, equimolal diffusion, evaporation process in atmosphere, significance of dimensionless numbers in mass transfer.

Text Books:

1. Sachdeva, R.C, "Fundamentals of Engineering Heat and Mass Transfer", New Age International Publications, 2014.
2. Holman, J. P., Heat Transfer, Tata McGraw Hill, New Delhi, 2010
3. M. Necati Ozisik, Heat Transfer - A Basic Approach, McGraw Hill, New York, 1985

Suggested Reading:

1. Yunus A Cenegal, Heat Transfer: A Practical Approach, Tata McGrahill, 2nd Edn,2002
2. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, John Wiley and Sons, New York, 2006

Data Book:

1. C. P. Kothandaraman, S. Subramanyan ,"Heat and Mass Transfer Data Book", New Age International Publishers, 2018

18ME E15

BLOCKCHAIN TECHNOLOGY

(Core Elective -IV)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Course Objectives:

1. To provide Conceptual understanding of how blockchain technology can be used to improve business processes.
2. To facilitate understanding of bit coin and working with consensus in Bitcoin.
3. To impart knowledge about designing and building Permissioned blockchains.
4. To introduce supply chain management and internet enabled supplychains.
5. To familiarize with blockchain applications.

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

1. Outline the concepts of blockchain technology. (BL-2)
2. Understand the bit coin, working with consensus in Bitcoin. (BL-2)
3. Develop knowledge about designing and building Permissioned block chains. (BL-3)
4. Explain the concepts of supply chain management and internet enabled supply chains. (BL-2)
5. Make use of blockchain applications involved in various sectors. (BL-3)

UNIT- I

Introduction: History, blockchain Architecture, nodes, crypto currency, tokens, cryptography- private and public keys, hash, ledgers, bitcoin, design Primitives- digital Signature, protocols, security, consensus, understanding Crypto currency.

UNIT- II

Bitcoin and block chain: creation of coins, payments and double spending, bitcoin scripts, bitcoin p2p network, transaction in bitcoin network, block mining, block propagation and block relay.

Working with consensus in bitcoin: distributed consensus in open environments, consensus in a bitcoin network, proof of work (pow) – basic introduction, hashcash pow, bitcoinpow, attacks on pow and the monopoly problem, proof of stake, proof of burn and proof of elapsed time, the life of a bitcoin miner, mining difficulty, mining pool.

UNIT- III

Permissioned Block chain: Definition, merits and demerits, differences between permissioned and permissionless blockchain, overview of Consensus models for permissioned block chain- Distributed consensus in closed environment, Paxos, RAFT, Byzantine fault tolerant (BFT) system, Lamport-Shostak-Pease BFT Algorithm.

Enterprise application of Block chain: Cross border payments, Know Your Customer (KYC), Food security, Mortgage over Blockchain, Blockchain enabled Trade.

UNIT- IV

Blockchain and the world economy: Supply chain industry-past and future, supply chain using blockchain technology, building blocks of a supply chain network, business processes in supply chains, types of supply chains and examples, strategic, tactical, and operational decisions, supply chain performance measures. ERP and automation.

Internet-enabled supply chains: e-marketplaces, e-procurement, e-logistics, e-fulfillment, customer relationship management, web services.

UNIT -V

Applications of blockchain technology: Uses of blockchain in e-governance, land registration, property records, notary, titles, micropayments, medical information systems, next generation of industry 4.0 and additive manufacturing, government identity management, auto executing contracts, three signature escrow, triple entry.

Text Books:

1. Melanie Swan, "Block Chain: Blueprint for a New Economy", 1st Edition O'Reilly, 2015.
2. Andreas Antonopoulos, “Mastering Bitcoin: Unlocking Digital Crypto currencies”, 1st Edition, O’Relly, 2015.
3. Tiana Laurence, “Introduction to blockchain technology”, Van Haren Publishing, ’s-Hertogenbosch, 2019.

Suggested Reading:

1. Daniel Drescher, “Block Chain Basics”, 1st Edition, Apress, 2017.
2. RiteshModi, “Solidity Programming Essentials: A Beginner’s Guide to Build Smart Contracts for Ethereum and Block Chain”, Packt Publishing, 2018.

18ME E17

RENEWABLE ENERGY SOURCES

(Core Elective - V)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Need and importance of non-conventional energy resources
2. Extent of solar energy which can be utilized as energy resource
3. Concept of wind energy and its merits and demerits
4. Operating principles of geothermal energy and bio-energy
5. Merits and demerits of tidal energy, wave energy and OTEC

Outcomes: At the end of the course, the students are able to

1. Understand the need for renewable energy sources in the context of environmental issues. (BL-2)
2. Apply the principles of solar energy for domestic and industrial usages. (BL-3)
3. Understand the working principle of wind power plants along with merits and demerits. (BL-2)
4. Describe the concepts of geothermal energy sources and biomass as a source of energy. (BL-2)
5. Explain the principles and impact of wave, tidal and OTEC plants on the environment. (BL-2)

UNIT-I

Energy Sources: Energy characteristics, forms of energy, energy chain (route), energy sectors, Indian energy scenario, energy pricing in India, energy and environment, energy security, energy conservation and its importance, energy strategy for future, classification of energy sources, availability of conventional and non-conventional (renewable) energy sources, classification of RES - solar, wind, geothermal, bio-mass, ocean tidal, ocean wave and ocean thermal energy conversion (OTEC), advantages and limitations of conventional and renewable energy sources.

UNIT-II

Solar Energy: Solar radiation, solar thermal collectors, working of flat plate and concentrating (focusing) solar collectors and their limitations, comparison of flat plate and focusing collectors, applications of solar collectors - water heating, space heating, low temperature power generation, solar cookers, water pumping, SODIS, solar thermal power plant, advantages and limitations of solar energy systems, PV materials, PV cells and their manufacturing, space based solar power (SBSP), solar satellite system, advantages and disadvantages of SBSP.

UNIT-III

Wind Energy: Sources of wind, merits and demerits of wind energy, site selection for wind energy conversion system, wind turbine (wind mill), classification of wind mills, working principle horizontal axis and vertical axis windmills, horizontal vs vertical axis windmills, power extracted from the wind, effect of velocity on power generation, new developments and problems in operating large wind power generators.

UNIT-IV

Geothermal Energy: Layers in earth, resources of geothermal energy, hydrothermal, petrothermal and geopressure resources, advantages, disadvantages, applications and environmental effects of geothermal energy sources.

Biomass Energy: Resources, biogas and its composition, process of biogas generation, wet process and dry process, raw materials available for biogas fermentation, economical, social, environmental and health benefits of biogas utilization, selection of site and constructional techniques of a biogas plant, working of KVIC, Pragathi design, Janata and Deenbandu biogas plants, common operational problems, causes and remedies relating to a biogas plant.

UNIT V

Tidal power: Tidal systems, site selection for tidal power plant, schematic layout of tidal power house, principle of operation of single basin and double basin tidal plants, advantages and disadvantages of tidal power.
Wave energy - Differences between tides and waves, advantages and disadvantages of wave power, problems associated with wave energy collection, working principle of wave energy conversion devices.
Ocean thermal energy conversion (OTEC) - OTEC power plants, location, open cycle and closed cycle OTEC plants, advantages, limitations and applications of OTEC, environmental impact of OTEC plants.

Text Books:

1. S. Hasan Saeed and D.K. Sharma, “Non Conventional Energy Resources”, S.K. Kataria & Sons, New Delhi, 2017.
2. Dr. R.K. Singal, “Non Conventional Energy Resources”, S.K. Kataria & Sons, New Delhi, 2005.
3. G.D. Rai, “Non Conventional Energy Sources”, Khanna Publishers, New Delhi, 2011.

Suggested Reading:

1. K. M. Mittal, “Non-Conventional Energy Systems”, Wheeler Publishing Co. Ltd, New Delhi, 2003.
2. Shali Habibulla, “Non-Conventional Energy Sources”, State Institute of Vocational Education, Hyderabad, 2005.

18ME E18

CONTROL SYSTEMS THEORY

(Core Elective - V)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. To provide with basic knowledge of control systems, associated terminologies, transfer function.
2. Familiar with basic electrical, mechanical & electromechanical system and their representation in Differential Equation /Transfer function form.
3. To make students familiar with system performance analysis in time & frequency domain.
4. To understand different methods of stability analysis
5. To provide basic pathway to space representation and controllability and observability

Outcomes: At the end of the course, the students are able to

1. Understand control system, modeling and transfer functions of different systems**.** (BL-3)
2. Apply the concept of block diagram and signal flow graphs to different systems. (BL-3)
3. Differentiate between time domain and frequency domain techniques. (BL-2)
4. Examine the stability of a system using different approaches. (BL-3)
5. Analyze the system in state space and to find out the controllability and observability. (BL-4)

UNIT-I
Mathematical Modeling: Introduction to control systems **,** Open loop & closed loop systems, Mathematicalmodeling & Mechanical systems, Transfer functions from Governing equations, Electrical, hydraulic systems pneumatic, thermal systems, AC,DC servomotors &Electromechanical servo systems

UNIT-II
Components of Control System: Introduction to Block diagrams & Problems, Signal flow graph & mason'sgain formula, Transient response &time domain specifications of 1^{st} order systems, 2^{nd} order systems & time domain specifications, Steady state error, error coefficients, Sensitivity Performance Indices

UNIT-III
Time Domain Analysis: Routh criteria & root locus method, Frequency response, Bode & polar plots,Correlation between Transient & frequency response, Band width, Experimental determination of transfer function

UNIT-IV
Stability Analysis: Nyquist Criteria, Phase & gain margins, Lead, lag compensator design lead-lagcompensator design, PID-controller, linearization of non linear systems

UNIT-V
State Space Representation: State space representation of linear control systems, State transition matrix, **Solution of State Space Equations**: Zero input response and Zero state response, Concept of controllability &observability

Text Books:

1. K. Ogata, “Modern control Engineering”, Prentice Hall, 2015.
2. M. Gopal., “Control Systems”, Tata McGraw Hill, 2012.
3. D. Roy Choudhury, “Control System Engineering”, PHI, 2005

Suggested Reading:

1. Norman S.Nise., “Control Systems Engineering”, John Wiley & sons, Inc., 2018.
2. R.C. Dorf, “Modern Control systems”, Addison Wesley, 2011

18ME E19

ARTIFICIAL INTELLIGENCE

(Core Elective - V)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Provide a strong foundation of fundamental concepts in Artificial Intelligence.
2. Discuss the various paradigms involved in solving an AI problems which involve perception, reasoning and learning
3. Apply the AI concepts to build an expert system to solve the real-world problems.
4. Familiarize with the types of machine learning.
5. Applications of AI in the field of mechanical engineering.

Outcomes: At the end of the course, the students are able to

1. Differentiate between a rudimentary Problem and an AI problem, its Characteristics and problem solving Techniques. (BL-2)
2. Compare and contrast the various knowledge representation schemes of AI. (BL-4)
3. Analyze various reasoning and planning techniques involved in solving AI problems. (BL-4)
4. Understand the different learning techniques. (BL-2)
5. Apply the AI techniques in the field of mechanical engineering. (BL-3)

UNIT - I
Introduction: Definition, history, applications. Problem Solving: AI problems, AI Technique, Defining problem as a State-Space Search, Problem Characteristics. Heuristic Search Techniques: Generate–and–test, Hill Climbing, Constraint Satisfaction.

UNIT - II
Knowledge Representation (Logic): Representing facts in logic, proposition logic, predicate logic, resolution and unification. Knowledge Representation (Structured): Declarative representation, Semantic nets, procedural representation, frames.

UNIT - III
Reasoning: Probability and Bayes theorem, certainty factors and rule based systems, Bayesian Networks, Dempster-Shafer theory. Planning: components, goal stack planning, nonlinear planning, hierarchical planning.

UNIT - IV
Learning: Introduction, Rote learning, learning by taking advice, learning in problem solving and learning from examples: decision tree. Intelligent Agents: classification, working of an agent, single agent and multi agent systems, multi agent application.

UNIT – V
Expert System: Representing and Using Domain Knowledge, Expert systems shells, Explanation, Knowledge Acquisition. Perception and Action: Real Time Search, Vision, Speech Recognition, Action: Navigation, Manipulation, Robot architectures. Scope and applications of AI in Mechanical Engineering

Text Books:

1. Elaine Rich, Kevin Night, Shivashankar B Nair, “Artificial Intelligence”, 3/e, TMH, 2008
2. Russell Norvig, “Artificial Intelligence-Modern Approach”, 3/e, PearsonEducation, 2010
3. Nilakshi Jain “Artificial Intelligence: Making a System Intelligent”, Wiley India, 2019

Suggested Reading:

1. Saroj Kaushik, “Artificial Intelligence”, Cengage Learning India, 2012
2. Deepak Khemani, “A First Course in Artificial Intelligence”, TMH, 2017

18ME E20

INDUSTRIAL ADMINISTRATION AND FINANCIAL MANAGEMENT

(Core Elective - V)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Various types of business organizations and organization structures and importance of plant location and plant layout
2. Importance of industrial engineering techniques like method study and work measurement.
3. The significance of quality control and production planning and control
4. The importance of project management techniques
5. The total cost of a product based on elements of cost

Outcomes: At the end of the course, the students are able to

1. Understand different types of business organizations, functions of management and importance of various types of plant layouts. (BL-2)
2. Apply techniques of method study and work measurement in organizations to enhance productivity (BL-3)
3. Usequality control charts and tools in industries. (BL-3)
4. Apply various optimization and project management techniques for solving real time problems. (BL-3)
5. Understand basic concepts of Cost accounting and financial management . (BL-2)

UNIT-I

Industrial Organization: Definition of an organization, types of various business organizations, organizationstructures and their relative merits and demerits, functions of management.

Plant location and layouts: Factors affecting the location of plant and layout, types of layouts and their meritsand demerits.

UNIT-II

Work study: Definitions, objectives of method study and time study, steps in conducting method study,symbols and charts used in method study, principles of motion economy, calculation of standard time by time study and work sampling, performance rating factor, types of ratings, job evaluation and performance appraisal, wages and incentive plans.

UNIT-III

Inspection and quality control: Types and objectives of inspection, S.Q.C., its principles. Quality control charts and sampling plans, quality circles, introduction to ISO.

Production planning and control (PPC): Types of production systems, principles of PPC and itsfunctions.

UNIT-IV

Optimization: Introduction to linear programming and graphical solutions, assignment problems.

Project Management: Introduction to CPM and PERT, determination of critical path.

Material Management: Classification of materials, materials planning, duties of purchase manager,determination of economic ordering quantities, types of materials purchase.

UNIT-V

Cost accounting: Elements of cost, various costs, types of overheads, break even analysis and its applications,depreciation, methods of calculating depreciation fund, nature of financial management, time value of money, techniques of capital budgeting and methods, cost of capital, financial leverage.

Text Books:

1. O.P. Khanna "Industrial Engineering and Management", Dhanapat Rai & Sons, 2018
2. S.D. Sharma, "Operations Research" , Kedarnat , Ramnath & Co., Meerut,2012
3. Pandey I.M. , " Financial Management", Vikas Publ. House, New Delhi, 2016

Suggested Reading:

1. William J Stevenson, "Operations Management", McGraw Hill, 2018
2. Paneer Selvam, "Production and Operations Management", Pearson Education, 2012.

18PE E11

PRINCIPLES AND APPLICATIONS OF ADDITIVE MANUFACTURING

(Core Elective - V)

Instruction	3	Hours per week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. To introduce students the basics of additive manufacturing, its advantages and limitations and concept of mass customization.
2. To familiarize students with different additive manufacturing techniques.
3. To teach students about STL file issues and familiarize them with various RP softwares.
4. To demonstrate various post processing techniques and rapid tooling concept.
5. To demonstrate the applications of rapid prototyping in various fields

Outcomes: At the end of the course, the students are able to

1. Understand the fundamental concepts of Additive manufacturing, its advantages and Disadvantages (BL-2)
2. Select suitable process and materials used in Additive Manufacturing (BL-5)
3. Analyze pre-processing issues for Additive Manufacturing and related operations for STL file generation. (BL-4)
4. Identify different post processing techniques for enhancing the properties of the 3D printed components (BL-3)
5. Infer the prospects of additive manufacturing in various industrial sectors. (BL-2)

UNIT-I

Introduction: Need for Additive Manufacturing, Generic AM process, Difference between AM and CNC, Classification of Additive Manufacturing processes, Metal systems,Milestones in AM development .Materilas used in Additive Manufacturing Related Technologies-Reverse Engineering.Advantages and Limitations of AM.

UNIT-II

Photo polymerization process: Stereolithography (SL), Materials, SL resin curing process, Process Benefits and Drawbacks, Applications of Photo polymerization Process.
Powder bed fusion process: Introduction, Selective laser Sintering (SLS), Materials, Powder fusion mechanism, Process Benefits and Drawbacks, Applications of Powder Bed Fusion Process.
Extrusion-based systems: Fused Deposition Modelling (FDM), Principles, Materials, Process Benefits and Drawbacks, Applications of Extrusion-Based Process.
Material Jetting Process: Evolution of Printing as an Additive Manufacturing Process, Materials, Process Benefits and Drawbacks, Applications of Material Jetting Process.

UNIT-III

Binder Jetting Process: Materials, Process Benefits and Drawbacks, Technical challenges in printing, Applications of Binder Jetting Process
Sheet Lamination Process: Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM, and UC applications

Directed Energy Deposition Process: Process Description, Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition, Benefits and drawbacks, Applications of Directed Energy Deposition Process.

UNIT-IV

Pre-processing in Additive Manufacturing: Preparation of 3D-CAD model, Reverse engineering, Reconstruction of 3D-CAD model using reverse engineering, Part orientation and support generation, STL Conversion, STL error diagnostics, Slicing and Generation of codes for tool path.

Post processing in AM: Post processing equipment – support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, Property enhancements using non–thermal and thermal techniques.

UNIT-V

Rapid Tooling: Introduction to Rapid Tooling (RT), Conventional Tooling Vs Rapid Tooling

AM Applications: Application in Design, Engineering, Analysis & Planning, Application in Aerospace Industry, Automotive Industry, Jewelry Industry, Coin Industry, Biomedical applications.

Text Books:

1. Chua Chee Kai, Leong Kah Fai, “3D Printing and Additive Manufacturing: Principles & Applications”, 4th Edition, World Scientific, 2015.
2. Ian Gibson, David W Rosen, Brent Stucker., “Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing”, 2nd Edition, Springer, 2015
3. K. Venuvinod and Weiyin Ma, “Rapid Prototyping: Laser-based and Other Technologies”, Springer, 2004.

Suggested Reading:

1. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001.
2. Rafiq Noorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006.

18ME C20

CAD/CAM LAB

Instruction	2	Hours per week
Duration of SEE	2	Hours
SEE	35	Marks
CIE	15	Marks
Credits	1	

Objectives:

1. To teach the basic design process and the importance and types of geometric modeling techniques
2. To teach Assembly modeling by applying suitable assembly constraints
3. To generate orthographic views of components and assemblies.
4. To demonstrate the Indication of size, form and positional tolerances on the drawing sheets
5. To demonstrate the working of CNC machines and write part programs for different operations

Outcomes: At the end of the course, the students are able to

1. Model components using CAD software. Select appropriate commands to generate 3D model (BL-3)
2. Select constraints to assemble the components (BL-3)
3. Develop manufacturing drawings from 3D models (BL-3)
4. Analyze the concept CNC part program to generate tool path for different machining operations (BL-4)
5. Develop a product using CAD/CAM technology (BL-6)

List of the Exercises:

1. Introduction to CAD Package, Working with sketch mode and introduction to various Part Features.
2. Part modeling of various machine components
3. Format of drawing sheet, title block, Generating and editing drawings
4 Assembly modeling of Stuffing Box
5 Assembly modeling of Screw Jack
6 Assembly modeling of Crosshead
7. Production drawing of components and indicating tolerances on size and geometrical form, Position; Indicate Surface finish, surface treatments if any and writing process sheet for anyone component
8. Introduction to CNC machines, Working, writing of process sheets, Contouring on CNC Milling Machine.
9. Rectangular & Circular Pocketing on CNC Milling Machine
10 Step Turning and Taper Turning on CNC Lathe Machine
11. Multiple Turning on CNC Lathe Machine
12. Study of 3D printer
13. Design a product and Manufacture / generate CNC Machining tool path for its components

Note: Student should complete a minimum of 10 exercises including exercise number 13 which is compulsory.

Text books:

1. P.N. Rao, "CAD/CAM: Principles and Applications",Tata McGraw-Hill, July 2017
2. N Mehta, "Machine Tool Design and Numerical Control", McGraw Hill Education, 3/e, 2017
3. Dassault Systems, "SOLIDWORKS Essentials: Training", SolidWorks corp., 2011

Suggested Reading:

1. https://my.solidworks.com/solidworks/guide/SOLIDWORKS_Introduction_EN.pdf
2. https://help.solidworks.com

18ME C21

THERMAL ENGINEERING LAB

Instruction	2	Hours per week
Duration of SEE	2	Hours
SEE	35	Marks
CIE	15	Marks
Credits	1	

Objectives:

1. To demonstrate knowledge in evaluating thermal conductivity of metal rod.
2. Student will understand how to evaluate critical heat flux.
3. Student will come to know the working principle of axial flow fan and centrifugal blower.
4. Student will understand to evaluate the COP of Refrigeration tutor and AC tutor.
5. Student will come to know to evaluate drag and lift coefficients for contoured bodies.

Outcomes: At the end of the course, the students are able to

1. Determine thermal conductivity of a metal rod and critical heat flux of a copper wire (BL-3)
2. Estimate the convective heat transfer coefficients for phase change heat transfer and effectiveness of cross flow heat exchanger. (BL-3)
3. Evaluate the performance of rotary compressors, refrigeration and air conditioned tutors. (BL-5)
4. Evaluate drag and lift coefficients for different profiles of automobiles. (BL-5)
5. Determine the pressure distribution in a nozzle and around symmetrical bodies. (BL-3)

List of the Experiments

1. Study of Thermal conductivity of metal rod.
2. Determination of critical heat flux for copper wire in water.
3. Evaluate the convective heat transfer coefficient for condensation and boiling equipment.
4. Determination of pressure distribution for convergent and divergent nozzle
5. Study of overall efficiency of axial flow fan
6. Determination of overall efficiency of centrifugal blower
7. Study of COP of refrigerating tutor
8. Study of COP of air conditioning tutor
9. Evaluate the effectiveness of cross flow heat exchanger.
10. Determination of pressure distribution for a cylinder
11. Determination of pressure distribution for an aerofoil.
12. Determination of lift and drag coefficient for different contours
13. Investigation of the wind tunnel performance by using the modeling and simulation

Note: Student should complete a minimum of 10 experiments including experiment number 13 which is compulsory.

Text Books:

1. S M Yahya, "Fundamentals of Compressible Flow", New Age International Publishers, 2014.
2. Mahesh M. Rathore, "Thermal Engineering", TMH, New Delhi, 2010
3. M L Mathur & F S Mehta, "Thermal Engineering", Jain Brothers, New Delhi, 2014

Suggested Reading:

1. V. Ganeshan, "Gas Turbines", Tata Mc Graw Hills, New Delhi, 2010.
2. R.K. Rajput, "Heat Transfer", Laxmi Publication, 2014

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)
AICTE MODEL CURRICULUM
B.E (Mechanical Engineering)

SEMESTER – VII

S. No.	Course Code	Title of the Course	Scheme of instruction			Scheme of examination			Credits
			Hours per week			Duration in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	18ME C22	Metrology and Instrumentation	3	--	--	3	30	70	3
2	18ME C23	Operations Research	3	--	--	3	30	70	3
3	18ME C24	Finite Element Analysis	3	--	--	3	30	70	3
4		Core Elective – VI	3	--	--	3	30	70	3
5		Open Elective – I	3	--	--	3	30	70	3
PRACTICALS									
6	18ME C25	Metrology and Instrumentation Lab	--	--	3	3	25	50	1.5
7	18ME C26	Computer Aided Engineering Lab	--	--	3	3	25	50	1.5
8	18ME C27	Project: Part – 1	--	--	4	--	50	--	2
		TOTAL	**15**	--	**10**	--	**250**	**450**	**20**

L: Lecture T: Tutorial D:Drawing P: Practical

CIE – Continuous Internal Evaluation SEE – Semester End Examination

Core Elective– VI (3/3)			**Open Elective–I (3/3)**		
S NO	**Subj.Code**	**Name of the Subject**	**S NO**	**Subj.Code**	**Name of the Subject**
1	18ME E21	Power Plant Engineering	1	18IT O01	Object Oriented Programming using JAVA
2	18ME E22	Engineering Research Methodology	2	18PY O01	History of Science & Technology
3	18ME E23	Data Analytics	3	18EG O02	Gender Sensitization
4	18ME E24	Innovation and Intellectual Property Rights	4	18IT O03	Principles of Internet of Things
5	18PE E12	Supply Chain Management	5	18CS O09	Basics of Artificial Intelligence

18ME C22

METROLOGY AND INSTRUMENTATION

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:
1. To familiarize with limits, fits & tolerances and fundamental concepts of linear and angular measurements.
2. To have adequate skill in the usage of various precision measuring instruments and the concepts of limit gauges.
3. To learn the importance of Geometric form and how to measure form errors.
4. To have knowledge in the concepts of classification of instrument errors and their characteristics.
5. To understand the working principles of various instruments used for the measurement of displacement, pressure and temperature.

Outcomes: At the end of the course, students are able to
1. Understand the need, accuracy and associated concepts of measurements. (BL-2)
2. Select appropriate gauges for inspection and design. (BL-3)
3. Calculate surface roughness by using appropriate instruments. (BL-3)
4. Analyze and interpret the types of errors, strain measurement and instrument characteristics. (BL-4)
5. Evaluate measuring methods and devices for displacement, pressure & temperature. (BL-5)

UNIT-I

Limits, Fits and Tolerances: Interchangeability, nominal size, limits , tolerances, allowance, fundamental deviation, unilateral and bilateral tolerances, types of fits, alpha numeric designation of limits/fits, hole and shaft basis systems, selective assembly.

Linear and angular measurement: Line and end standards, slip gauges, Tomlinson gauges and sine bar.

UNIT-II

Design of limit gauges: Taylor’s Principle for plan limit gauges, design of GO and NO GO gauges, use of plug, ring and snap gauges.

Comparators: Introduction, dial indicator, sigma mechanical comparator, back pressure type pneumatic comparator.

Optical measuring instruments: Optical projector principle and its uses, tool maker’s microscope principle and its uses, interferometry.

UNIT-III

Straightness, Flatness and Roundness Measurement: Definitions, measurement by beam comparator, straight edge, spirit level, and bench centers.

Surface roughness measurements: Roughness and waviness, numerical assessment of surface roughness, surface roughness measurement by profilometer, Taylor Hobson Talysurf, ISI symbols for indication of surface finish.

UNIT-IV

Screw thread metrology: Basic terminology of screw thread, measurement of effective diameter by 2 wire and 3 wire methods, best wire size.

Gear tooth metrology: Spur gear nomenclature, gear tooth thickness measurement by gear tooth vernier.

Instrumentation: Static and dynamic characteristics of instruments, types of errors, strain measurement with strain gauges, gauge factor, rosette Gauges.

UNIT-V

Transducers: Displacement measurement by L.V.D.T, pressure measurement by bourdon pressure gauge, bulk modulus pressure gauge, pirani gauge, temperature measurement by thermo couples, laws of thermo electricity, types of materials used in thermocouples.

Text Books:

1. R.K. Jain, “Engineering Metrology”, Khanna Publications, 1996.
2. Doeblin, "Measurement Systems Application and Design", TMH, 5/e., 2004.
3. Beckwith, Buck, Lienhard, "Mechanical Measurements", PEA, 3rd Indian Reprint, 2001.

Suggested Reading:

1. RegaRajendra,"Principles of Engineering Metrology", Jaico Publishing House, Mumbai, 2008.
2. B.C. Nakra& K.K. Chaudhary , "Instrumentation Measurement and Analysis", 3/e, McGrawhill, 2014 .

18ME C23

OPERATIONS RESEARCH

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:

1. Students will come to know the formulation of LPP models.
2. Students will understand the Algorithms of Graphical and Simplex Methods.
3. Students will understand the Transportation and Assignment techniques.
4. Students will come to know the procedure of Project Management along with CPM and PERT techniques.
5. Students will understand the concepts of sequencing and queuing theory.

Outcomes: At the end of the course, the students are able to

1. Understand the concepts of linear programming problems. (BL-2)
2. Solve the given transportation problem. (BL-3)
3. Develop optimum pair of operations and resources by using Assignment technique. (BL-3)
4. Analyze project management techniques like CPM and PERT to plan and execute projects successfully. (BL-4)
5. Apply sequencing and queuing theory concepts for industry applications. (BL-3)

UNIT-I

Introduction: Definition and scope of operations research.
Linear programming: Introduction, formulation of linear programming problems, graphical method of solving LP problem, simplex method, degeneracy in simplex, duality in simplex.

UNIT-II

Transportation models: Finding an initial feasible solution - north west corner method, least cost method, Vogel's approximation method, finding the optimal solution, special cases in transportation problems - unbalanced transportation problem, degeneracy in transportation, profit maximization in transportation.

UNIT-III

Assignment techniques: Introduction, Hungarian technique of assignment techniques, unbalanced problems, problems with restrictions, maximization in assignment problems, travelling salesman problems.

UNIT-IV

Project management: Definition, procedure and objectives of project management, differences between PERT and CPM, rules for drawing network diagram, scheduling the activities, Fulkerson's rule, earliest and latest times, determination of ES and EF times in forward path, LS & LF times in backward path, determination of critical path, duration of the project, free float, independent float and total float, crashing of network.

UNIT-V

Sequencing models: Introduction, General assumptions, processing 'n'jobs through two machines, processing 'n' jobs through three machines.

Queuing theory: Introduction, Kendall's notation, single channel - Poisson arrivals-exponential service times.

Text Books:

1. Hamdy A. Taha, "Operations Research-An Introduction", 10/e, Pearson education India, 2017.
2. S.D. Sharma, "Operations Research", Kedarnath, Ramnath& Co., Meerut,2009.
3. V.K. Kapoor, "Operations Research", S. Chand Publishers, New Delhi, 2004.

Suggested Reading:

1. R. PaneerSelvam, "Operations Research", 2/e, PHI Learning Pvt. Ltd., New Delhi,2008.
2. Nita H. Shah, Ravi M. Gor, HardikSoni, "Operations Research", PHI Learning Private Limited,2013.

18ME C24

FINITE ELEMENT ANALYSIS

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:

1. Equip the students with the Finite Element Analysis fundamentals and formulations.
2. Enable the students to formulate the axial, truss, beam and circular shaft problems.
3. Enable the students to formulate 2D problems with special cases.
4. Enable the students to formulate quadrilateral element, use of numerical integration, Gaussian quadrature and one dimensional dynamic problems.
5. Enable the students to understand the convergence requirements, heat transfer, formulate 3D problems and perform engineering simulations using Finite Element Analysis software (ANSYS).

Outcomes: At the end of the course, the students are able to

1. Understand FE method for solving field problems using energy formulations. (BL-2)
2. Analyze bars, trusses, beams and circular shafts for static and dynamic analysis. (BL-4)
3. Formulate 2D structural components using triangular element for plane stress, plane strain and axi-symmetric problems. (BL-4)
4. Derive stiffness matrix for 4 node quadrilateral isoparametric element for static analysis and 3 D elements. (BL-6)
5. Solve heat transfer problems and apply finite element analysis software for engineering solutions. (BL- 3)

UNIT - I

Fundamental concepts: Introduction to finite element method, stresses and equilibrium, boundary conditions, strain –displacement and stress – strain relationship.

One dimensional problem: Finite element modeling co-ordinates and shape functions, virtual work and potential energy approach, assembly of global stiffness matrix and load vector, finite element equations, treatment of boundary conditions, analysis of axial element and quadratic element.

UNIT - II

Analysis of trusses and frames: Element stiffness matrix for a truss member, analysis of plane truss with two degrees of freedom at each node.

Analysis of beams: Element stiffness matrix for two nodes (two degrees of freedom per node), analysis of frames with two translations and rotational degrees of freedom per node, analysis of circular shaft subjected to torsion.

UNIT - III

2D triangular elements: Plane stress, plane strain and axisymmetry,finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions, finite element modeling of axisymmetric solids subjected to axisymmetric loading with triangular elements.

UNIT - IV

Quadrilateral elements and numerical integration: Two dimensional four nodedisoparametric elements, numerical integration and gauss quadrature.

Dynamic Analysis: Formulation of finite element model, element mass matrices, evaluation of Eigen values and Eigen vectors for a stepped bar and beam.

UNIT - V

Heat transfer analysis: Steady state heat transfer analysis, one dimensional analysis of a fin and two dimensional analysis of thin plate, formulation of time dependent field problems, applications to one dimensional heat flow in a rod.

3D elements and FEA software: Introduction to finite element formulation of three dimensional problems in stress analysis, convergence requirements.

Introduction to finite element analysis software: Modeling, analysis and post processing.

Text Books:

1. G. Ramamurthy, "Applied Finite Element Analysis", I.K. International Publishing House Pvt. Ltd., New Delhi, 2009.
2. Tirupathi R Chandraputla and Ashok D Belagundu, "Introduction to Finite Elements in Engineering", Prentice Hall of India, 1997
3. Daryl L. Logan, "A First Course in the Finite Element Method", Cengage Learning, 2011.

Suggested Reading:

1. S.S. Rao, "The Finite Element Method in Engineering", Pergamon Press, 1989.
2. L. J. Segerlind, "Applied Finite Element Analysis", Wiley Eastern, 1984.

18ME E21

POWER PLANT ENGINEERING

(Core Elective - VI)

Instruction	3	Hours Per Week
Duration of SEE	3	Hours
SEE	70	Marks
CIE	30	Marks
Credits	3	

Objectives:

1. Different types of power plants and their site selection criteria
2. Operation of thermal power plant
3. About hydraulic power plants, dams and spillways
4. Different types of nuclear power plants including Pressurized water reactor, Boiling water reactor, Liquid metal fast breeder reactor and Gas cooled reactor
5. The power plant economics, environmental and safety aspects of power plant operation.

Outcomes: At the end of the course, the students are able to

1. Select the suitability of site for a power plant in the context of environment. (BL-4)
2. Discuss ash handling and coal handling methods in thermal power plants. (BL-2)
3. Understand the importance of site selection for a hydro-power plant in the context of societal and environment. (BL-2)
4. Explain the safety aspects of nuclear waste disposal. (BL-2)
5. Estimate the economic factors and pollutant formation from power plants. (BL-3)

UNIT – I

Introduction: Power plant, classification of power plants, conventional and non-conventional power plants, merits and demerits of conventional and non-conventional power plants.

Steam power plant: Selection of site for steam power plant, plant layout, formation and types of coal, stages in coal handling, working of coal handling equipment – belt conveyors, screw conveyors, bucket elevators and grab bucket conveyors, general layout of ash handling and dust collection system, uses of ash and dust, ash handling systems – mechanical, pneumatic, steam jet and hydraulic systems of ash handling.

UNIT- II

Combustion process in steam power plant: Stoker firing, overfeed stokers - travelling grate stokers and spreader stokers, underfeed stokers - single retort and multi-retort underfeed stokers, elements of pulverized fuel burning system, advantages and disadvantages of pulverized fuel burning system, pulverized fuel burners – long flame, short flame, tangential and cyclone burners, fluidized bed combustion (FBC), benefits and disadvantages of FBC.

UNIT- III

Hydro electric power plant: Hydrological cycle, hydrograph, flow/mass duration curve, selection of site for hydro-electric plant, advantages and disadvantages of hydro-electric plants, elements (flow-sheet) of hydro-electric power plant, types and working of hydroelectric power plants, storage and pondage, parts and terminology of a dam, selection of site for dams, classification and working of different types of dams, spillways, necessity and location of spillways, classification and working of different types of spillways.

UNIT - IV

Nuclear power plant: Nuclear fuel, breeding and fertile materials, distinction between fissionable, fissile and fertile materials, advantages and disadvantages of nuclear power, components of nuclear reactor, types of nuclear reactors, working of pressurized water reactor, boiling water reactor, sodium-graphite reactor, fast breeder reactor and gas cooled reactors – radioactive (nuclear) waste disposal methods.

UNIT - V

Power plant economics and environmental considerations: Definition and related exercises on connected load, demand (load), maximum demand (peak load), demand factor, average load, load factor, diversity factor, utilization factor, plant capacity factor and plant use factor, fixed cost and variable cost, methods to find depreciation cost and related numerical problems, economics in plant selection, effluents from power plants and impact on environment, pollutants, pollution control.

Text Books:

1. R.K. Rajput, “A Text Book of Power Plant Engineering”, 4/e, Laxmi Publications (P) Ltd., New Delhi, 2015.
2. P.K. Nag, “Power Plant Engineering”, 4/e, McGraw-Hill Education (India) Private Limited, New Delhi, 2014.
3. P.C. Sharma, “A Text Book of Power Plant Engineering”, S.K. Kataria& sons, 2019

Suggested Reading:

1. R. Yadav, “Fundamentals of Power Plant Engineering”, Central Publishing House, Allahabad, 2012.
2. S.C. Arora and S. Domkundwar, “A Course in Power Plant Engineering”, DhanpatRai& Sons, New Delhi, 2005.

18ME E22

ENGINEERING RESEARCH METHODOLOGY

(Core Elective - VI)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:
1. To make the students to formulate the research problem.
2. To identify various sources for literature review and data collection.
3. To prepare the research design.
4. To equip the students with good methods to analyze the collected data.
5. To explain how to interpret the results and report writing.

Outcomes: At the end ofthe course, the students are able to
1. Define researchproblem. (BL-1)
2. Review and assess the quality of literature from varioussources. (BL-2)
3. Understand and develop various research designs. (BL-2)
4. Analyze problem by statistical techniques: ANOVA, F-test, Chi-square. (BL-4)
5. Improve the style and format of writing a report for technical paper/ Journalreport. (BL-4)

UNIT – I

Research methodology: Objectives and motivation of research, types of research- descriptive vs. analytical, applied vs. fundamental, quantitative vs. qualitative, conceptual vs. empirical, research approaches, significance of research, research methods vs. methodology, research process, criteria of good research, problems encountered by researchers in India, technique involved in defining aproblem.

UNIT–II

Literature survey: Importance of literature survey, sources of information-primary, secondary, tertiary, assessment of quality of journals and articles, information through internet.

UNIT – III

Research design: Meaning of research design, need of research design, feature of a good design important concepts related to research design, different research designs, basic principles of experimental design, steps in sample design.

UNIT – IV

Data collection: Collection of primary data, Secondary data, measures of central tendency-mean, mode, median, measures of dispersion- range, mean deviation, standard deviation, measures of asymmetry (skewness), important parametric tests -z, t, F, Chi-Square, ANOVA significance.

UNIT – V

Research report formulation and presentation: Synopsis, dissertation, technical paper and journal paper, writing research grant proposal, making presentation with the use of visual aids,writing a proposal for research grant.

Text Books*:*

1. C.R Kothari, “Research Methodology Methods & Technique”, New Age International publishers, 2004.
2. R. Ganesan, “Research Methodology for Engineers”, MJP Publishers,2011.
3. Vijay Upagade and AravindShende, “Research Methodology”, S. Chand &Company Ltd., NewDelhi, 2009.

Suggested Reading:

1. G. NageswaraRao, “Research Methodology and Quantitative methods”, BS Publications, Hyderabad, 2012.
2. Naval Bajjai, “Business Research Methods”, Pearson Education, 2011.

18ME E23

DATA ANALYTICS

(Core Elective - VI)

Instruction	3Hours per Week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:

1. To familiarise the students with the concept of descriptive and inferencial statistics.
2. To make the students to understand the concept of machine learning.
3. To make the students to understand various techniques of supervised learning.
4. To make the students to learn the concepts of unsupervised learning.
5. To make the students to learn the prescriptive analytics.

Outcomes: At the end of the course, the students are able to

1. Solve the problems using statistics, regression analysis and ANOVA. (BL-3)
2. Understand the concept of machine learning. (BL-2)
3. Apply various supervised learning techniques to a given problem. (BL-3)
4. Understand unsupervised learning and problems in big data analysis. (BL-2)
5. Demonstrate prescriptive analytics methods to the given data. (BL-2)

UNIT-I

Introduction: Introduction to data and analytics ,taxonomy of data analytics, typical data challenges (data quality, enrichment, integration of ERP & PLM data) ,preparing data for analytics (techniques to improve data quality, integration - ETL).

Descriptive and inferential statistics: Descriptive statistics: introduction, probability distributions, inferential statistics, inferential statistics through hypothesis tests permutation & randomization test, regression & ANOVA.

UNIT-II

Machine Learning: Introduction and concepts, differentiating algorithmic and model based frameworks, regression, ordinary least squares, K nearest neighbours regression & classification.

UNIT-III

Supervised learning with regression and classification techniques: Model validation approaches, discriminantanalysis, quadratic discriminant analysis, regression and classification trees, support vector machine.

Ensemble Methods: Neural networks, deep learning.

UNIT-IV

Unsupervised learning and challenges for big data analytics: Clustering, associative rule mining, challenges for big data analytics.

UNIT-V

Prescriptive analytics: Creating data for analytics through designed experiments, creating data for analytics through active learning, creating data for analytics through reinforcement learning.

Text Books:

1. Hastie, Trevor, "The elements of statistical learning", Vol. 2. No.1.New York, springer, 2009.
2. Montgomery, Douglas C., and George C. "Ranger.Applied statistics and probability for engineers", John Wiley & Sons, 2010
3. Christopher Tong and D. Sriram, "Artificial Intelligence in Engineering Design:Knowledge acquisition, commercial systems, and integrated environments", Boston : Academic Press,1992.

Suggested Reading:

1. Anil Maheswari, "Data Analytics", McGraw-Hill,2017.
2. V.K.Jain "Data Science and Analytics (with Python, R and SPSS Programming)", Khanna Publishers, 2018.

18ME E24

INNOVATION AND INTELLECTUAL PROPERTYRIGHTS
(Core Elective - VI)

Instruction 3 Hours per Week	
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:

1. Fundamental aspects of IP
2. Aspects of IPR acts.
3. Awareness of multi disciplinary audience.
4. Awareness for innovation and its importance.
5. The changes in IPR culture and techno-business aspects of IPR.

Outcomes: At the end of the course, the students are able to

1. Understand the evolution of Intellectual property, working of organization's at global level to protect and promote intellectual property. (BL-2)
2. Apply the patent filing process at national and international level. (BL-3)
3. Derive logical conclusion of research, innovation and patent filing. (BL-4)
4. Compare different kinds of Intellectual property and their patenting system. (BL-2)
5. Understand the techno-legal-business angle of Intellectual property, infringement and enforcement Mechanismsfor protection. (BL-2)

UNIT-I

Overview of IPR: Introduction and the need for intellectual property rights (IPR), IPR in India– genesis and development, IPR abroad, some important examples of IPR, importance of WTO, TRIPS agreement, international conventions and PCT.

Patents: Macro economic impact of the patent system, patent and kind of inventions protected by a patent,patent document, how to protect your inventions, granting of patent, rights of a patent, how extensive is patent protection, why protect inventions by patents, searching a patent, drafting of a patent, filing of a patent, the different layers of the international patent system, (national, regional and international options), compulsory licensing and licensers of right & revocation, utility models, differences between a utility model and a patent, trade secrets and know-how agreements.

UNIT-II

Industrial designs: What is an industrial design, protection of industrial design, kind ofprotection available, term of protection of industrial design and need for protection.

UNIT-III

Trademarks: Definition oftrademarks, types of trademarks and functions of a trademark, registration of Trademark, benefits of registration of trademark, procedure for registration of trademark and term of validity of trademark, infringement and passing off.

UNIT-IV

Copyright: What is copyright, what is covered by copyright, term of enforcement of copyright and need for copyright protection, copyright and related rights, copyrights in computer programming.

UNIT-V

Geographical indications: Introduction, definition, difference between GI and trademark, difference between GI and appellation of origin, GI as factors of rural development, developing a geographical indication and protection

Enforcement of intellectual property rights: Infringement of intellectual property rights enforcement measures emerging issues in intellectual property protection, case studies of patents and IP protection.

Unfair competition: What is unfair competition, relationship between unfair competition and intellectual property laws.

Text Books:

1. AjitParulekar and Sarita D’ Souza, “Indian Patents Law – Legal & Business Implications”; Macmillan India ltd, 2006.
2. B. L.Wadehra;” Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications”; Universal law Publishing Pvt. Ltd., India 2000.
3. P. Narayanan; “Law of Copyright and Industrial Designs”; Eastern law House, Delhi 2010.

Suggested Reading:

1. Cronish W.R, “Intellectual Property; Patents, copyright, Trademarks and allied rights”, Sweet & Maxwell, 1993.
2. P. Narayanan, “Intellectual Property Law”, Eastern Law Edn, 1997.

18PE E12

SUPPLY CHAIN MANAGEMENT

(Core Elective - VI)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:

1. The awareness about transportation and warehouse management systems.
2. The designing supply chain networks.
3. The concept of demand and supply and integrating it with supply chain management.
4. The planning and managing inventories.
5. The pricing and revenue management.

Outcomes: At the end of the course, the students are able to

1. Understand fundamentals of supply chain and its key concepts. (BL-2)
2. Design an effective supply chain network. (BL-4)
3. Understand the essence of demand and supply and associated gaps. (BL-2)
4. Apply inventory management techniques. (BL-3)
5. Evaluate pricing and revenue management systems. (BL-5)

UNIT-I

Concept of SCM: Supply chain definition, stages of supply chain, objectives, drivers of SCM-facilities, inventory, transportation, information, sourcing and pricing, decision phases in Supply chain, pull and push processes introduction to logistics management.

UNIT-II

Designing the supply chain network: Role of distribution in supply chain and factors influencing its network design and decisions, types of distribution networks – manufacturer storage with direct shipping, manufacturer storage with direct shipping and in transit merge, distributor storage with package carrier delivery, distributor storage with last mile delivery, manufacturer/distributor storage with customer pickup, retail storage with customer pick up, framework for network design decisions-supply chain strategy, regional facility configuration, desirable sites and location choices.

UNIT-III

Planning supply and demand: Planning demand & supply in a supply chain, demand forecasting- moving averages, exponential smoothing, trend and seasonality, aggregate planning, master scheduling, materials requirement planning, time phased order plan, critical ratio, product tree structures.

UNIT-IV

Planning & managing inventories in a supply chain: Inventory control, objectives of inventory management in supply chain, deterministic inventory and probabilistic inventory control, economic order quantity, quantity discounts, Reorder point, basics of ABC analysis, FNSD analysis, VED analysis.

UNIT-V

Sourcing, pricing, coordination and IT in supply chain: Sourcing decisions, key sourcing related processes, In-house or outsource, pricing & revenue management, differential pricing strategies, coordination in supply chain, bullwhip effect, information technology and supply chain, supply chain macro processes-CRM, ISCM, SRM, TMF.

Text Books:

1. Sunil Chopra & Peter Meindl, "Supply Chain Management – Strategy, Planning and Operation", Pearson Education, Inc., Upper Saddle River, New Jersey, 2003.
2. N. J. Kumar &Mukesh Bhatia, "Supply Chain Management", Neha publishers & Distributors, 2010.
3. Michael H. Hugos, "Essentials of Supply Chain Management", 3/e, John Wiley & Sons, Inc, Hoboken, New Jersy, 2011.

Suggested Reading:

1. Martin Christopher, "Logistics & Supply Chain Management", 5/e, Financial Times Series, 2010.
2. Dobler Donald. W, David.N.Burt, "Purchasing & supply Management Text & Cases", McGraw-Hill, 1996.

18IT O01

OBJECT ORIENTED PROGRAMMINGUSING JAVA

(Open Elective)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives:

1. To familiarize with fundamentals of object-oriented programming paradigm.
2. To impart the knowledge of string handling, interfaces, packages and inner classes.
3. To facilitate learning Exception handling and Multithreading mechanisms.
4. To gain knowledge on collection framework, stream classes.
5. To familiarize with event driven GUI programming and Database connectivity.

Outcomes: Upon completing this course, students are able to:

1. Understand Object-Oriented concepts.
2. Create Java applications using sound OOP practices e.g. Inheritance, Interfaces, Packages, and Inner Classes.
3. Implement Exception Handling and Multithreading concepts in java programs.
4. Develop programs using the Java CollectionAPI and Stream classes.
5. Design and Develop GUI applications with the integration of event handling, JDBC.

Modified Course Outcomes:

1. Understand the concepts of Object-Oriented Programming and class concept in Java.
2. Apply concepts of OOP such as Inheritance, Interfaces, Packages and Inner classes.
3. Handle exceptions and demonstrate the concepts of Multithreading and Generic classes.
4. Develop programs using Java Collection API and Stream classes.
5. Design and Develop GUI applications with JDBC.

UNIT-I

OOP concepts - Data abstraction, encapsulation, inheritance, benefits of inheritance, polymorphism, classes and objects, Procedural and object oriented programming paradigms.

Introduction to Java: Java's Magic: The Byte code, The Java Buzzwords, Simple Java Programs, Java Primitive Types, Arrays: How to create and define arrays, Basic Operators, Control statements.

Introducing Classes: Declaring objects, methods, Constructors, this keyword, Method Overloading and Constructor Overloading, Objects as parameters, Returning objects, Use of static and final keywords.

UNIT-II

Inheritance: super and subclasses,Member access rules ,super keyword**,** Method overriding, Dynamic method dispatch , Abstract classes, using final with inheritance , Introduction to Object class.

Packages: Defining, Creating and Accessing a Package, Understanding CLASSPATH, importing packages.

Interfaces : Defining and implementing interfaces, Nested Interfaces.

Strings Handling: String &StringBuffer classes, StringTokenizer class and Wrapper classes and conversion between Objects and primitives.

Inner classes in Java: Types of inner classes, Creating static / non-static inner classes, Local and anonymous inner classes.

UNIT-III

Exception Handling in Java: what areExceptions? Exception types**,** Usage of try, catch, throw, throws and finally clauses, writing your own exception classes.

Multithreading in Java: The java Thread Model, How to create threads, Thread class in java, Thread priorities, Thread synchronization.

Generics: What are Generics? Generic classes, bounded types, Generic methods and interfaces.

UNIT-IV

Collections Framework: Overview of Collection Framework, Commonly used Collection classes – ArrayList, LinkedList, HashSet, LinkedHashSet, TreeSet, Collection Interfaces –Collection, List, Set, SortedSet, Accessing a collection via an Iteration,Storing user-defined classes in collections, Map Interfaces and Classes, Using a comparator. Legacy classes – Vector, Hashtable, The Enumeration interface.

Input/Output : How to read user input (from keyboard) using scanner class,Stream classes, InputStream, OutputStream, FileInputStream, FileOutputStream, Reader and Writer, FileReader, FileWriter cl asses. File class.

UNIT-V

GUI Design and Event Handling: Component, Container, window, Frame classes. Working with Frame windowGUI Controls, Layout Managers, Introduction to Swings, Delegation Event Model, Event Classes, Source of Events, Event Listener Interfaces, Handling button click events, Adapter classes. Writing GUI Based applications.

Database Handling in Java: Java Database Connectivity (JDBC) using MySQL.

Text Books:

1. Herbert Schildt, "Java: The Complete Reference", 8^{th}Edition, Tata McGraw Hill Publications, 2011.
2. Cay S. Horstmann, Gary Cornell, "Core Java, Volume I, Fundamentals", 8^{th}Edition, Prentice Hall, 2008.

Suggested Reading:

1. E Balagurusamy "Programming with JAVA", 6th Edition , Tata McGraw-Hill Publishing company Ltd,2019.
2. Sachin Malhotra & Saurabh Choudhary, "Programming in Java", 2^{nd}Edition, Oxford University Press, 2014.
3. C. Thomas Wu, "An introduction to Object-oriented programming with Java", 4^{th}Edition, Tata McGraw-Hill Publishing company Ltd., 2010.
4. Kathy Sierra, Bert Bates, "Head First Java: A Brain-Friendly Guide" 2^{nd} Edition, O'Reilly,2005

Web Resources:

1. https://www.cse.iitb.ac.in/~nlp-ai/javalect_august2004.html.
2. http://nptel.ac.in/courses/106106147/
3. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-092-introduction-to-programming-in-java-january-iap-2010/lecture-notes/

18 PY O01

HISTORY OF SCIENCE AND TECHNOLOGY

(Open Elective)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives: The objectives of the course is to make the student

1. Gains the knowledge about origin of science in the Stone Age and its progress during Antiquity period.
2. Familiar with scientific views in the Medieval period and during the Industrial revolution..
3. Aware of modern scientific developments from 19^{th} century onwards.

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

1. Demonstrate the process of beginning of science and civilization, knowledge acquisition and philosophical approach of science and its advancements in the Stone Ages and Antiquity period.
2. Illustrate the advancements in science and technology in the medieval period across Asia and Arab countries and decline and revival of science in Europe.
3. Explain the scientific approach and its advances of the Europeans and how the role of engineer during the industrial revolution and the major advancements.
4. Make use of the advancements in the field of science and technology by adopting new philosophies of 19^{th} and first half of 20^{th} century in finding ethical solutions to the societal problems.
5. Interpret the changes in specializations of science and the technology and build the relation between information and society from second half of 20^{th} century onwards.

UNIT-I

Science - The Beginning (through 599 BCE): The Stone Ages, Knowledge among hunter gatherers, Agricultural Revolution and other revolutions, Civilization, Major advances.

Science in Antiquity (600 BCE- 529 CE): Philosophy- a precursor to science, Hellenistic world and the Roman Empire, Other cultures of the period, Major advances.

UNIT-II

Medieval Science (530 CE - 1452 CE): The decline of science in Europe, Science in China, Science and mathematics in India, Arab science, Revival of science in Europe, Technology revolution of the Middle ages, Major advances.

The Renaissance and the Scientific Revolution (1453 CE – 1659 CE): Renaissance, Scientific Revolution, Technology, Major advances.

UNIT-III

Scientific Method: Measurement and Communication (1660 CE – 1734 CE): European domination,The scientific method, Major advances.

The Industrial Revolution (1735 CE – 1819 CE): Industrial Revolution, Rise of the engineer, Major Advances.

UNIT-IV

Science and Technology in the 19th Century (1820 CE – 1894 CE): Philosophical basis of 19th-century science,Science and the public, Science and technology, Major advances.

Rise of Modern Science and Technology (1895 CE – 1945 CE): The growth of 20thcentury science, Newphilosophies, Quantum reality, Energy sources, Electricity: a revolution intechnology, Majoradvances.

UNIT-V

Big Science and the Post-Industrial Society (1946 CE – 1972 CE): Big science, Specialization and changing categories, Technology changes society, Major advances.

The Information Age (1973 CE – 2015 CE): Information and society, Globalization, The post-industrial society,Problems of the Information age, Major Advances

Text Books:

1. Bryan Bunch and Alexander Hellemans, “The History of Science and Technology”, Houghton Mifflin Company (New York), 2004
2. JD Bernal, “Science in History”, 4 Volumes, Eklavya Publishers, 2012

Suggested Readings:

1. “The 100 Most Influential Scientists of All Time”, Edited by Kara Rogers, Britannica Educational Publishing, 2010
2. Alberto Hernandez, “A Visual History of Science and Technology”, The Rosen Publishing Group, 2016

18EG O 02

GENDER SENSITIZATION
(Open Elective)

Instruction	3 Periods per week
Duration of SEE Examination	3 Hours
SEE Examination	60 Marks
CIE	40 Marks
Credits 3	

Objectives: This course will introduce the students to:

1. Sensibility regarding issues of gender in contemporary India.
2. A critical perspective on the socialization of men and women.
3. Popular debates on the politics and economics of work while helping them reflect critically on gender violence.

Outcomes: After completion of the course the students are able to

1. Understand the difference between "Sex" and "Gender" and be able to explain socially constructed theories of identity.
2. Recognize shifting definitions of "Man" and "Women" in relation to evolving notions of "Masculinity" and "Femininity".
3. Appreciate women's contributions to society historically, culturally and politically.
4. Analyze the contemporary system of privilege and oppressions, with special attention to the ways gender intersects with race, class, sexuality, ethnicity, ability, religion, and nationality.
5. Demonstrate an understanding of personal life, the workplace, the community and active civic engagement through classroom learning.

UNIT – I
Understanding Gender:
Gender: Why Should We Study It? (Towards a World of Equals: Unit -1)
Socialization: Making Women, Making Men (Towards a World of Equals: Unit -2) Introduction. Preparing for Womanhood. Growing up Male. First lessons in Caste. Different Masculinities.

UNIT – II
Gender And Biology:
Missing Women: Sex Selection and Its Consequences (Towards a World of Equals: Unit -4) Declining Sex Ratio. Demographic Consequences.
Gender Spectrum: Beyond the Binary (Towards a World of Equals: Unit -10) Two or Many? Struggles with Discrimination.

UNIT – III
Gender and Labour:
Housework: the Invisible Labour (Towards a World of Equals: Unit -3) "My Mother doesn't Work." "Share the Load."
Women's Work: Its Politics and Economics (Towards a World of Equals: Unit -7) Fact and Fiction. Unrecognized and Unaccounted work. Additional Reading: Wages and
Conditions of Work.

UNIT-IV
Issues Of Violence
Sexual Harassment: Say No! (Towards a World of Equals: Unit -6) Sexual Harassment, not Eve-teasing- Coping with Everyday Harassment- Further Reading: "Chupulu".

Domestic Violence: Speaking Out (Towards a World of Equals: Unit -8) Is Home a Safe Place? -When Women Unite [Film]. Rebuilding Lives. Additional Reading: New Forums for Justice. Thinking about Sexual Violence (Towards a World of Equals: Unit -11) Blaming the Victim-"I Fought for my Life…." - Additional Reading: The Caste Face of Violence.

UNIT – V
Gender: Co - Existence
Just Relationships: Being Together as Equals (Towards a World of Equals: Unit -12) Mary Kom and Onler. Love and Acid just do not Mix. Love Letters. Mothers and Fathers. Additional Reading: Rosa Parks-The Brave Heart.

Textbook:

1. A. Suneetha, Uma Bhrugubanda, DuggiralaVasanta, Rama Melkote,VasudhaNagaraj, AsmaRasheed, GoguShyamala, DeepaSreenivas and Susie Tharu **"Towards a World of Equals: A Bilingual Textbook on Gender"** published by Telugu Akademi, Hyderabad, Telangana State, **2015**.

Suggested Reading:

1. Menon, Nivedita. Seeing like a Feminist. New Delhi: Zubaan-Penguin Books, 2012
2. Abdulali Sohaila. **"I Fought For My Life…and Won."**Available online at: http://www.thealternative.in/lifestyle/i-fought-for-my-lifeand-won-sohaila-abdulal/

Web Resources:
1. https://aifs.gov.au/publications/gender-equality-and-violence-against-women/introduction
2. https://theconversation.com/achieving-gender-equality-in-india

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Note: Since it is an Interdisciplinary Course, Resource Persons can be drawn from the fields of English Literature or Sociology or Political Science or any other qualified faculty who has expertise in this field from engineering departments.

18ITO03

PRINCIPLES OF INTERNET OF THINGS
(Open Elective)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives:

1. To provide an overview of Internet of Things, building blocks of IoT andreal-world applications.
2. To explore various IOT enabling technologies.
3. To facilitate students, understand Python scripts for IoT platform.
4. To identify steps in IOT design Methodology.
5. To introduce about the Raspberry Pi device, its interfaces and Django Framework.

Outcomes: Upon completing this course, students are able to:

1. Comprehend the terminology, protocols and communication modelsof IoT.
2. Define the various IoT enabling technologies and differentiate between M2M and IoT.
3. Acquire the basics of Python Scripting Language used in developing IoT applications.
4. Describe the steps involved in IoT system design methodology.
5. Design simple IoT systems using Raspberry Pi board and interfacing sensors with Raspberry Pi.

Modified Course Outcomes:

1. Outline the terminology, protocols, Communication models and Communication APIs of IoT.
2. Define the various IoT enabling technologies, Levels, Domain Specific applications and differentiation between M2M and IoT.
3. Make use the basics of Python Scripting Language for developing IoT applications.
4. Infer the steps involved in IoT system design methodology with Home Automation case study.
5. Examine IoT systems using the Raspberry Pi board and interfacing sensors.

UNIT-I

Introduction & Concepts: Introduction to Internet of Things- Definitions & Characteristics ofIoT, Physical Design of IOT-Physical Layer, Network Layer, Transport Layer, Application Layer, Things in IoT, IoT Protocols, Logical Design of IOT-IoTFunctional Blocks, IoT Communication Models-Request-reponse,Publisher-Subscriber,Push-Pull,Exclusive Pair, IoT Communication APIs-REST API, Websocket API,

UNIT-II

IOT Enabling Technologies: Wireless Sensor Networks, Cloud Computing, Big Data Analytics,Communication Protocols, Embedded Systems, IOT Levels & Deployment Templates. Differences and similarities between IOT and M2M, Domain Specific IoT’s – IoT applications for Home Automation, Cities, Environment, Energy,Retail, Logistics, Agriculture, Industry, health and Lifestyle.

UNIT-III

Introduction to Python–Motivation for using Python for designing IoT systems, Languagefeatures of Python, Data types- Numbers, Strings, Lists, Tuples, Dictionaries, Type Conversions,Data Structures: Control of flow-if, for, while, range, break/continue, pass, functions, modules,packaging, file handling, data/time operations, classes, Exception handling,

UNIT-IV

IoT Platforms Design Methodology: Introduction, IoT Design Methodology Steps-Purpose andRequirements Specification, Process Specification, Domain Model Specification, InformationModel Specification, Service Specifications, IoT Level Specification, Functional ViewSpecification, Operational View Specification, Device and Component Integration, ApplicationDevelopment, Case Study on IoT System for Weather Monitoring.

UNIT-V

IoT Physical Devices and End Points: Basic building blocks of an IoT device, RaspberryPi abouttheRaspberry Pi board, Raspberry Pi interfaces-Serial, SPI,I2C, Other IoTDevicespcDuino,BeagleBone Black, Cubieboard.Python Web Application Framework: Django Framework-Roles of Model, Template and View.

Text Books:

1. ArshdeepBahga and Vijay Madisetti, “Internet of Things - A Hands-on Approach, Universities Press, 2015.
2. Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014.

18CSO 09

BASICS OF ARTIFICIAL INTELLIGENCE

(Open Elective)

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	3

Pre-requisites: Basic Mathematics.

Course Objectives: The main objectives of this course are:

1. To Provide fundamental concepts in Artificial Intelligence.
2. Discuss the various paradigms involved in solving an AI problems which involve perception, reasoning and learning
3. Apply the AI concepts to build an expert system to solve the real-world problems.

Course Outcomes: On Successful completion of this course, student will be able to

1. Identify various search strategies to solve problems.
2. Compare and contrast knowledge representation schemes.
3. Apply Bayesian Networks and Dempster Shafer theory for reasoning
4. Explain the role of agents and interaction with the environment
5. Determine different learning paradigms.
6. Explain robotic architectures and expert systems.

UNIT - I

Introduction: Definition, history, applications. Problem Solving: AI problems, AI Technique, Defining problem as a State-Space Search, Problem Characteristics. Heuristic Search Techniques: Generate–and–test, Hill Climbing, Constraint Satisfaction.

UNIT - II

Knowledge Representation (Logic): Representing facts in logic, proposition logic, predicate logic, resolution and unification. Knowledge Representation (Structured): Declarative representation, Semantic nets, procedural representation, frames.

UNIT - III

Reasoning: Probability and Bayes theorem, Certainty factors and Rule based systems, Bayesian Networks, Dempster-Shafer Theory. Planning: Components, goal stack planning, nonlinear planning, hierarchical planning.

UNIT - IV

Learning: Introduction, Rote learning, learning by taking advice, learning in problem solving and learning from examples: Decision tree. Intelligent Agents: Classification, Working of an agent, single agent and multi agent systems, multi agent application.

UNIT - V

Expert System: Representing and Using Domain Knowledge, Expert systems shells, Explanation, Knowledge Acquisition. Perception and Action: Real Time Search, Vision, Speech Recognition, ACTION: Navigation, Manipulation, Robot architectures.

Text Books:

1. Elaine Rich, Kevin Night, Shivashankar B Nair, “Artificial Intelligence”, 3rd Edition, 2008
2. Russell Norvig, “Artificial Intelligence-Modern Approach”, 3rd edition, 2010.

Suggested Reading:

1. Saroj Kaushik, “Artificial Intelligence”, Cengage Learning India, 2012.
2. Nelson M. Mattos, “An Approach to Knowledge Base Management”, Springer Berlin Heidelberg, 1991.

Online Resources:

1. http://nptel.ac.in/courses/106106126/
2. http://nptel.ac.in/courses/106105077/

18ME C25

METROLOGY AND INSTRUMENTATION LAB

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	50Marks
CIE	25 Marks
Credits	1.5

Objectives:
1. To choose the proper measuring instrument for the precise measurement of length, height and diameter.
2. To classify the different measuring instruments used for the angular measurement.
3. To develop gear & screw thread parameters using optical projector and tool maker's microscope.
4. To analyze the limits, fits and tolerances for selection and design of gauges.
5. To determine the working principles in the measurement of Flatness, Roundness and Surface roughness.

Outcomes: At the end of the course, the students are able to
1. Measure the linear dimension by using appropriate method & device. (BL-3)
2. Demonstrate the knowledge of angular measurementsand use measuring instruments as per requirements. (BL-2)
3. Determine the gear and screw thread parameters using profile projector and tool makers' microscope. (BL-3)
4. Design and test plain limit gauges for a given specimen. (BL-3)
5. Evaluate and estimate the measurement of flatness, roundness and surface roughness. (BL-5)

Experiments:
1. Measurement with inside, outside and depth micrometers.
2. Measurement with height gauges, height masters.
3. Measurement of linear and angular dimensions with Tool maker's microscope – diameter of thin wire and single point cutting tool angle.
4. Measurement with dial indicator and its calibration.
5. Measurement of angles with sine bar and clinometers.
6. Measurement of roundness errors with bench centers.
7. Measurement of flatness errors of a surface plate with precision spirit level.
8. Measurement with optical profile projector.
9. Design of plugand snap gauges for a given component.
10. Surface roughness measurement by Taylor Hobson -Talysurf.
11. Measurement of gear tooth thickness by gear tooth vernier.
12. Displacement measurement with LVDT.
13. Analyze, assess, measure and document all Measuring attributes of a selected component by using appropriate methods and devices.

Note: Student should complete a minimum of 10 experiments including experiment number 13 which is compulsory.

Text Books:

1. R.K. Jain, "Engineering Metrology", Khanna Publications, 1996.
2. Doeblin, "Measurement Systems Application and Design", TMH, 5/e., 2004.
3. Beckwith, Buck, Lienhard, "Mechanical Measurements", PEA, 3rd Indian Reprint, 2001.

Suggested Reading:

1. RegaRajendra," Principles of Engineering Metrology", Jaico Publishing House, Mumbai, 2008.
2. B.C. Nakra& K.K. Chaudhary , "Instrumentation Measurement and Analysis", 3/e, McGraw-Hill, 2014 .

18ME C26

COMPUTER AIDED ENGINEERING LAB

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	25 Marks
Credits	1.5

Objectives:

1. Trusses , Bars of constant cross section area, tapered cross section area and stepped bar.
2. Beams -Simply supported, cantilever, beams with UDL, and beams with varying load etc.
3. Stress analysis of a rectangular plate with a circular hole, axisymmetric problems.
4. Buckling analysis and Dynamic Analysis.
5. Steady state and Transient heat transfer analysis.

Outcomes: At the end of the course, the students are able to

1. Apply basics of Theory of Elasticity to continuum problems. (BL- 3)
2. Analyze finite elements like 1D, 2D and 3D structures for linear static analysis. (BL-4)
3. Solve heat transfer problems. (BL- 3)
4. Examine problems of limited complexity in buckling and dynamic analysis. (BL-4)
5. Evaluate solutions to practical problems by finite element software. (BL-5)

List of Exercises:

1. Analysis of plane truss & special truss with various cross sections and materials.
2. 2D & 3D beam analysis with different sections, different materials for different loads
3. Static analysis of plate with a hole.
4. Plane stress, plane strain and axisymmetric loading on the in plane members.
5. Static analysis of connecting rod with tetrahedron and brick elements.
6. Static analysis of flat and curved shell due to internal pressure.
7. Buckling analysis of plates, shells and beams to estimate BF and modes.
8. Modal analysis of beams, plates and shells for natural frequencies and mode shapes.
9. Harmonic analysis of a shaft and transient analysis of plate.
10. Steady state heat transfer analysis of chimney and transient analysis of casting.
11. Non linear analysis of cantilever beam.
12. Coupled field analysis.
13. Static/Buckling/Modal/Harmonic/Transient/Non-Linear/ heat transfer analysis of a selected component.

Note:

1. **Students should complete a minimum of 10 exercises including exercise number 13 which is compulsory.**
2. Students may use any or combination of FEA software(ANSYS/ABAQUS/NASTRAN/NISA/CAEFEM/ADINA).

Suggested Reading:

1. Tadeusz, A. Stolarski, Y. Nakasone, S. Yoshimoto, “Engineering Analysis with ANSYS Software”, 1/e, Elsevier Butterworth-Heinemann publications, 2007.
2. ANSYS Inc., “User Manuals for Release 15.0”.

18ME C27

PROJECT: PART - 1

Instruction	4 Hours per week
Duration of SEE	----
SEE	----
CIE	50 Marks
Credits	2

Objective: The objectiveof Project Part -1 is to enable the student take up investigative study in the broad field of Engineering / Technology, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on an individual basis or two/three students in a group, under theguidance of a supervisor. This is expected to provide a good initiation for the student(s) towards R&D.

Outcomes: At the end of the course, the students are able to

1. Identify a topic in advanced areas of Mechanical / Allied fields of Engineering. (BL-1)
2. Review literature to identify the gaps, define the objectives and scope of the work. (BL-2)
3. Generate innovative ideas for societal benefit and Nation building. (BL-6)
4. Develop prototypes/models, experimental setup and software systems necessary to meet the objectives. (BL-6)
5. Prepare a technical report and present before the departmental committee (BL-5)

The work shall include:

1. Survey and study of published literature on the assigned topic.
2. Working out a preliminary Approach to the Problem relating to the assigned topic.
3. Conducting preliminary Analysis/Modelling/Simulation/Experiment/Design/Feasibility.
4. Preparing a Written Report on the Study conducted for Presentation to the Department.
5. Final Seminar, as oral Presentation before a departmental Committee.

Guidelines for the award of marks:

Evaluation by	Maximum Marks	Evaluation Criteria / Parameter
Supervisor	20	Project Status / Review
	5	Report
Departmental Committee	5	Relevance of the Topic
	5	PPT Preparation
	5	Presentation
	5	Question and Answers
	5	Report Preparation

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)
AICTE MODEL CURRICULUM
B.E (Mechanical Engineering)

SEMESTER – VIII

S. No.	Course Code	Title of the Course	Scheme of instruction			Scheme of examination			Credits
			Hours per week			Duration in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1		Open Elective – II	3	--	--	3	30	70	3
2		Open Elective – III	3	--	--	3	30	70	3
PRACTICALS									
3	18ME C28	Technical Seminar (On the latest trends and other than Project)	--	--	2	--	50	--	1
4	18ME C29	Project Part - 2	--	--	20	--	100	100	10
TOTAL			**6**	--	**22**	--	**210**	**240**	**17**

L: Lecture T: Tutorial D: Drawing P: Practical
CIE - Continuous Internal Evaluation SEE – Semester End Examination

Open Elective – II (3/3)			**Open Elective – III (3/3)**		
S NO	**Subj. Code**	**Name of the Subject**	**S NO**	**Subj. Code**	**Name of the Subject**
1	18EC O01	Remote Sensing and GIS	1	18EG O01	Technical Writing Skills
2	18MT O01	Dession Theory	2	18BT O01	Basics of Biology
3	18EE O03	Energy Auditing	3	18CE O02	Disaster Mitigation and Management
4	18CS O04	Basics of Cyber Security	4	18EE O05	Waste Management
5	18EC O05	MEMS and its Applications	5	18EC O07	Systems Automation & Control

18EC O01

REMOTE SENSING AND GIS
(Open Elective)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives:

This course aims to:
1. Explain the fundamental concepts of remote sensing and digital imaging techniques.
2. Make the students to understand the principles of thermal and microwave remote sensing.
3. Make the students understand the significance of GIS and the process of GIS.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Demonstrate the understanding of basic concepts of remote sensing and interpret energy interactions.
2. Choose an appropriate technique for a given scenario by appreciating the types of remote sensing.
3. Distinguish the principle behind the working of microwave and LiDAR sensing.
4. Apply an appropriate data model from the acquired knowledge of the basics of GIS.
5. Explain the procedure for encoding data and geospatial data analysis.

UNIT-I
Concept of Remote Sensing: Remote sensing definition, data, process, EM bands used in remote sensing, Interactions and recording of energy: interaction with atmosphere, interaction with earth surface features (soil, water, vegetation), recording of energy by sensors, Transmission, reception and processing, Image interpretation and analysis, Applications, Advantages and limitations of Remote sensing, Orbits of Remote sensing satellites, Indian remote sensing satellites.

UNIT-II
Digital Imaging: Types of Remote sensing, Sensor resolutions, Digital Image, Sensor components, Principle of a long-track and across-track scanning, Hyperspectral Imaging, Thermal Remote Sensing.

UNIT-III
Microwave Remote Sensing: Active and Passive Microwave Remote Sensing, Radar Imaging: Key components of imaging radar, viewing geometry, spatial resolution, principle of RAR, SAR and their range resolution, Satellite Radar Imaging, LIDAR.

UNIT-IV
Concept of Geographic Information Systems: Key components of GIS, joining spatial and attribute data, functions, advantages and applications of GIS, Spatial data model, Raster data model, Vector data model.

UNIT-V
Process of GIS and Geospatial analysis: Data sources, encoding raster data, encoding vector data, encoding attribute data, linking spatial and attribute data, Geospatial data analysis methods database query, geospatial measurement, overlay operations, network analysis and surface analysis. Integration of GIS and remote sensing.

Text Books:
1. Basudeb Bhatta, “Remote Sensing and GIS”, 2/e, Oxford University Press, 2012.
2. Lillesand T.M., and Kiefer R.W. “Remote Sensing and Image Interpretation”, 6/e, John Wiley &Sons, 2000.

Suggested Reading:
1. James B. Campbell and Randolph H. Wynne, “Introduction to Remote Sensing”, the Guilford Press, 2011.
2. Michael N DeMers, “Fundamentals of GIS”, 2/e, John Wiley, 2008.

18MTO 01

DECISION THEORY
(OPEN ELECTIVE)

Instruction	3L Hours per week
Duration of Semester End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	3

Course Objectives:

1. To explain procedure of LPP
2. To discuss various methods to get optimum solution.
3. To analyse the optimum solution by Hungarian method.
4. To demonstrate the algorithm for job sequencing.
5. To discuss method of finding solution of Dynamic programming problem..

Course Outcomes:

On the successful completion of this course, the student shall be able to

1. Calculate the optimum values for given objective function by LPP
2. Solve the solution for maximise the profit with minimum cost by Transportation problem.
3. Determine the optimum feasible solution for sequencing the Jobs
4. Arrange the jobs for different Machines to get optimum values
5. Measure the solution of dynamical system problems

UNIT-I: Introduction to Operations Research: Basics definition, scope, objectives, phases, models and limitations of Operations Research, Linear Programming Problem-Formulation of LPP, Graphical solution of LPP, Simplex Method, Artificial variables, big-M method.

UNIT-II: Transportation problems, Formulation, solution, unbalanced transportation problems, finding basic feasible solutions-Northwest corner rule, least cost method and Vogel's approximations method, Optimality test: the stepping stone method and MODI method.

UNIT-III: Assignment model, formulation, Hungarian method for optimal solution, solving unbalanced problem, Traveling salesman problem and assignment problem

UNIT IV: Sequencing models, solution of sequencing problem-processing n jobs through 2 Machines-processing n jobs through 3 Machines-processing 2 jobs through m machines-processing n jobs through m machines.

UNIT-V: Dynamic Programming, Characteristics of dynamic programming, Solution of LPP by dynamic programming and Network scheduling by PET/CPM.

Text Books:

1. P.SankaraIyer, "Operations Research", Tata McGraw-Hill, 2008.
2. A.M.Natarajan, P.Balasubramani, A.Tamilarasi, "Operations Research", Pearson Educairons, 2005.

Suggested Reading:

1. J K Sharma, "Operations Research Theory & Applications, 3e", Macmillan India Ltd, 2007.
2. P.K.Gupta and D.S.Hira, "Operations Research", S.Chand& Co, 2007.
3. Kranti Swarup , P.K.Gupta and Man Mohan "Operations Research", Sultan Chand & Sons, 2019.

18EE O 03

ENERGY AUDITING

Instruction	3 Hours per week
Duration of Semester End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	3

Course objectives:
1. To know the concept of Energy auditing
2. To understand the formulation of efficiency for various engineering systems
3. To explore the different ways to design various technologies for efficient engineering systems.

Outcomes: After completion of this course, students are able to:
1. Know the current energy scenario and importance of energy auditing.
2. Understand the concepts of energy auditing.
3. Evaluate the performance of existing engineering systems
4. Explore the methods of improving energy efficiency in different engineering systems
5. Design different energy efficient devices.

UNIT-I

Basics of Energy and its various forms: Overview of engineering, elements Solar energy, electricitygeneration methods using solar energy, PV cell, elements of wind energy, electricity generation using wind energy, elements of bio energy, bio mass energy conservation, elements of geothermal energy, sources of geothermal energy, sources of chemical energy, fuel cells, Energy Scenario in India

UNIT-II

Energy Auditing-1: Introduction : Need for energy audit, directions for the study of energy auditing,inclusions for energy auditing, types of energy audit: preliminary audit, general/mini audit, investment-grade/ comprehensive audit. Major energy consuming equipments and systems, energy audit team, energy auditing methodology: preliminary and detailed. Process flow diagram, energy audit report format

UNIT-III

Energy Auditing-2: For buildings: Energy auditing instruments, energy efficiency, energy auditing forbuildings: stages in programs, surveying, measurements and model analysis. Energy audit form of commercial buildings, checklist for energy saving measures

UNIT –IV

Energy Efficient Technologies-I: Importance of energy efficiency for engineers, Energy efficient technology in mechanical engineering: Heating, ventilation and air-conditioning, boiler and steam distribution systems Energy efficient technology in civil engineering: future of roads, harnessing road and transport infrastructure;

UNIT-V

Energy Efficient Technologies-II : Energy efficient technology in electrical engineering: Electricity billing,electrical load management and maximum demand control, power factor improvement and its benefit, selection and location of capacitors; Energy efficient technology in chemical engineering: green chemistry, low carbon cements, recycling paper

Text Books:

1. Umesh Rathore, 'energy management', Kataria publications, 2nd ediiton, 2014.
2. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects
3. Hargroves, K., Gockowiak, K., Wilson, K., Lawry, N., and Desha, C. (2014) An Overview of Energy Efficiency Opportunities in Mechanical/civil/electrical/chemical Engineering, The University of Adelaide and Queensland University of Technology.

Suggested reading:

1. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org)

18CSO 07

BASICS OF CYBER SECURITY

(Open Elective)

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	3

Pre-requisites: Operating System, Computer Network, Cryptography.

Course Objectives: The main objectives of this course are:

1. To Identify and present indicators that a cybercrime has occurred and understand methods and tools used in cybercrimes.
2. To collect, Process, Analyze and Present Computer Forensics Evidence.
3. To understand the legal perspectives and Organizational implications of Cyber Security

Outcomes: On Successful completion of this course, student will be able to

1. Listthe different types of cybercrimes and analyze legal frameworks to handle cybercrimes.
2. Identify the Tools and Methods used in cybercrimes.
3. Analyze and resolve cyber security issues and laws governing Cyberspace.
4. Describe the need of Digital Forensics and the importance of digital evidence in prosecution.
5. Interpret the commercial activities in the event of significant information security incidents in the Organization.
6. Discuss the vulnerabilities in networking protocols and their mitigation techniques.

UNIT - I

Introduction to Cyber Crime: Cyber Crime: Definition and Origins of the Word, Cyber crime and Information Security, Classification of Cyber Crimes, Cyber Crime: The Legal Perspective, Cyber Crime: An Indian Perspective, A Global Perspective of Cyber Crime.

UNIT - II

Cyber Offenses: Introduction, How Criminals plan the Attacks, Social Engineering, Cyber stalking, Cyber cafe and Cybercrimes, Botnets: The Fuel for Cybercrime, Attack Vector.
Tools and Methods Used in Cybercrime: Introduction, Proxy Servers and Anonymizers, Phishing, Password Cracking, Keyloggers and Spywares, Virus and Worms, Trojan Horse and Backdoors, Steganography, DoS and DDoS attacks, SQL Injection, Buffer Overflow.

UNIT - III

Cyber Security: The Legal Perspectives: Cyber Crime and the Legal Landscape around the World, Need of Cyber laws: the Indian Context, The Indian IT Act, Challenges to Indian Law and Cyber Crime Scenario in India, Digital Signatures and the Indian IT Act, Cyber Crime and Punishment, Cyber Law, Technology and Students: The Indian Scenario.

UNIT - IV

Understanding Cyber Forensics: Introduction ,Digital Forensics Science, Need for Computer Forensics, Cyber Forensics and Digital Evidence, Forensics Analysis of Email, Digital Forensics Life Cycle, Chain of Custody Concept, Network Forensics, Approaching a Cyber Forensics Investigation, Challenges in Computer Forensics.

UNIT - V

Cyber Security: Organizational Implications: Introduction, Cost of Cybercrimes and IPR issues, Web threats for Organizations, Security and Privacy Implications, Social media marketing: Security Risks and Perils for Organizations, Social Computing and the associated challenges for Organizations.

Text Books:

1. Sunit Belpre and Nina Godbole, “Cyber Security: Understanding Cyber Crimes, Computer Forensics And Legal Perspectives”, Wiley India Pvt.Ltd, 2011.
2. Kevin Mandia, Chris Prosise, “Incident Response and computer forensics”, Tata McGraw Hill, 2006.

Suggested Reading:

1. Alfred Basta, Nadine Basta, Mary Brown, Ravinder Kumar, “Cyber Security and Cyber Laws”, Paperback – 2018.
2. Mark F Grady, Fransesco Parisi, “The Law and Economics of Cyber Security”, Cambridge university press, 2006.

Online Resources:

1. https://www.edx.org/learn/cybersecurity
2. https://www.coursera.org/courses?query=cyber%20security
3. https://swayam.gov.in/course/4002-cyber-law

18EC O05

MEMS AND ITS APPLICATIONS

(Open Elective)

Instruction	3 L Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives:

This course aims to:

1. Provide knowledge of semiconductors, various materials used for MEMS.
2. Introduce various Electrostatic and Thermal Sensors and Actuators.
3. Educate on the applications of MEMS to various disciplines.

Course Outcomes:

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

1. Understand various materials used for MEMS.
2. Design the micro devices and systems using the MEMS fabrication process.
3. Analyze the operation of different Sensors and Actuators.
4. Interpret the micro devices and systems using Polymer MEMs.
5. Apply different MEMS devices in various disciplines.

UNIT- I

Introduction: The History of MEMS Development, The Intrinsic Characteristics of MEMS: Miniaturization, Microelectronics Integration, Parallel Fabrication with Precision, Devices: Sensors and Actuators- Energy Domains and Transducers, Sensors Considerations, Sensor Noise and Design Complexity: Actuators Considerations.

UNIT- II

Introduction to Micro Fabrication: Overview of Micro fabrication, Overview of Frequently used Micro fabrication Processes: Photolithography, Thin Film Decomposition, Thermal Oxidation of Silicon, Wet Etching, Silicon Anisotropic Etching, Plasma Etching and Reactive Etching, Doping, Wafer Dicing, Wafer Bonding, Microelectronics Fabrication Process Flow, Silicon based MEMS Processes, Packaging and Integration, Process Selection and Design.

UNIT- III

Electrostatic Sensing and Actuation: Introduction to Electrostatic Sensors and Actuators, Parallel: Plate Capacitor, Applications of Parallel Plate Capacitors, Interdigitated Finger Capacitors, Applications of Combo Drive Devices: Inertia Sensors, Actuators. Thermal Sensing and Actuation: Introduction to Thermal Sensors, Thermal Actuators, Fundamentals of Thermal Transfer, Sensors and Actuators Based on Thermal Expansion, Thermal Couples, Thermal Resistors, Applications- Inertia Sensors, Flow Sensors, Infrared Sensors.

UNIT- IV

Piezo resistive Sensors: Origin and Expression of Peizo resistivity, Piezo resistive Sensor Materials: Metal Strain Gauges, Single crystal Silicon, Polycrystalline Silicon, Applications of Piezo resistive Sensors: Inertial sensors, Pressure Sensors, Tactile Sensors, flow Sensors. Piezoelectric Sensors: Introduction, Properties of Piezoelectric Materials, Applications- Inertia Sensors, Acoustic Sensors, Tactile Sensors, Flow Sensors.

UNIT- V

Polymer MEMS: Introduction, Polymers in MEMS- Polyimide, SU-8, Liquid Crystal Polymer(LCP), Representative Applications- Acceleration Sensors, Pressure Sensors, Flow Sensors, Tactile Sensors. Case Studies of Selected MEMS Products: Blood Pressure (BP) Sensor, Microphone, Acceleration Sensor and Gyros.

Text Books:

1. Chang Liu, "Foundations of MEMS", 2/e, Pearson Education Inc., 2012.
2. Tai Ran Hsu, "MEMS & Micro Systems Design and Manufacture", Tata McGraw Hill, 2002.

Reference Books:

1. P. Rai Choudary, "MEMS and MEMS Technology and Applications", PHI publications, 2009.
2. Mohamed Gad-el-Hak, "The MEMS Handbook", CRC press, 2001.

18EG O01

TECHNICAL WRITING SKILLS
(Open Elective)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	60 marks
CIE	40 marks
Credits	3

Objectives : The course will introduce the students to:

1. Process of communication and channels of communication in general and technical writing.
2. Technical Writing and also contextual use of technology specific words.
3. Business letters and technical articles.
4. Technical reports and technical proposals.
5. Transferring data from verbal to graphic and vice versa and making technical presentations.

Outcomes : After successful completion of the course students are able to:
1. Understand the channels of communication and define nature and aspects of Technical communication
2. Compare and contrast technical communication to that of general communication while constructing error free sentences applying features of technical writing.
3. Analyze data, draw inferences to write Journal articles and conference papers and to compose business letters.
4. Evaluate data to draft technical reports and technical proposals.
5. Design a technical presentation by understanding the nuances of presentation skills and also transfer data from verbal to graphic and vice versa.

Unit I
Communication – Nature and process.
Channels of Communication – Downward, upward and horizontal and lateral communication; Barriers to communication.
Technical Communication – Definition ; oral and written communication. Importance and need for Technical communication. Nature of Technical Communication; Aspects and forms of Technical communication. Technical communication Skills – Listening, Speaking, Reading & Writing.

Unit II
Technical Writing – Techniques of writing. Selection of words and phrases in technical writing. Differences between technical writing and general writing. Abstract and specific words. Sentence structure and requisites of sentence construction. Paragraph length and structure.

Unit III
Business correspondence – Sales letters, letters of Quotation; Claim and Adjustment letters.
Technical Articles: Nature, significance and types of technical articles. Writing an abstract. Journal articles and Conference papers. Elements of technical articles.

Unit IV
Technical Reports : Types, significance, structure, style and writing of reports. Routine reports, Project reports.
Technical Proposals : Definition, types, characteristics, structure and significance.

Unit V
Information Transfer – Graphic to verbal (written) and verbal to graphic.
Technical Presentations : Important aspects of oral and visual presentations.

Text Book :

1. Meenakshi Raman & Sangeeta Sharma, **"Technical Communications-Principles and Practice",** Oxford University Press, Second Edition, 2012.
2. 1.M Ashraf Rizvi, **"Effective Technical Communication",** Tata McGraw Hill Education Pvt Ltd, 2012.

Suggested Reading :

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1. .Kavita Tyagi & Padma Misra, **"Basic Technical Communication"**, PHI Learning Pvt Ltd, 2012.
2. R.C Sharma & Krishna Mohan, **"Business Correspondence and Report Writing",** Tata McGraw Hill, 2003

Web Resources:

1. **https://onlinecourses.nptel.ac.in/noc18_mg13/preview**
2. **https://www.technical-writing-training-and-certification.com/**
3. **https://academy.whatfix.com/technical-writing-skills**

18BT O01

BASICS OF BIOLOGY

(Open Elective-I)

Instruction	3LHoursperWeek
DurationofSEE	3Hours
SEE	70Marks
CIE	30Marks
Credits	3

Course Objectives: This course aims to:

1. Impart knowledge of origin and evolution of biological organisms.
2. Understand the structure and functions of humanorgan systems.
3. Understand theprinciples behind medicaldevices for diagnosis of human health and environment protection.
4. Give an insight of biological information, relationship and genome sequencing of various organisms.

Course Outcomes: Afterthe completion of this course, the student will be able to:

1. Explain the theories of origin and evolution of life.
2. Describe the anatomical structure and physiological functions of thehuman organ systems.
3. Outline the principle and applications of medical devises.
4. Discussthe technology advancements in improving human health and environment
5. Explain the biological information, sequencing and evolutionary relationship among organisms.

UNIT-I

IntroductiontoBiology: ClassicalVsModernBiology;ImportanceofBiological Science and Historical developments; Origin of Life, UreyMillerExperiment, Spontaneous Generation Theory; Three Domains of Life; Principle and ApplicationsofMicroscope(LightandElectronMicroscope),Prokaryoticand Eukaryotic Cell-Structure and their differences.

UNIT-II

Humanorgansystemsandtheirfunctions -I:Introduction to various organ systems of humanbody and their functions; SkeletalSystem-Bones,Tendon,Ligaments,principleandapplicationsinknee replacement; Nervous System - Structure of Brain, Spinal Cord, Neuron, Neurotransmitters,Synapse,Alzheimer's-acasestudy,principleandapplications ofImagingTechniques(CT&MRIscans);CirculatorySystem-Heartstructureand functions, principle and applications of cardiac devices (Stent and Pacemaker), Artificial heart, blood components and typing, haemocytometer.

UNIT-III

HumanAnatomyandFunctions-II: RespiratorySystems-Lungstructureand function, principle and applications of Peak FlowMeter,ECMO(ExtraCorporeal Membrane Oxygenation); Excretory Systems-Kidney structure and function, principleandapplicationsofDialysis;Prenataldiagnosis;Assistedreproductive techniques- IVF,Surrogacy.

UNIT-IV

Medical Biotechnology and Bioremediation: Cells of Immune System, Etiology of cancer, Cancer treatment (Radiation Therapy); Stem Cells and its Clinical applications; Scaffolds and 3D printing of organs; Bio sensors and their applications; Parts of bioreactor and its types; Bioremediation.

UNIT-V

Bioinformatics: Nucleic acid composition, Genetic Code, Amino acid, Polypeptide, Levels of protein structure, Homolog, Ortholog and Paralog, Phylogenetics, Genome Sequencing, Human GenomeProject, Next generation sequencing.

TextBooks:

1. Campbell,N.A.,Reece,J.B.,Urry,Lisa, Cain,M,L.,Wasserman,S.A.,Minorsky,P.V.,Jackson,R.B. "Biology: A Global Approach", 11th edition,Pearson EducationLtd. 2017
2. Shier,David,Butler,Jackie, Lewis,Ricki., "Hole'sHumanAnatomy&Physiology",13th edition, McGrawHill2017.
3. Dubey RC " A Text book of Biotechnology" 5th Edition, S Chand and Company limited, 2014.
4. Bernard R. Glick, T. L. Delovitch, Cheryl L. Patten, "Medical Biotechnology", 1st edition, ASMPress,2014.

18CE O02

DISASTER MITIGATION AND MANAGEMENT (M)

(Open Elective)

Instruction	3 L Hours per Week
End Examination	3 Hours
Semester End Examination	70 Marks
Continuous Internal Evaluation	30 Marks
Credits	3

Course Objectives: This course aims to,

1. Equip the students with the basic knowledge of hazards, disasters, risks and vulnerabilities.
2. Impart knowledge in students about the nature, causes, consequences and mitigation measures of the various Hydro-meteorological disasters.
3. Introduce the concepts of causes, consequences and mitigation measures of the various Geographical disasters.
4. Enable the students to understand risks, vulnerabilities and human errors associated with human induced disasters.
5. Equip the students with the knowledge of the impacts of disaster, chronological phases in a disaster management cycle and to create awareness about the disaster management framework and legislations in the context of Central and State Level Authorities.

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

1. Identify and understand the fundamental terminologies in disaster management.
2. Distinguish between the Hydro-meteorological disasters and apply the concepts of structural and non- structural mitigation measures.
3. Categorize different Geographical Disasters and apply the knowledge in utilizing the early warning systems.
4. Analyze various mechanisms and consequences of human induced disasters.
5. Develop an awareness of disaster management phases and formulating effective disaster management plans, ability to understand various participatory roles of stakeholders- Central and State Government bodies at different levels.

UNIT- I:
Introduction: Basic definitions- Hazard, Disaster, Vulnerability, Risk, Resilience, Mitigation, Management; classification of types of disaster- Natural and manmade; Introduction to Disaster management cycle; International Decade for natural disaster reduction (IDNDR); International strategy for disaster reduction (ISDR), National disaster management authority (NDMA).

UNIT- II:
Natural Disasters:
Hydro meteorological disasters:
Causes, Early warning systems- monitoring and management, structural and non-structural measures for floods, drought and Tropical cyclones; Applications. Case studies related to various hydro-meteorological disasters.

UNIT- III:
Geographical based disasters: Causes, zoning, Early warning systems- monitoring and management, structural and non-structural mitigation measures for earthquakes, tsunami, landslides, avalanches and forest fires. Case studies related to various geographical based disasters.

UNIT- IV:

Human Induced Disasters: Chemical disaster- Causes, impacts and mitigation measures for chemical accidents, Risks and control measures in a chemical industry, chemical disaster management; Case studies related to various chemical industrial hazards eg: Bhopal gas leakage; Management of chemical terrorism disasters and biological disasters; Case studies related to power break downs, fire accidents, traffic accidents, oil spills and stampedes, building failure disasters.

UNIT- V:

Concept of Disaster Impacts and Management:

Disaster impacts- environmental, physical, social, ecological, economical, political, etc.; health, psycho-social issues; demographic aspects, gender, age, special needs; hazard locations; global and national disaster trends; climate change and urban disasters.

Disaster management cycle and its phases, risk analysis, vulnerability and capacity assessment; Post-disaster environmental response water, sanitation, food safety, waste management, disease control; Roles and responsibilities of government, community, local institutions, NGOs and other stakeholders; Policies and legislation for disaster risk reduction, DRR programmes in India and the activities of National Disaster Management Authority.

Text Books:

1. Pradeep Sahni, “Disaster Risk Reduction in South Asia”, Prentice Hall, 2003.
2. B. K. Singh, “Handbook of Disaster Management: Techniques & Guidelines”, Rajat Publication, 2008.

Suggested Reading:

1. Ministry of Home Affairs, Government of India, “National Disaster Management Plan, Part I and II”,
2. K. K. Ghosh, “Disaster Management”, APH Publishing Corporation, 2006.
3. http://www.indiaenvironmentportal.org.in/files/file\disaster_management_india1.pdf
4. http://www.ndmindia.nic.in/ (National Disaster management in India, Ministry of Home Affairs)
5. Hazards, Disasters and your community: A booklet for students and the community, Ministry of Home Affairs.
6. Disaster Medical Systems Guidelines, Emergency Medical Services Authority, State of California, EMSA no.214, June 2003.
7. Inter Agency Standing Committee (IASC) (Feb. 2007). IASC Guidelines on Mental Health and Psychosocial Support in Emergency Settings, Geneva: IASC.
8. http://ndma.gov.in/ (Home page of National Disaster Management Authority)

19EEO 101

WASTE TO ENERGY

(Open Elective)

Instruction		3 Theory Hours perweek
DurationofSemesterEndExamination		3 Hours
SEE	70Marks	
CIE	30Marks	
Credits		3

Objectives:

1. To know the various forms ofwaste
2. To understand the processes of BiomassPyrolysis.
3. To learn the technique of BiomassCombustion.

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

1. Understand the concept of conservation, and Identify the devices for conservation
2. Classify the different forms ofwastage
3. Explain the process of Gasification, and Demonstrate the design and operation of Gasifiers
4. Explain the process of Combustion, and Demonstrate the construction and operation of various combustors
5. Describe the process of biomass conversion, and to Differentiate biomass, biogas, biochemical and biodiesel plants

UNIT - I

IntroductiontoEnergyfromWaste:Classificationofwasteasfuel–Agrobased, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers,digestors

UNIT – II

Biomass Pyrolysis: Pyrolysis – Types, slow, fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT – III

BiomassGasification:Gasifiers–Fixedbedsystem–Downdraftandupdraft gasifiers–Fluidizedbedgasifiers–Design,constructionandoperation–Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electricalpower–Equilibriumandkineticconsiderationingasifieroperation.

UNIT–IV

BiomassCombustion:Biomassstoves–Improvedchullahs,types,someexotic designs,Fixedbedcombustors,Types,inclinedgratecombustors,Fluidizedbedcombustors,Design,constructionando peration-Operationofalltheabove biomasscombustors.

UNIT – V

Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technologyandstatus-Bioenergysystem-Designandconstructionalfeatures

- Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysisandliquefaction-biochemicalconversion-anaerobicdigestion-Types ofbiogasPlants–Applications-Alcoholproductionfrombiomass-Biodiesel production-Urbanwastetoenergyconversion-Biomassenergyprogrammein India.

Text Books:

1. V.AshokV.,"NonConventionalEnergy",Desai,WileyEasternLtd., 1990.
2. K.C.KhandelwalandMahdi,S.S.,"BiogasTechnology-APractical HandBook"-Vol.I&II,TataMcGrawHillPublishingCo.Ltd.,1983.

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Suggested Readings:

1. D.S.Challal,"Food,FeedandFuelfromBiomass",IBHPublishingCo. Pvt. Ltd.,1991.
2. C. Y. WereKo-Brobby and E. B. Hagan, "Biomass Conversion and Technology",JohnWiley&Sons,1996.

18EC O07

SYSTEM AUTOMATION AND CONTROL
(Open Elective)

Instruction	3 L Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives: This course aims to:

1. Learn the concepts industrial control systems
2. Learn how to measure the physical parameters in industry
3. Learn the applications of Robots in industry.

Course Outcomes: After completion of this course, students are able to:

1. Understand the features of various automatic and process control systems.
2. Define and analyze various measuring parameters in the industry.
3. Compare performance of various controllers (P, PD, PI, and PID).
4. Illustrate the role of digital computers in automation.
5. Develop various robot structures for different applications.

UNIT-I

Introduction to Automatic Control Systems: Purpose of Automatic Control, How an Industrial Control System is implemented, Introduction to Automatic Control theory.

Sensors: Sensor definition, Different types of Sensors: Motion, Position, Force, Level sensors, and Thermo couples.

UNIT-II

Theory of Measurements: Measurement goals and concepts, Scale factor, Linearity, accuracy, Range, Resolution, Precision and repeatability.

Measurement Techniques and Hardware: Typical Sensor outputs, Bridge measurements: General equation for bridge balance, Resistance balanced Wheatstone bridge, Variable voltage type measurements, Frequency type measurements.

UNIT-III

Process Controllers: What is a Controller, uses of Controllers, Open loop and closed loop Control, proportional, PD, PI, PID Controllers, Analog and Digital methods of Control.

Controller Hardware: Analog and Digital Controllers.

UNIT-IV

Digital Computers as Process Controllers: Use by Digital Computer for process control, Information required by the computer, Information required by the process, Computer Interface electronics, Digital Computer input-output, computer processing of data, Digital Process control computer design, Computer programming.

Actuators: Electro mechanical - Linear motion and rotary motion solenoids, DC motors, AC motors and Stepped motors.

UNIT-V

Robots: What are robots, Robots and process Control systems, Degrees of freedom, factories of the future, Delivery, Disposal and transport systems, Sensing elements, Robot Classifications and Applications. Trouble shooting System failures: Preliminary steps and other troubleshooting aids.

Text Books:

1. Ronald P. Hunter, “Automated process control systems – concepts and Hardware”, 2/e, PHI, 1987.
2. Norman A. Anderson, “Instrumentation for process measurement and Control”, 3/e, CRC Press, 2005.

Suggested Reading:

1. Kuo B. C, “Automatic Control Systems”, 9th edition
2. A.K Sawhney,“A course on Electrical and Electronic Measurements and Instrumentation”.

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18ME C28

TECHNICAL SEMINAR

Instruction	2 Hours per week
Duration of SEE	----
SEE	----
CIE	50 Marks
Credits	1

Objective: The goal of a seminar is to introduce students to critical reading, understanding, summarizing, explaining and preparing report on state of the art topics in a broad area of his/her specialization. Seminar topics may be chosen by the students with advice from the faculty members and the student shall read further relevant articles in the domain.

Outcomes: At the end of the course, the students are able to
1. Identify the recent advances in the field of engineering/technology. (BL-1)
2. Develop the skills and expertise in report writing. (BL-6)
3. Compile the content and prepare comprehensive report. (BL-4)
4. Demonstrate skills required for preparation of a technical report. (BL-3)
5. Present technical know-how and professional skills before the committee. (BL-3)

The seminar must be clearly structured and the power point presentation shall include following aspects:
1. Introduction to the field
2. Literature survey
3. Consolidation of available information
4. Summary and conclusions
5. References

Each student is required to:

1. Submit a one page synopsis of the seminar talk for display on the noticeboard.
2. Deliver the seminar for a maximum duration of 30 minutes, where the presentation should be for 20 minutes in PowerPoint, followed by question and answers session for 10minutes.
3. Submit the detailed report of the seminar in spiral bound in a précised format as suggested by the department.

Seminars are to be scheduled from 3rd week to the last week of the semester and any change in schedule shall be discouraged. For the award of sessional marks students are judged by three (3) faculty members and are based on oral and written presentations as well as their involvement in the discussions during the oral presentation.

Note: Topic of the seminar shall be preferably from any peer reviewed recent journal publications.

Guidelines for awarding marks		
Sl No.	Description	Max Marks
1.	Contents and relevance	10
2.	Presentation skills	10
3.	Preparation of PPT slides	05
4.	Questions and answers	05
5.	Report in a prescribed format	20
Total Marks		**50**

18ME C29

PROJECT: PART - 2

Instruction	20Hours per week
Duration of SEE	----
SEE	100 Marks
CIE	100 Marks
Credits	10

Objectives: The objective of Project Part-2 is to enable the student extend further the investigative study taken up, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from the Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected toprovide a good training for the student(s) in R&D work and technical leadership.

Outcomes: At the end of the course, the students are able to

1. Summarize the literature review for the identified problem. (BL-2)
2. Identify methods and materials to carry out experiments/ develop code/simulation. (BL-4)
3. Integrate the methodology and engineering tools adopted for solving the problem. (BL-6)
4. Analyze and discuss the results to draw valid conclusions. (BL-4)
5. Exhibit knowledge, skill, attitude and technical knowhow in preparing report as per format and presenting as a professional engineer. (BL-3)

The assignment to normally include:

1. In depth study of the topic assigned.
2. Review and finalization of the Approach to the Problem relating to the assigned topic.
3. Preparing an Action Plan for conducting the investigation, including teamwork.
4. Detailed Analysis/Modelling/Simulation/Design/Problem Solving/Experiment as needed.
5. Final development of product/process, testing, results, conclusions and future directions.
6. Preparing a paper for Conference presentation/ Publication in Journals, if possible.
7. Preparing a Dissertation in the standard format for being evaluated by the Department.
8. Final Seminar presentation before Departmental Committee.

Guidelines for the award of marks in CIE:

Evaluation by	**Maximum Marks**	**Evaluation Criteria / Parameter**
Department Review Committee	10	Review 1
	15	Review 2
	25	Submission
Supervisor	10	Regularity and Punctuality
	10	Work Progress
	10	Quality of the work which may lead to publications
	10	Report Preparation
	10	Analytical / Programming / Experimental Skills

Guidelines for awarding marks in SEE:

<table>
<tr><th>Evaluation by</th><th>Maximum Marks</th><th>Evaluation Criteria / Parameter</th></tr>
<tr><td rowspan="4">External and Internal Examiners together</td><td>20</td><td>Power Point Presentation</td></tr>
<tr><td>40</td><td>Thesis Evaluation</td></tr>
<tr><td>20</td><td>Quality of the project
• Innovations
• Applications
• Live research projects
• Scope for future study
• Application to society</td></tr>
<tr><td>20</td><td>Viva-Voce</td></tr>
</table>

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)
AICTE MODEL CURRICULUM
B.E (Mechanical Engineering)

OPEN ELEECTIVE COURSES OFFERED BY MED

S.No.	Semester	Open elective courses
1.	SEMESTER – V to SEMESTER – VIII	18ME O01 : Robotics 18ME O02 : Human Values and Professional Ethics 18ME O03 : Research Methodologies 18ME O04 : Entrepreneurship 18ME O05 : Human Rights and Legislative Procedure 18ME O06 : Nano Materials and Technology 18ME O07 : Intellectual Property Rights 18ME O08 : Mechatronics 18ME O09 : Organizational Behaviour 18ME O10 : Introduction to Operations Research 18ME O11 : Modern Manufacturing Processes 18ME O12 : 3D Printing 18ME O13 :Industrial and Financial Management

18ME O01

ROBOTICS
(Open Elective)

Instruction	3 Hours per week
Duration of SEE	3Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:

1. Principle of working of a robot, types and specifications, configuration, work envelop and motion controls and applications.
2. Transformations, kinematics and dynamics of robots.
3. Singularities, Jacobian and trajectory planning of a robot to prepare the robot for various tasks
4. Design of end effectors, drives, working of sensors and controllers for finding position and orientation.
5. Robot vision for image acquisition and processing and plan for various tasks and various Languages and Programming methods of robot.

Outcomes: At the end of the course, the students are able to

1. Describe the basic components, specifications and applications of the Robots. (BL-1)
2. Understand transformations, direct and inverse kinematics of robots. (BL-2)
3. Calculate forces in links and joints of a robot and find the singularities, Jacobian and trajectory planning of a robot for various tasks. (BL-3)
4. Classify drives, sensors and grippers for various applications. (BL-4)
5. Program a robot to predict motions for a given task with machine vision and sensors. (BL-5)

UNIT- I

Introduction to robotics: History and evolution of robots, basic configuration, degree of freedom, work envelope, motion control methods, various applications in industry, material handling, loading & unloading, processing, welding & painting, assembly, and inspection, requirements and specifications of robots.

UNIT- II

Rigid motions and homogeneous transformations: Rotation matrix, homogenous transformation matrix, Denavit- Hartenberg convention, Euler angles, RPY representation, direct and inverse kinematics for industrial robots for position and orientation.

UNIT- III

Velocity kinematics – the manipulator Jacobian: joint, end effect or velocity, direct and inverse velocity analysis. **Trajectory planning**: Interpolation, cubic polynomial, linear segments with parabolic blending, static force and moment transformation, solvability, stiffness, singularities.

UNIT- IV

Robot dynamics: Lagrangian Formulation for link inertia tensor and manipulator inertia tensor, Newton-Euler formulation for RR & RP manipulators.
Control: Individual, joint and computed torque.

UNIT -V

End effectors: Position and velocity measurement. **Sensors:** Proximity and range, tactile, force and torque, **Drives for Robots:** Electrical, Hydraulic and Pneumatic.

Robot vision: Introduction to technique, image acquisition and processing, introduction to robot programming languages

Text Books:

1. Spong and Vidyasagar, “Robot Dynamics and Control”, John Wile and Sons,1990.
2. R.K. Mittal, I.J. Nagrath, “Robotics and control”, Tata Mcgraw-Hill Publishing Company Ltd., 2003.
3. Groover, “Industrial Robotics”, Mcgraw-Hill Publishing Company Ltd.2003.

Suggested Reading:

1. Asada and Slotine, “Robot analysis and Intelligence”, Wiley Interscience, 1986.
2. K.S. Fu GonZalezRC., lEEc.S.G.,“Robotics, Control Sensing Vision and Intelligence”, McGraw Hill, Int.ed,1987.

18ME O02

HUMAN VALUES AND PROFESSIONAL ETHICS
(Open Elective)

Instruction	3 Hours perweek
Durationof SEE	3Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:
1. Understand the significance of values in life.
2. Understand the need for value adoption and prepare them meet the challenges.
3. Develop the potential to adopt values, develop a good character and personality and lead a happy life.
4. Practice the values in life and contribute for the society around them and for the development of the institutions/organization.
5. Understand the professional ethics and their applications to engineering profession.

Outcomes: At the end of the course, the students are able to
1. State basic values and the need for value education. (BL-2)
2. Analyze the situation and prioritize values for making right decisions in their personal as well as professional life. (BL-4)
3. Understand the role of a human being in ensuring harmony in society and nature. (BL-2)
4. Demonstrate the knowledge of ethics at their work place and apply different theoretical approaches to solve ethical dilemmas. (BL-3)
5. Apply risk and safety measures in the engineering practice. (BL-3)

UNIT-I

Concepts and classification of values –need and challenges for value adoption: Definition of values , concept of values, classification of values, hierarchy of values, types of values, espoused and applied values, value judgment based on culture , value judgment based on tradition , interdependence of values, need for value education ,findings of commissions and committees, corruption and illegal practices , science and technology without values, exploitation of nature, increasing use of violence and intoxicants , lack of education in values , implications of education in values , vision for a better India, challenges for value adoption , cultural, social, religious, intellectual and personal challenges.

UNIT-II

Personality development and values in life: Enlightened self-interest, accountability and responsibility , desires and weaknesses , character development, good relationships, self-restraint, spirituality and purity, the quest for character , tests of character , the key to good character ,values in life, building an ethical policy, integrating values in everyday life, archaic social values , parenting practices, critical thinking, analyzing and prioritizing values, practicing yoga and meditation.

UNIT-III

Practicing values for the development of society: Resentment management and self-analysis, positive thinking and emotional maturity, the importance of women , children and taking care of them, helping the poor and needy, fighting against addictions and atrocities, environmentalawareness ,working for the sustainable development of the society, values in education system, present scenario, engineering education, current trends, need for quality improvement, adoption of value education, principles of integrity, institutional development.

UNIT-IV

Basic concepts of professional ethics: Ethics, morals and human life , types of ethics, personal ethics, professional ethics, ethical dilemmas, Indian and global thoughts on ethics, profession, professional and professionalism, ethical role of a professional basic ethical principles, some basic ethical theories, use of ethical theories - science, religion ethics, genders and ethics, media and ethics, computer ethics, case studies on professional ethics, exemplary life sketches of prominent Indian personalities.

UNIT- V

Ethics in engineering profession: Engineering profession, technology and society, engineering as social experimentation, engineering ethics, ethical obligations of engineering professionals, role of engineers, engineers as managers, professional responsibilities of engineers, engineers responsibility for safety, a few case studies on risk management, conflicts of interest, occupational crimes, plagiarism, self plagiarism, ethics audit, consideration for ethics audit, ethics standards and bench marking.

Text Books:

1. Subramanian R., “Professional Ethics”, Oxford University Press,2017.
2. Dinesh BabuS., “Professional Ethics and Human Values”, LaxmiPublications ,2016.
3. Nagarajan R.S., “A Text Book on Human Values and Professional Ethics”, New Age Publications,2007.

Suggested Reading:

1. SantoshAjmera and Nanda Kishore Reddy, “Ethics,Integrity and Aptitude”, McGrawhill Education Private Limited, 2014.
2. GovindaRajan M., Natarajan S., Senthil Kumar V.S., “Professional Ethics and Human Values”, Prentice Hall India Private Limited,2013.

18ME O03

RESEARCH METHODOLOGIES

(Open Elective)

Instruction	3 Hours per week
Duration of SEE	3Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. To make the students to formulate the research problem.
2. To identify various sources for literature review and data collection.
3. To prepare the research design.
4. To equip the students with good methods to analyze the collected data.
5. To explain how to interpret the results and report writing.

Outcomes: At the end of the course, the students are able to

1. Define research problem. (BL-1)
2. Review and assess the quality of literature from various sources. (BL-2)
3. Understand and develop various sresearch designs. (BL-2)
4. Analyze problem by statistical techniques: ANOVA,F-test,Chi-square. (BL-4)
5. Improve the style and format of writing a report for technical paper/Journal report. (BL-4)

UNIT – I

Research methodology: Objectives and motivation of research, types of research- descriptive vs. analytical, applied vs. fundamental, quantitative vs. qualitative, conceptual vs. empirical, research approaches, significance of research, research methods vs. methodology, research process, criteria of good research, problems encountered by researchers in India, technique involved in defining a problem.

UNIT–II

Literature survey: Importance of literature survey, sources of information-primary, secondary, tertiary, assessment of quality of journals and articles, information through internet.

UNIT – III

Research design: Meaning of research design, need of research design, feature of a good design important concepts related to research design, different research designs, basic principles of experimental design, steps in sample design.

UNIT – IV

Data collection: Collection of primary data, Secondary data, measures of central tendency-mean, mode, median, measures of dispersion- range, mean deviation, standard deviation, measures of asymmetry (skewness), important parametric tests -z, t, F, Chi-Square, ANOVA significance.

UNIT – V

Research report formulation and presentation: Synopsis, dissertation, technical paper and journal paper, writing research grant proposal, making presentation with the use of visual aids, writing a proposal for research grant.

Text Books*:*

1. C.R Kothari, “Research Methodology Methods & Technique”, New Age International Publishers,2004.
2. R. Ganesan, “Research Methodology for Engineers”, MJP Publishers,2011.

3. Vijay Upagade and AravindShende, “Research Methodology”, S. Chand &Company Ltd., New Delhi,2009.

Suggested Reading:

1. G. NageswaraRao, “Research Methodology and Quantitative methods”, BS Publications, Hyderabad,2012.
2. Naval Bajjai, “Business Research Methods”, Pearson Education,2011.

18ME O04

ENTREPRENEURSHIP

(Open Elective)

Instruction	3 Hours perweek
Duration of SEE	3Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. Concept and procedure of idea generation.
2. The nature of industry and related opportunities and challenges.
3. Elements of business plan and it s procedure.
4. Project management and its techniques.
5. Behavioural issues and Time management.

Outcomes: At the end of the course, the students are able to

1. Understand the concept and essence of entrepreneurship. (BL-2)
2. Identify business opportunities and natureof enterprise. (BL-3)
3. Analyze the feasibility of new business plan. (BL-4)
4. Apply project management techniques like PERT and CPM for effective planning and execution of projects. (BL-3)
5. Use behavioral, leadership and time management aspects in entrepreneurial journey (BL-3)

UNIT-I

Entrepreneurship: Definition, functions of entrepreneurship, qualities of entrepreneurs, identification and characteristics of entrepreneurs, entrepreneur vs. intrapreneur, first generation entrepreneurs, women entrepreneurs, conception and evaluation of ideas and their sources.

UNIT-II

Indian industrial environment: Competence, opportunities and challenges, entrepreneurship and economic growth, small scale industry in India, objectives, linkage among small, medium and heavy industries, types of enterprises, corporate social responsibility.

UNIT-III

Business plan: Introduction, elements of business plan and its salient features, business model canvas, technical analysis, profitability and financial analysis, marketing analysis, feasibility studies, executive summary, selection of technology and collaborative interactions.

UNIT-IV

Project management: During construction phase, project organization, project planning and control using CPM, PERT techniques, human aspects of project management, assessment of tax burden.

UNIT-V

Behavioral aspects of entrepreneurs: Personality, determinants, attributes and models, leadership concepts and models, values and attitudes, motivation aspects, time management: approaches of time management, their strengths and weaknesses. time management matrix and the urgency addiction .

Text Books:

1. Vasant Desai, “Dynamics of Entrepreneurial Development and Management”, Himalaya Publishing House, 1997.
2. Prasanna Chandra, “Project-Planning, Analysis, Selection, Implementation and Review”, Tata Mcgraw-Hill Publishing Company Ltd.1995.
3. S.S. Khanka, “Entrepreneurial Development”, S. Chand & Co. Pvt. Ltd., New Delhi,2015.

Suggested Reading:

1. Robert D. Hisrich, Michael P. Peters, “Entrepreneurship”, 5/e, Tata Me Graw Hill Publishing Company Ltd., 2005.
2. Stephen R. Covey and A. Roger Merrill, “First Things First”, Simon and Schuster Publication,1994.

18ME O05

HUMAN RIGHTS AND LEGISLATIVE PROCEDURE
(Open Elective)

Instruction	3 Hours per week
Duration of SEE	3Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. Understand the value of human rights.
2. Understand the Lawful rights available to him and others.
3. Create understanding the rights of under privileged and respect them.
4. Understand role of an individual in the Civil Society.
5. UnderstandthesafetyaspectswhileusingtechnologyandtounderstandtheroleofNGO‟sinprotecting human rights and environment.

Outcomes: At the end of the course, the students are able to

1. Recall the human rights in the global and national context. (BL-1)
2. Understand the overall view on working of Indian constitution. (BL-2)
3. Analyze the societal problems in the context of human rights . (BL-4)
4. Evaluate implementation of right to development and right to information. (BL-5)
5. Application of human rights for human safety and clean environment. (BL-3)

UNIT-I

Meaning and concept of human rights: Notion and classification of rights, moral and legal rights, three generations of rights (civil, and political rights, economic social and cultural rights, collective/solidarity rights), Indian bill of rights and sarvodaya, preamble of Indian constitution, fundamental rights-directive principles- fundamental duties .

UNIT-II

Human rights enforcement mechanism: Human Rights Act, 1993, judicial organs-Supreme Court (Article 32) and high court (Article 226), human rights commission, National and State commission of Women/Children/Minority/SC/ST.

UNIT-III

A right to development: Socio-economic and cultural effects of globalization, right to education, transparency in governance and right to information, consumer protection act.

UNIT-IV

Environment rights such as right to clean environment and public safety: Issues of industrial pollution, prevention, and rehabilitation, safety aspects of new technologies such as chemical and nuclear technologies, issues of waste disposal, protection of environment.

UNIT-V

Role of advocacy groups: Professional bodies, press, media role of lawyers legal Aid., educational institutions , corporate Sector and N.G.Os .

Text Books:

1. Kapoor, S.K., “Human rights under International Law and Indian Law”, Prentice Hall of India, New Delhi,2002
2. P.M. Katare and B.C. Barik, “Development, Deprivation and Human Rights, Violation”, New Delhi, Rawat,2002.
3. S.N. Chaudhary, “Human Rights and Poverty in India: Theoretical Issues”, Delhi: Concepts, 2005.

Suggested Readings:

1. Frankena, W.K., “Ethics, Prentice Hall of India”, New Delhi, 1990.
2. K.P. Saksena, “Human Rights and the Constitution: Vision and the Reality”, New Delhi: GyanPubliations, 2003.

18ME O06

NANO MATERIALS AND TECHNOLOGY

(Open Elective)

Instruction	3 Hours per week
Duration of SEE	3Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. Nanotechnology approach and challenges.
2. Materials and characterization procedures.
3. Zero and one dimensional nanostructures.
4. Various fabrication techniques.
5. Special nano materials and nano biomaterials.

Outcomes: At the end of the course, the students are able to

1. Understand the basic concepts, developments and challenges in nanotechnology.(BL-2)
2. Describe the methods of evaluating magnetic and electronic properties, microstructure by spm and atomic force microscopy. (BL-2)
3. Apply heterogeneous methods and characterization techniques of zero & one dimensional nanostructures. (BL-3)
4. Evaluate various nano material fabrication techniques.(BL-5)
5. Analyze nano materials and nano bio materials for obtaining solutions to societal problems. (BL-4)

UNIT - I

Introduction: Nanoscale, properties at nanoscale, advantages and disadvantages, importance of nanotechnology, bottom-up and top-down approaches, challenges in nanotechnology.

UNIT - II

Materials of Nanotechnology: Introduction, Si-based materials, Ge-based materials, ferroelectric materials, polymer materials, GaAs &InP (HI-V) group materials, nano tribology and materials, characterization using scanning Probe microscope, AFM.

UNIT - III

Nano structures: Zero dimensional nanostructure, synthesis procedure by heterogeneous method, characterization techniques, properties and applications of nano particles

One dimensional nanostructures: Synthesis procedure, characterization procedure and principles involved, properties and applications of nanowires .

UNIT - IV

Nano fabrication: Introduction, basic fabrication techniques by lithography and doping, MEMS fabrication techniques, nano fabrication techniques by E-beam, nano-imprint fabrication, epitaxy and strain engineering.

UNIT - V

Special nano materials: Introduction, synthesis procedure by metal-polymer, characterization procedures, applications.

Nano biomaterials: Introduction, biocompatibility, anti-bacterial activity, applications.

Text Books:

1. Dieter Vollath, “Nanomaterials: An introduction to Synthesis, properties and applications”, Wiley,2013.
2. GuozhongCao,“NanostructuresandNanoMaterials,Synthesispropertiesandapplications”,ImperialCollege Press,2004.
3. Carl C Koch, “Nano materials Synthesis, Properties and applications”, Jaico Publishing House,2008.

Suggested Reading:

1. WilliaTllsey Atkinson, “Nano Technology”, Jaico Publishing House,2009.
2. George W. Hanson, “Fundamentals of Nano electronics”, Pearson Education,2009.

18ME O07

INTELLECTUAL PROPERTY RIGHTS

(Open Elective)

Instruction	3 Hours perweek
Durationof SEE	3Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. Fundamental aspects ofIP.
2. Salient features of IPRacts.
3. The methods of registrations of Intellectualproperty.
4. Awareness for innovation and its importance ofprotection.
5. The changes in IPR culture and techno-business aspects ofIPR.

Outcomes: At the end of the course, the students are able to

1. Understand the evolution of IP, working of organization's at global level to protect and promote IP.(BL-2)
2. Familiarize with the patent filing process at national andinternationallevel.(BL-2)
3. Draw the logical conclusion of research, innovation andpatentfiling.(BL-3)
4. Compare different kinds of IP and their patentingsystem.(BL-4)
5. Understand the techno-legal-business angle of IP, infringement and enforcement mechanisms for protection. (BL-2)

UNIT-I

Introduction: Definition of intellectual property, the need for intellectual property rights (IPR), kinds of intellectual property rights, IPR in India – genesis and development, IPR abroad, importance of WTO, TRIPS agreement, patent cooperation treaty, Berne and universal copyright conventions.

UNIT-II

Patents: Definition of patent, commercial significance , term of patent, patentable subject- matter, rights and obligations of patentee, searching of existing patents, drafting of patent, specification of patent, filing of a patent, the different layers of the patent system (national, regional and international options), compulsory licensing and licenses of rights, revocation of patents, differences between utility model andpatent.

UNIT-III

Industrial designs: Definition of designs, registration of design, rights and duties of proprietor of design, piracy of registered design.

Trademarks: Meaning of trademarks, purpose of protecting trademarks, registration of trademarks, passing off, assignment and licensing of trademarks, infringement of trademarks.

Geographical indications: Definition, differences between GI and trademarks.

UNIT-IV

Copy right: Nature and scope of copy right, term of copyright, subject matter of copyright, rights conferred by copyright ,publication, broad casting, telecasting, computer program, database protection, assignment and transmission of copyright, infringement of copy right trade secrets and know-how agreement.

UNIT-V

Enforcement of intellectual property rights: Infringement of intellectual property rights, enforcement measures, emerging issues in intellectual property protection, case studies of patents and IP Protection.

Unfair competition: What is unfair competition, relationship between unfair competition and intellectual property laws.

Text Books:

1. AjitParulekarandSaritaD"Souza, “IndianPatents Law-Legal&BusinessImplications”,MacmillanIndia Ltd., 2006.
2. B.L.Wadehra, “Law relating to Patents, Trade Marks, Copyright, Designs &Geographical Indications”, Universal law Publishing Pvt Ltd., India,2000.
3. P.Narayanan, “Law of Copyright and Industrial Designs”; Eastern law House, New Delhi,2010.

Suggested readings:

1. CronishW.R , “ Intellectual Property Patents, Copyright, Trade Marks and Allied rights”, Sweet & Maxwell,1993.
2. P.Narayanan, “Intellectual Property Law” Eastern Law Edn.,1997.

18ME O08

MECHATRONICS

(Open Elective)

Instruction	3 Hours perweek
Duration of SEE	3Hours
SEE	70Marks
CIE	30MarksCredits
	3

Objectives:

1. To identify, formulate and solve current engineering problems.
2. To design a system, component, or process to meet desired needs within realisticconstraints.
3. To use the techniques, skills, and modern engineering tools necessary for engineeringpractice.
4. The use of drive mechanisms and fluid power systems and related electronicdevices.
5. To demonstrate the design of modern CNC machines and modern mechatronicssystems.

Outcomes: At the end of the course, the students are able to

1. Understand the concept of mechatronics and analyze electrical and mechanical systems and their interconnection for agivenapplication. (BL-2)
2. Apply mechanical, electronics, control, and computer engineering in the design of mechatronics systems to specificapplications. (BL-3)
3. Analyze the design, interfacing, and actuation of a mechatronics system togivenspecifications.(BL-4)
4. Recommend the use of industrial electronic devices, fluid power systems in various mechatronics applications.(BL-5)
5. Develop the design of modern CNC machines and modernmechatronicssystems.(BL-6)

UNIT-I

Introduction to mechatronics systems, measurement systems and control systems: Need of interface of electrical & electronic devices with mechanical elements, the concept of mechatronics, flow chart of mechatronics system, elements of mechatronics system, drive mechanisms, actuators, feedback devices and control system, application in industries and systems development .

UNIT-II

Actuation systems: Pneumatic and hydraulic systems, values, pumps and accessories, hydraulic circuits, mechanicalservocontrolcircuits,electro-hydraulicservocontrolandhydro-pneumaticcircuitsexamples.
Mechanical actuation systems: Cams-gear trains, ratchet and pawl etc.**Electrical actuation systems:** mechanical switches, solenoids, DC motors, AC motors, stepper motors, servo motors .

UNIT-III

Sensors and transducers: Performance terminology, sensors for displacement, position and proximity, velocity, motion, force, fluid pressure, liquid flow, liquid level, temperature, (thermistor, thermo couple), light sensors, selection of sensors.

UNIT-IV

8085 Microprocessor: Introduction, architecture, configuration- programming using 8085 instructions , interfacing input and output devices, D/A connectors and A/D connectors, applications.
Programmable logic controllers: Introduction, basic structure, input/output processing, programming, mnemonics,timers, internal relays and counters, data handling, analog input/output, selection of a PLC.

UNIT-V

Design of modern mechatronics systems: Stages in designing of mechatronics, traditional and mechatronic design,possible design solutions, case studies of mechatronics systems, pick and place robot, automatic car park systems, automatic washing machine, engine management systems.

Text Books:

1. WilliamBolton,“Mechatronics:Electroniccontrolsystemsinmechanicalandelectricalengineering”, 6/e, PearsonEducation.
2. HMT Ltd, “Mechatronics”, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1998.
3. Michaels Histand& David G, Alciatore, “Introduction to Mechatronics and Measurement Systems”,Tata McGraw- Hill, International Edition, 2011.

Suggested Reading:

1. DevdasShetty, Richard A. Kolk, “Mechatronics System Design”, Cengage Learning,2010.
2. S.R. Majumdar, “Oil Hydraulic Systems – Principles & Maintenance”, McGraw-Hill Publishing Company Limited, New Delhi,2006

18ME O09

ORGANIZATIONAL BEHAVIOUR

(Open Elective)

Instruction	3 Hours perweek
Durationof SEE	3Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. Define basic organizational behavior principles and analyze how these influence behavior in theworkplace.
2. Analyze the influence of perceptions and personality on individual human behavior in theworkplace.
3. Discuss the theories of Motivation andLeadership.
4. Provide knowledge on different organizational structures; and concepts of culture, climate and organizational development and make the students familiarize with individualbehavior.
5. Describe the interpersonal and their intrapersonal reactions within the context of the group and also demonstrate effective communication and decision making skills in small groupsettings.

Outcomes: At the end of the course, the students are able to

1. Understand Organizational Behavioral principlesand practices.(BL-2)
2. Compare various organizational designs and cultures enablingorganizational development. (BL-4)
3. Apply motivational theories and leadership styles in resolving employee’s problems and decision making processes. (BL-3)
4. Understand the group dynamics, communication network,skills needed to resolve organizational conflicts. (BL-2)
5. Analyze the behavior, perception and personality of individuals and groups in organizations in terms of the key factors that influenceorganizationalbehavior. (BL-4)

UNIT –I

Introduction: Organizational behaviour, nature and levels of organizational behavior, individuals in organization, individual differences , personality and ability, the big 5 model of personality , organizationally relevant personality traits, the nature of perception , characteristics of the perceiver, target and situation , perceptual problems.

UNIT – II

Organization structure: Organizational designs and structures, traditional and contemporary organizational designs, organizational culture and ethical behavior , factors shaping organizational culture, creating an ethical culture, concepts, organizational climate, organization conflict, and organization development.

UNIT – III

Motivation and leadership: Motivation, early and contemporary theories of motivation, leadership, early and contemporary approaches to leadership.

UNIT – IV

Group dynamics: Groups and group development, turning groups into effective teams, managing change , process, types and challenges, communicating effectively in organizations, communication process, barriers to communication, overcoming barriers to communication, persuasive communication, communication in crisis situations.

UNIT – V

Power, Politics, Conflict and Negotiations: Power, politics, conflict and negotiations, sources of individual, functional and divisional power, organizational politics conflict, causes and consequences, Pondy's model of organizational conflict, conflict resolution strategies.

Text Books:

1. Jennifer George and Gareth Jones, "Understanding and Managing Organizational Behavior", Pearson Education Inc.,2012.
2. Jon L Pierce and Donald G. Gardner, "Management and Organizational behavior", Cengage Learning India (P) Limited,2001.
3. Richard Pettinger, "Organizational Behaviour", Routledge,2010.

Suggested Reading:

1. Stephen P. Robbins, Jennifer George and Gareth Jones, "Management and Organizational Behaviour", Pearson Education Inc.,2009.
2. John Schermerhorn, Jr., James G. Hunt and Richard N. Osborn, "Organizational Behaviour", 10/e, Wiley India Edition,2009.

18MEO10

INTRODUCTION TO OPERATIONS RESEARCH

(Open Elective)

Instruction	3 Hours perweek
DurationofSEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. Students will come to know the formulation of LPPmodels.
2. Students will understand the Algorithms of Graphical and Simplex Methods,
3. Students will understand the Transportation and Assignmenttechniques.
4. Students will come to know the procedure of Project Management alongwith CPM and PERTtechniques.
5. Students will understand the concepts ofsequencing.

Outcomes: At the end of the course, the students are able to

1. Understand the concepts of linearprogrammingproblem. (BL-2)
2. Solve the giventransportationproblem. (BL-3)
3. Develop optimum pair of operations and resources by usingassignment technique. (BL-3)
4. Analyze project management techniques like CPM and PERT to plan and execute projectssuccessfully. (BL-4)
5. Apply sequencing concepts for industryapplications. (BL-3)

UNIT-I

Introduction: Definition and scope of operations research

Linear programming: Introduction, formulation of linear programming problems, graphical method of solving LP problem, simplex method, degeneracy in simplex method

UNIT-II

Transportation models: Finding an initial feasible solution - north west corner method, least cost method, vogel's approximation method, finding the optimal solution, special cases in transportation problems - unbalanced transportation problem, degeneracy in transportation

UNIT-III

Assignment techniques: Introduction, Hungarian technique of assignment techniques, unbalanced problems, problems with restrictions, maximization in assignment problems, travelling salesman problems

UNIT-IV

Project management: Definition, procedure and objectives of project management, differences between CPM and PERT , rules for drawing network diagram, scheduling the activities, Fulkerson's rule, earliest and latest times, determination of ES and EF times in forward path, LS & LF times in backward path, determination of critical path, duration of the project

UNIT-V

Sequencing models: Introduction, general assumptions in sequencing, sequencing rules processing n"jobs throughtwomachines, processing n"jobs throughthreemachines

Text Books:

1. Hamdy A. Taha, “Operations Research-An Introduction”, 10/e, Pearson education edition, 2017.
2. S.D. Sharma, “Operations Research”, Kedarnath, Ramnath& Co., Meerut,2009.
3. V.K. Kapoor, “Operations Research”, S. Chand Publishers, New Delhi,2004.

Suggested Reading:

1. R. Paneerselvam, “Operations Research”, 2/e, PHI Learning Pvt. Ltd., New Delhi,2008.
2. Nita H. Shah, Ravi M. Gor, HardikSoni, “Operations Research”, PHI Learning Private Limited,2013.

18ME O11

MODERN MANUFACTURING PROCESSES

(Open Elective)

Instruction	3 Hours perweek
DurationofSEE	3Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. Understand the opportunities and challenges brought about by Industry4.0.
2. Familiarize with the basic concept and process of digital manufacturing.
3. Understand real-life scenarios and recommend the appropriate use of 3D printingtechnology.
4. Acquire the knowledge of non-traditional machiningprocesses.
5. Learn the procedure for the fabrication of micro-electronicdevices.

Outcomes: At the end of the course, the students are able to

1. Understand the opportunities, challenges brought about by Industry 4.0 and how organizations and individuals should prepare to reapthe benefits. (BL-2)
2. Apply the concept, architecture and process ofdigitalmanufacturing. (BL-3)
3. Evaluate real-life scenarios and recommend the appropriate use of 3Dprintingtechnology. (BL-5)
4. Compare various non-traditionalmachiningprocesses. (BL-4)
5. Demonstrate the procedure for the fabrication of micro-Electronicdevices. (BL-2)

UNIT –I

Introduction to industry 4.0: The various industrial revolutions, digitalization and its impact, comparison of industry 4.0 factory and today's factory. business issues in industry 4.0, internet of things (IoT) & industrial internet of things (IIoT) & internet of services, smart manufacturing, cyberphysical systems, trends of industrial big data, cloud computing, robotic automation and collaborative robots, cyber security.

UNIT –II

Digital manufacturing process : Introduction to digital manufacturing and design, concepts , research and development status of digital manufacturing, definition, features and development of digital manufacturing, transition to digital manufacturing and design, advantages of digital manufacturing and design. digital thread, information sharing in the digital thread, data procurement standards, manufacturing supply chains, integrated information systems in the productlifecycle.

UNIT –III

Additive manufacturing processes: Introduction to 3D printing, evolution, distinction between 3D printing & CNCmachining.

Processes and principles: Photo polymerization, powder bed fusion, binder jetting, material jetting, sheet metal lamination, material extrusion, direct energy deposition. application in aerospace industry, automotive industry, jewelry industry, medical and bioengineering applications, planning and simulation of complex surgery, forensic science.

UNIT–IV

Nontraditional machining processes: Requirement, process description of ultrasonic machining, abrasive jet machining, water jet machining, water abrasive jet machining, electro discharge machining, electrochemical machining, chemical machining, ion beam etching, plasma arc machining, laser beam machining and electron beam machining.

UNIT-V

Fabrication of micro- electronic devices: Introduction, semiconductors and silicon, fabrication of integrated circuits and silicon wafers, film deposition, lithography, etching, diffusion and ion implantation, metallization and testing, bonding and packaging, printed circuit boards.

Text Books:

1. Mikell P. Grover, "Fundamentals of Modern Manufacturing Materials, Processes and Systems", 4/e, John wiley& sons, inc,2009.
2. Zude Zhou, Shane (Shengquan) Xie and DejunChen, "Fundamentals of Digital Manufacturing Science", Springer-Verlag London Limited,2012.
3. Brent Stucker, David Rosen, and Ian Gibson, "Additive Manufacturing Technologies" Springer,2010.

Suggested Reading:

1. Serope Kalpak Jain, Steven R.Schmid, "Manufacturing Engineering and Technology", 4/e, Pearson Education India, 2006
2. Amitabh Ghosh and Mallick, "Manufacturing Science", Assoc. East West Press Pvt. Ltd., 4/e,2011.

18ME O12

3DPRINTING

(OpenElective)

Instruction	3 Hours perweek
DurationofSEE	3Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. To make students understand the basic concept of digitalmanufacturing.
2. To teach different processes involved in digital fabrication ofproducts.
3. To demonstrate the STL file generation andmanipulations.
4. To demonstrate various post processingtechniques.
5. To demonstrate the applications of RP in different fields ofengineering.

Outcomes: At the end of the course, the students are able to

1. Understand the concept of 3D printing processes, advantagesandlimitations. (BL-2)
2. Evaluate real-life scenarios and recommend the appropriate 3Dprintingtechnology. (BL-5)
3. Analyze various pre-processing and postprocessingtechniques. (BL-4)
4. Explain current and emerging 3D printing technologies indiversified applications. (BL-2)
5. Identify components required in construction of3Dprinter. (BL-3)

UNIT-I

Introduction to 3D Printing: Introduction to 3D printing, evolution, distinction between 3D printing & CNC machining.

Design considerations: Materials, size, resolution, mass customization. additive vs. subtractive manufacturing, its advantages and limitations

UNIT-II

Photo polymerization processes: Photo polymerization, Stereolithography Apparatus (SLA), Applications, advantages and disadvantages.

Powder bed fusion processes: Introduction, Selective laser Sintering (SLS), Materials, Applications, advantageand disadvantages.

Extrusion-based systems: Fused deposition modeling (FDM), laminated object manufacturing (LOM), Principles, Materials, Process Benefits and Drawbacks.

Material Jetting AM Processes: Evolution of Printing as an Additive Manufacturing Process, Materials, Process Benefits and Drawbacks, Applications of Material Jetting Processes.

UNIT-III

Pre processing in AM: Modeling and viewing - 3D scanning; Model preparation – STL conversion, STL error diagnostics, STL file Repairs, generic solution, slicing, newly proposed file formats.

Post processing in AM: Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non–thermal and thermal techniques.

UNIT-IV

Construction of basic 3D printer: Construction of 3D printing machine – axes, linear motion guide ways, ball screws, motors, bearings, encoders, process chamber, safety interlocks, sensors.

UNIT-V

Applications of AM: Application in aerospace industry, automotive industry, jewelry industry, coin industry. medical and bioengineering applications: planning and simulation of complex surgery, forensic science.

Text Books:

1. Gibson, DW. Rosen and B.Stucker; “Additive manufacturing methodologies : Rapid prototyping to direct digital manufacturing ”, Springer,2010.
2. Chee Kai Chua, Kah Fai Leong, “3D printing and additive manufacturing: principles and application”, 4/e of rapid proto typing, World scientific publishing company,2014.
3. P.K. Venuvinod, “Rapid prototyping – Laser based and other technologies”,Kluwer,2004.

Suggested Reading:

1. Jacob, Paul, “Rapid tooling : Technologies and industrial applications”, Taylor & Francis Group , 2000.
2. Alain Bernard, Georges Taillandier, “Additive Manufacturing”,Wiley,2014.

18ME O13

INDUSTRIAL AND FINANCIAL MANAGEMENT

(Open Elective)

Instruction	3 Hours perweek
Durationof SEE	3Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. Various types of business organizations and organization structures. Principles. Ofmanagement and importance of plant location and plantlayout.
2. Importance of industrial engineering techniques like method study and workmeasurement.
3. The significance of quality control and production planning andcontrol.
4. The importance of project management techniques.
5. The total cost of a product based on elements ofcost.

Outcomes: At the end of the course, the students are able to

1. Understand different types of business organizations, functions of management and importance of various types ofplant layouts. (BL-2)
2. Apply techniques of method study and work measurement in organizations to enhance productivity. (BL-3)
3. Use quality control charts and toolsinindustries. (BL-3)
4. Apply various optimization and project management techniques for solving real time problems.(BL-3)
5. Understand basic concepts of cost accounting andfinancialmanagement. (BL-2)

UNIT-I

Industrial organization: definition of an organization, types of various business organizations, organization structures and their relative merits and demerits, functions of management, principles of management.

Plant location and layouts: Factors affecting the location of plant and layout, types of layouts and their merits and demerits.

UNIT-II

Productivity: Definition, concepts, principles and techniques of improving productivity

Work study: Definitions, objectives of method study and time study, steps in conducting method study, symbols and charts used in method study, principles of motion economy, calculation of standard time by time study and work sampling, performance rating factor, types of ratings, Job evaluation and performance appraisal, Wages and incentivesplans.

UNIT-III

Inspection and quality control: Types and objectives of inspection, S.Q.C., its principles, quality control charts and sampling plans, quality circles, introduction to ISO and TQM.

Production planning and control (PPC): Types of production systems, Principles of PPC and its functions.

UNIT-IV

Optimization: Introduction to linear programming and graphical solutions.

Project management: Introduction to CPM and PERT, determination of critical path and project duration.

Materials management: Classification of materials, materials planning, duties of purchase manager, determination of economic orderingquantities.

UNIT-V

Cost accounting: Elements of cost, various costs, types of overheads, break even analysis and its applications, depreciation, methods of calculating depreciation fund, nature of financial management, time value of money, techniques of capital budgeting and methods, cost of capital, financial leverage.

Text Books:

1. O.P. Khanna "Industrial Engineering and Management", DhanapatRai& Sons,2018.
2. S.D. Sharma, "Operations Research" ,Kedarnath,Ramnath& Co.,Meerut,2012.
3. Pandey I.M. , " Financial Management", Vikas Publ. House, New Delhi,2016.

Suggested Reading:

1. William J Stevenson, "Operations Management", McGraw Hill,2018.
2. Paneerselvam, "Production and Operations Management", Pearson Education,2012.

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

AICTE MODEL CURRICULUM

B.E- MECHANICAL ENGINEERING (Honours)

S.No.	Course Code	Title of the Course	Credits
1	18ME H01	Automation in Manufacturing.	3
2	18ME H02	Advanced Materials and Processes.	3
3	18ME H03	Industrial Safety Engineering	3
4	18ME H04	Surface Engineering For Corrosion and Wear Resistance Applications	3
5	18ME H05	Mathematical Modeling Of Manufacturing Processes	3
6	18ME H06	Work System Design	3
7	18ME H07	Sustainability Through Green Manufacturing Systems: An Applied Approach	3
8	18ME H08	Functional and Conceptual Design.	3
9	18ME H09	Weldability of Metals: Mechanisms, Weld Defects & Prevention.	2
10	18ME H10	Design for Quality, Manufacturing and Assembly.	2
11	18ME H11	Dealing With Materials Data: Collection, Analysis and Interpretation.	3
12	18ME H12		2

		Manufacturing Strategy.	
13	18ME H13	Knowledge Management.	2
14	18ME H14	Design Thinking - A Primer.	1
15	18ME H15	Innovation by Design.	1
16	18ME H16	Understanding Design.	1
17	18ME H17	Structural Analysis of Nano materials.	1
18	18ME H18	Mechanical Measurement Systems	2
19	18ME H19	Patent Drafting for Beginners	1
20	18ME H20	Heat Exchangers: Fundamentals and Design Analysis	3
21	18ME H21	Solar Energy Engineering and Technology	3
22	18ME H22	Advanced Fluid Mechanics	3
23	18ME H23	Aircraft Propulsion	3
24	18ME H24	Energy Conservation and waste heat recovery	3
25	18ME H25	Fluidization Engineering	3
26	18ME H26	CFD using Finite Volume Method	3
27	18ME H27	Fundamentals of Convective Heat Transfer	3
28	18ME H28	Dynamic behavior of Materials	3
29	18ME H29	System design for Sustainability	3
30	18ME H30	Computational Continuum Mechanics	3
31	18ME H31	Engineering Fracture Mechanics	3
32	18ME H32	Numerical methods for Engineers	3

33	18ME H33	Robotics and Control: Theory and Practice	2
34	18ME H34	Acoustic materials and Metamaterials	2
35	18ME H35	MATLAB Programming for Numerical Computation	2
36	18ME H36	Ergonomics in Automotive design	1
37	18ME H37	Foundations of Cognitive Robotics	1
38	18ME H38	Theory of Rectangular Plates	1
TOTAL			**90**

Note: The students opting for honors degree in mechanical engineering need to choose and register the courses from the above list leading to a total of 20 credits.

18ME H01

AUTOMATION IN MANUFACTURING

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Explain the design and development of automated systems in the manufacturing. (BL-2)
2. Describe working of various blocks of automated system. (BL-2)
3. Illustrate the principle of operation and construction details of sensors/transducers, actuators, drives and mechanisms, hydraulic and pneumatic systems for automation. (BL-3)
4. Summarize the microprocessor technology, programming and CNC technology. (BL-2)
5. Use automation principles for manufacturing industrial applications. (BL-3)

UNIT- I

Introduction: Importance of automation in the manufacturing industry. Use of mechatronics, systems required.

Design of an automated system: Building blocks of an automated system, working principle and examples.

UNIT- II

Fabrication: Fabrication or selection of various components of an automated system, specifications of various elements, use of design data books and catalogues.

Sensors: Study of various sensors required in a typical automated system for manufacturing, construction and principle of operation of sensors.

UNIT- III

Microprocessor technology: Signal conditioning and data acquisition, use of microprocessor or micro controllers, configurations, working.

Drives: Electrical drives, types, selection criteria, construction and operating principle.

UNIT - IV

Mechanisms: Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, and transfer systems.

Hydraulic systems: Hydraulic power pack, pumps, valves, designing of hydraulic circuits.

UNIT –V

Pneumatic systems: Configurations, compressors, valves, distribution and conditioning.

CNC technology: Basic elements, interpolators and programming.

Text Books:

1. Boltan, W., “Mechatronics: electronic control systems in mechanical and electrical engineering”, Longman, Singapore, 1999.
2. Groover, M.P., “Automation, Production Systems, and Computer-Integrated Manufacturing”, Prentice Hall, 2001.
3. Gaonkar, R.S., “Microprocessor architecture, programming, and applications with the 8085”, Penram International Publishing (India), Delhi, 2000.

Suggested Reading:

1. Regtien, P. P. L., “Sensors for mechatronics”, Elsevier, USA, 2012.
2. Parr, A. A., “Hydraulics and pneumatics”, Elsevier, 1999.

Handbooks:

1. Smid, P., “CNC Programming Handbook”, Industrial Press, New York, USA, 2008.
2. Rothbart, H. A., “CAM Design Handbook”, McGraw-Hill, 2004.
3. Norton, R. L., “Cam Design and Manufacturing Handbook”, Industrial press Inc, 2002.

18ME H02

ADVANCED MATERIALS AND PROCESSES

Instruction	3 Hours per week
Course Duration	12 Weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Understand the classification of structural and functional materials. (BL-2)
2. Learn the processing and applications of bulk metallic glasses. (BL-1)
3. Identify the use of various materials. (BL-2)
4. Design materials based on applications. (BL-3)
5. Understand the importance of shape memory alloys and super alloys. (BL-2)

UNIT – I

Introduction: Metastable and functional alloys.

Bulk metallic glasses: Fundamental concepts, mechanical and functional properties.

UNIT - II

Shape memory alloys, Pseduelasticity, shape memory alloys applications and case studies.

UNIT - III

Introduction to high temperature materials.

Super alloys: Alloy design, microstructure and properties.

UNIT - IV

Nano-materials.

UNIT - V

Soft and hard magnetic materials, non-equilibrium processes, single crystal growth, rapid solidification, inert gas condensation and advanced functional alloys.

Text Books:

1. Leonardo Lecce and Antonio Concilio, "Shape Memory Alloy Engineering: For Aerospace, Structural and Biomedical Applications", Butterworth-Heinemann, 2014.
2. Helmi A. Youssef, "Machining of Stainless Steels and Super Alloys: Traditional and Nontraditional Techniques", Wiley, 2016.
3. Guozhong Cao and Ying , "Nanostructures and Nanomaterials: Synthesis, Properties, and Applications", World Scientific Publishing Company, 2010.

Suggested Reading:

1. Mark J. Mezger, Kay J. Tindle, "Energetic Materials: Advanced Processing Technologies for Next Generation Materials", CRC Press, 2017.
2. C. Suryanarayana and A. Inoue, "Bulk Metallic Glasses", CRC Press; 2 edition, 2017

18 ME H03

INDUSTRIAL SAFETY ENGINEERING

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Identify the causes for industrial accidents and suggest preventive measures for safety. (BL-2)
2. Use the concepts of engineering systems safety, dimensions of engineering systems safety.(BL-3)
3. Apply the principles of safety design and carry out analysis. (BL-3)
4. Design for engineering systems safety and control for safety. (BL-3)
5. Integrate safety with other operational goals such as quality and reliability. (BL-5)

UNIT - I

Introduction: key concepts, terminologies, and safety quantification, safety by design, hazard identification techniques (e.g., HAZOP, FMEA, etc.) .

UNIT - II

Fault tree and event tree analysis (qualitative & quantitative)andBow-tie and quantitative risk assessment (QRA) .

UNIT - III

Safety function deployment, safety vs reliability, quantification of basic events (repair to failure, repair-failure-repair, and combined processes).

UNIT - IV

Systems safety quantification (e.g., truth tables, structure functions, minimal cut sets), human error analysis and safety.

UNIT – V

Accident investigation and analysis, application of virtual reality, OSHAS 18001 and OSHMS.

Text Books:

1. Komamoto and Henley, “Probabilistic Risk Assessment for Engineering and Scientists”, IEEE Press, 1995.
2. Heinrich et al., “Industrial Accident Prevention”, McGraw Hill, 1980.
3. Petersen D, “Techniques for safety management - A systems approach”, ASSE 1998.

Suggested Reading:

1. H. P. Garg, “Maintenance Engineering”, S. Chand and Company, Year 2010.
2. Tyler G. Hicks and T. W. Edwards, “Pump Application Engineering", McGraw-Hill, 1971.

18ME H04

SURFACE ENGINEERING FOR CORROSION AND WEAR RESISTANCE APPLICATIONS

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the degradation of engineering materials through wear and corrosion. (BL-2)
2. Develop wear and corrosion resistant materials. (BL-6)
3. Analyze the role of microstructure in controlling the surface dependent failure of components. (BL-3)
4. Apply advanced surface modification techniques to protect engineering components. (BL-4)
5. Evaluate various surface engineering techniques. (BL-5)

UNIT - I

Introduction: Materials, surface, thermodynamics of surface, surface dependent engineering properties, Common surface initiated engineering failure, mechanism of surface degradation, role of microstructure and materials behavior in controlling the surface dependent failure of components, importance of surface engineering, classification and scope of surface engineering of materials, surface modification and coating techniques.

UNIT - II

Conventional surface modification methods: Age hardening, induction hardening, carburizing, nitriding, and diffusion assisted surface alloying.

Advanced surface modification methods: Laser, plasma and electron beam assisted surface modification, surface coating by chemical/electro-chemical routes electro/electroless deposition, anodizing, micro-arc oxidation.

UNIT-III

Surface coating by physical routes: Physical vapor deposition, pulsed laser deposition, cathodic arc evaporation.

Surface coating by chemical routes: Chemical vapor deposition, laser assisted chemical vapor deposition.

UNIT- IV

Hot dipping: Galvanizing, tinning, aluminizing, babitting.

Thermal spraying: Ame spraying, HVOF spraying, wire arc spraying, kinetic spraying.

UNIT-V

Special coating techniques: Weld overlaying, laser surface cladding, surface characterization and testing.

Text Books:

1. J R Davis, "Surface Engineering for Corrosion and Wear Resistance", ASM International, 2001.
2. Manish Roy "Surface Engineering for Enhanced Performance against wear", Springer Science & Business Media, 2013.
3. K. Holmberg, A. Matthews, "Coatings Tribology: Properties, Techniques and Applications in Surface Engineering" , Elsevier,1994.

Suggested Reading:

1. Tadeusz Burakowski, Tadeusz Wierzchon, "Surface engineering in metals", CRC Press, 1999.
2. Jamal Takadoum, "Surface Engineering: Enhancing life of Tribological component", Springer, 2017.
3. London A W Batchelor, "Materials Degradation and its control by surface engineering", Imperial College Press, 2006.

18ME H05

MATHEMATICAL MODELING OF MANUFACTURING PROCESSES

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the basic mechanism such as heat and mass transport with associated fluid flow including metallurgical transformation, distortion and residual stress generation in different manufacturing processes. (BL-2)
2. Explain the analysis, numerical simulation at different scale and experimentation for different types of manufacturing processes. (BL-4)
3. Develop the computational models for a manufacturing process relies on mathematical expression of the governing mechanism. (BL-6)
4. Understand the most general to advanced manufacturing processes based on scientific principle. (BL-2)
5. Develop physics based computational model of manufacturing process using standard commercial package. (BL-6)

UNIT – I
Introduction to manufacturing processes, physics of manufacturing processes.

UNIT – II
Conventional machining, non-conventional machining.

UNIT - III
Metal forming, welding.

UNIT – IV
Casting and powder metallurgy, coating and additive manufacturing.

UNIT - V
Heat treatment, micro/nano scale manufacturing, processing of non-metallic materials.

Text Books:

1. A Ghosh and A K Mallik, “Manufacturing Science”, East-West Press Pvt Ltd,2nd Ed., 2010.
2. D A Brandt, J C Warner, “Metallurgy Fundamentals”, Goodheart- Willcox, 2009.
3. C Lakshmana Rao and Abhijit P Deshpande, “Modelling of Engineering Materials”, Ane Books Pvt. Ltd., New Delhi, India, 2010.

Suggested Reading:

1. J. Chakrabarty, “Theory of plasticity”, 3rd Eds, Elsevier India, 2009.
2. Norman Y Zhou, “Micro joining and Nanoioining”, Woodhead publishing, 2008.

18ME H06

WORK SYSTEM DESIGN

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Scientifically establish the time required for a qualified worker to carry out a work element at a defined rate of working. (BL-5)
2. Apply ergonomic aspects of work system design. (BL-3)
3. Carry out systematic examination of the methods of doing work with an aim of finding the means of effective and efficient use of resources. (BL-3)
4. Establishing standards of performance for the work being carried out. (BL-5)
5. Carry out in-depth analysis of all the elements, factors, resources and relationships affecting the efficiency and effectiveness of the work being studied. (BL-3)

UNIT- I

Work system design: Introduction, concept of productivity, measurement of productivity, productivity measures, productivity measurement models, factors influencing productivity, causes of low productivity, productivity improvement techniques, numerical problems on productivity, case study on productivity.

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UNIT -II

Work study: Basic concept, steps involved in work study, concept of work content, techniques of work study, human aspects of work study

Method study: Basic concept, steps involved in method study, recording techniques, operation process charts, examples.

Flow process charts: Examples, two-handed-process charts, multiple activity charts, flow diagrams.

UNIT-III

String diagrams, principles of motion economy, micro-motion study, therbligs, SIMO charts, memo-motion study, cycle graph and chrono-cycle graph, critical examination techniques, development and selection of new method, installation and maintenance of improved methods.

UNIT- IV

Work measurement: Basic concept, techniques of work measurement, steps involved in time study, steps and equipment of time study, performance rating.

Performance rating: Examples, allowances, computation of standard time-I, computation of standard time-II, case study.

UNIT – V

Work sampling: Basics, procedure of work sampling study, numerical problems on work sampling, introduction to synthetic data and PMTS, introduction to MTM and MOST.

Ergonomics: Basic concept, industrial ergonomics, anthropometry, man-machine system-1&2.

Case studies: Office chair, tower crane cabin, car seat, computer system, assembly line.

Text Books:

1. M. Telsang, "Industrial Engineering and Production Management", S. Chand and Company Ltd, 2015.
2. Ralph M. Barnes, Wiley "Motion and Time Study Design and Measurement of Work", The University of California, 2005.
3. Groover M.P., "Work Systems: The Methods, Measurement & Management of Work", Prentice Hall, 2000.

Suggested Reading:

1. Alexander D., The practice and Management of industrial ergonomics, Prentice Hall, 2006.
2. Konz S., and Johnson S., Work Design and Industrial Ergonomics, Holcomb Hathaway Publishers, 2001.

18ME H07

SUSTAINABILITY THROUGH GREEN MANUFACTURING SYSTEMS: AN APPLIED APPROACH

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the over view of the sustainability through green manufacturing systems. (BL-2)
2. Analyze the various methodologies and its applications in improving the eco-efficiency. (BL-4)
3. Suggest ways to conserve energy and natural sources and to ensure that they have minimal impact on the environment and society. (BL-6)
4. Apply sustainable aspects of management methodologies such as lean manufacturing, green supply chain management and product life cycle management. (BL-3)
5. Carry out simulation of the manufacturing systems and use modern tools that are used in the virtual environment. (BL-3)

UNIT - I

Introduction: Concept of sustainability, manufacturing, operations, processes, practices, resources in manufacturing, simulation models for manufacturing, validation, verification, output analysis, concepts of optimization, numerical optimization through simulation.

UNIT - II

Life cycle analysis: Remanufacture and disposal, tools for LCA, optimization for achieving sustainability in unit manufacturing, green manufacturing.

UNIT - III

Green manufacturing techniques: Dry and near-dry machining, edible oil based cutting fluids, cryogenic machining for eco-efficiency.

UNIT - IV

Implementation of lean methods: Validating requirements, green supply chain and carbon footprints in transportation.

Product life cycle management: Energy and mass, work pool and throughput.

UNIT - V

Modern approaches for sustainable manufacturing, toxic substances in industry, and need of renewable sources, simulation for sustainable manufacturing, building a smart green factory, simulation techniques.

Text Books:

1. Nylund, Hasse, “Impacts of Product Lifecycle and Production System Design on Competitive and Sustainable Production”,McGraw Hills Publication, 2013**.**
2. David A. Dornfeld “Green Manufacturing: Fundamentals and Applications” Springer, 2012.
3. Mrityunjay Singh Tatsuki Ohji Rajiv Asthana “Green and Sustainable Manufacturing of Advanced Material” , Elsevier, 2015.

Suggested Reading:

1. Bin Chang, “Systems Analysis for Sustainable Engineering: Theory and Applications (Green Manufacturing & Systems Engineering)”, McGraw-Hill Education, 2010.
2. Jiri Klemes , Ferenc Friedler, “Sustainability in the Process Industry: Integration and Optimization (Green Manufacturing & Systems Engineering)”, McGraw-Hill Education**,** 2010.

18ME H08

FUNCTIONAL AND CONCEPTUAL DESIGN

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Learn the importance of system design process in product design. (BL-1)
2. Identify various steps involved in the design process. (BL-2)
3. Learn the importance of function and form in the design process. (BL-1)
4. Apply the systematic design process for product development. (BL-3)
5. Apply the concept development tools in the design process. (BL-3)

UNIT - I

Overview of the design process: How engineering design is different from conventional design.
Steps in design process: Understanding the opportunity, mission statement.

UNIT - II

Customer need identification: Like/Dislike method, affinity diagram.
Product specifications: Design metrics, bench marking, QFD, HOQ and examples.

UNIT - III

Functional design: Functional decomposition, FAST, function structure, function tree, functional decomposition, examples.

UNIT - IV

Product architecture: Portfolio architecture, unshared, modular, customizable architectures, choosing portfolio architecture, module heuristics.

UNIT - V

Concept development: Converting functions to concepts, concept development tools- intuitive and logical methods, brainstorming, 6-3-5, TRIZ.
Concept selection: Concept screening, scoring and ranking.

Text Books:

1. Kevin Otto & Krisitn Wood, “Product Design”, Pearson Education, 2010.
2. D.G. Ullman, “The Mechanical Design Process”, McGraw- Hill, 2015.
3. G. Pahl and W.Beitz, “Engineering Design- A systematic Approach”, Springer, 2007.

Suggested Reading:

1. Michael Joseph French, “Conceptual Design for Engineers”, Springer; 3rd edition, 2013.
2. Clive L. Dym, “Engineering Design: A Project-Based Introduction”, Wiley; 4th edition, 2013.

18ME H09

WELDABILITY OF METALS: MECHANISMS, WELD DEFECTS & PREVENTION

nstruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, students are able to

1. Recall various aspects related with weldability of various metal systems of commercial importance. (BL-1)
2. Analyze weldability factors affecting weldability of metals, weldability of plain carbon steel, alloy steel and stainless steels. (BL-4)
3. Understand discontinuities in metal systems like ferrous and non-ferrous metals. (BL-2)
4. Understand weldability of pre-coated steel-I, II and stainless steel. (BL-2)
5. Apply the concepts of weldability to martensitic stainless Steel-I, II, ferritic stainless steel and austenitic stainless steel. (BL-3)

UNIT - I
Understanding weldability, introduction, metal properties & weldability, weldability of work hardenable metals.

UNIT - II
Weldability of work hardenable & precipitation strengthened metals, weldability of precipitation strengthened metals, weldability of metals strengthened by grain refinement, dispersion hardening and transformation hardening, weldability of transformation hardening metals, weldability of metals, combination of strengthening mechanisms.

UNIT - III
Weldability consideration, weldability of carbon and alloy steels, weldability of low carbon steel and mild steel, weldability of medium carbon steel and high carbon steel, weldability of carbon and welding processes, weldability of carbon steel and radiation welding and thermal cutting.

UNIT - IV
Weldability of high strength low alloy steels, weldability of Q & T steels, weldability of HTLA steel, weldability of Cr-Mo steel.

UNIT - V
Weldability of pre-coated steel, weldability of stainless steel, weldability of martensitic stainless steel, weldability of martensitic stainless steel, weldability of ferritic stainless steel, weldability of austenitic stainless steel, weldability of PH stainless steel

Text Books:

1. John C. Lippold**, “**Welding Metallurgy and Weldability”, Wiley India Publications, 2014.
2. Larry Jeffus, “Welding: Principles and Applications” , Cengage Learning Publications, 2011.
3. <u>Stout</u> “Weldability of Steels”, Amer Welding Society Publishers 3rd edition, 1978.

Suggested Reading:

1. Damian J. Kotecki John C. Lippold, “Welding Metallurgy and Weldability of Stainless Steels”, Wiley Publications India, 2011.
2. “Welding Handbook: Metals and Their Weldability (Vol. 4)”**,** American Welding Society, 1982.

18ME H10

DESIGN FOR QUALITY, MANUFACTURING AND ASSEMBLY.

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

.**Outcomes:** At the end of the course, the students are able to

1. Recall the concepts such as quality, robustness, six sigma and orthogonal array. (BL-1)
2. Understand the limitations of a design from manufacturing and assembly perspective. (BL-2)
3. Suggest techniques to produce high quality products at low cost. (BL-4)
4. Design teams in simplifying product structure to reduce manufacturing & assembly costs and quantify improvements. (BL-4)
5. Interpret the reasons for variability, mathematically represent, formulate and control it. (BL-6)

UNIT - I

Introduction: Discussion on quality**,** measuring quality, quality loss function, discussion on robustness, six sigma concepts.

UNIT - II

Quantifying robustness: Signal to noise ratio, problem formulation using SNR, design of experiment discussions, orthogonal array, linear graphs, triangular tables, finding optimum combinations, case studies.

UNIT – III

Design for manufacturing: Over the wall design, most influential phase in design, best practices in injection molding and sheet metal working, design for additive manufacturing, single point and multipoint tools.

UNIT – IV

Design for assembly: Boothroyd Dewhurst method, theoretical minimum number of parts, Xerox producibility index (XPI) method.

UNIT – V

Do’s and dont’s in manual assembly, assembly time estimation, design for robotic assembly considerations, design for sustainability.

Text Books:

1. J. M. Juran, “Juran on Quality by Design: The New Steps for Planning Quality into Goods and Services”, McGraw-Hill Education,1992.
2. Daniel E. Whitney, "Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development”, Oxford University Press, 2004.
3. Geoffrey Boothroyd, Peter Dewhurst, “Product Design for Manufacture and Assembly (Manufacturing Engineering and Materials Processing)”, CRC Press, 3/e , 2010.

Suggested Reading:

1. James Bralla, “Design for Manufacturability Handbook”, McGraw-Hill Education, 2/ e,1998
2. David M. Anderson , “Design for Manufacturability: How to Use Concurrent Engineering to Rapidly Develop Low-Cost, High-Quality Products for Lean Production”, Productivity Press, 1/e, 2014.

18ME H11

DEALING WITH MATERIALS DATA: COLLECTION, ANALYSIS AND INTERPRETATION

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Recall the basics of the probability and statistics. (BL-1)
2. Describe data collection, descriptive analysis, error and report presentation. (BL-5)
3. Understand the experimental data processing and probability distributions using R. (BL-2)
4. Understand the graphical data handling, data fitting and hands-on sessions using R programming language. (BL-2)
5. Apply the concept design of experiments, hypnosis testing, Bayesian inference and R for different case study. (BL-3)

UNIT - I

Introduction, basic probability and statistics, basic R.

UNIT – II

Presenting data, inaccuracies and error and its propagation, R for descriptive data analysis.

UNIT – III

Probability distributions, probability distributions using R, processing of experimental data using R.

UNIT - IV

Fitting functions to data, regression, testing significance of fit, R for graphical handling of data and fitting .

UNIT – V

Basics of design of experiments, Bayesian inference and its uses, case studies using R.

Text Books:

1. John I Mc Cool, Using the Weibull Distribution: Reliability, Modeling, and Inference”, Wiley, 2012
2. Douglas C. Montgomery and George C. Runger , “Applied Statistics and Probability for Engineers”, Springer, 2016.
3. John I. McCool, Schumacker and Sara Tomek, “Understanding Statistics Using R”, Springer, 2013.

Suggested Reading:

1. Herman J C Berendsen, “A student’s guide to data and error analysis”, Cambridge University Press, 2011.
2. , An Introduction to Statistical Learning: with Applications in R”, Springer, 2013.

18ME H12

MANUFACTURING STRATEGY

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Understand the process of formulation of manufacturing strategy. (BL-2)
2. Apply various tools and techniques for making a world class organization like Toyota production System. (BL-3)
3. Analyze manufacturing functions to gain competitive advantage. (BL-4)
4. Understand the concepts of total quality management and manufacturing excellence. (BL-2)
5. Apply Deming's approach to improve quality in industry. (BL-3)

UNIT-I

Introduction: Manufacturing output, operations systems, operations strategy, functional strategy within context of a firm functional dominance within corporate strategy, concept of world class manufacturing organization, 6 Ps of manufacturing, skinners' view and Hayes and Wheelwright framework of manufacturing strategy, alternative paradigm of manufacturing strategy

UNIT-II

Generic manufacturing strategies: Developing a manufacturing strategy, understanding markets, the concept of order winners and qualifiers, basic characteristics and specific dimensions of order winners and qualifiers, some specific order winners and qualifiers-I,II &III, some specific order winners and qualifiers (Non operation related criteria.

UNIT-III

Developing an operations strategy: Methodology, Roth and Miller classification, enlightened view of manufacturing.
Manufacturing strategy taxonomy: Some evidences from China, quality management, manufacturing excellence, and total quality management.

UNIT-IV

Deming's approach to quality, business excellence awards, process choice and 3 dimensional view, product profiling, critical success factors for world class manufacturing, value added engineering, total employee involvement, HR theories for operations strategy, flexible manufacturing system.

UNIT-V

Concept of focus WRT manufacturing strategy, Toyota production system, world class manufacturing and India, achieving world class status.

Text Books:

1. John Miltenburg ,"Manufacturing Strategy: How to Formulate and Implement a Winning Plan", Productivity Press, 2017.
2. Danny Samson ,"Manufacturing & Operations Strategy", Prentice Hall publication, 1993.
3. Terry Hill and Alex Hill, **"**Manufacturing Operations Strategy" Palgrave Macmillan publication, 2009.

Suggested Readings:

1. Taiichi Ohno, "Evolution of Toyota Production System", Kindle Edition, 2017.
2. Richard J. Schonberger, "World class Manufacturing", Free Press, 2008.

18ME H13

KNOWLEDGE MANAGEMENT

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, students are able to

6. Use the current theories, practices, tools and techniques in knowledge management. (BL-3)
7. Understand the role and use of knowledge in organizations and institutions. (BL-2)
8. Apply fundamental concepts of knowledge and its creation, acquition, representation, dissemination, use and re-use. (BL-3)
9. Perform exchange of knowledge, knowledge codification and system development, its testing. (BL-3)
10. Recommend appropriate KM tools and portals, by considering ethical, managerial and legal issues in knowledge management. (BL-5)

UNIT - I

Introducing the concept of knowledge management (KM): Why KM, KM system life cycle, and aligning KM and business strategy.

KM cycle: Knowledge creation, capturing tacit knowledge, types of knowledge and its implications for KM.

UNIT - II

Knowledge codication and system development: Codication, system testing and deployment, knowledge transfer and knowledge sharing, the role of culture and structure.

UNIT – III

Analysis design and development: Knowledge infrastructure, knowledge audit, knowledge team, analysis, design and development of KM system.

UNIT - IV

KM tools and portals: Inferences from data, data mining and knowledge portals.

Evaluation of KM effectiveness: Tools and metrics, ethical, legal and managerial issues.

UNIT – V

KM experiences form Indian companies, KM innovation and learning organization, the future of KM.

Text Books:

1. Awad, E.M, “Knowledge Management” Pearson India, Delhi, 2007.
2. Fernandez I. B. and Sabherwal.R, “Knowledge Management: System and Resources”, PHI Delhi, 2010.
3. Kimiz Dalkir, “Knowledge Management in Theory and Practice” Elsevier, 2005.

Suggested Reading:

1. Tiwana Amrit, “The Knowledge Management Toolkit”, Prentice Hall PTR, 1999.
2. Dr.Tiny Neeraja, Dr.Jayam & Dr Tanu,“Knowledge Management”, 2014.

18ME H14

DESIGN THINKING - A PRIMER

Instruction	3	Hour per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Understand the basic concept of design thinking. (BL-2)
2. Recall the step involved in design thinking. (BL-1)
3. Apply the principles of design thinking by observing, interviewing or just experiencing a situation. (BL-3)
4. Improve the situation of the humans by solving problems facing them. (BL-5)
5. Analyze problems using brain storming, 5 why's. (BL-3)

UNIT-I

Design thinking: Introduction, history, discussion and case study.

UNIT-II

Empathize phase: Customer journey mapping.

UNIT-III

Analyze phase: 5-Whys, 5 whys-IIT stadium levels and solve-workshop I & II.

UNIT-IV

Solve phase: Ideation, free brainstorming.

UNIT-V

Make/Test phase: Customer reactions to prototype, finale and appeal for proposals.

Text Books:

1. Prof. Karl Ulrich, "Design: Creation of Artifacts in Society", University of Pennsylvania, 2011.
2. Tim Brown, "Change by Design" Harper Business Publication, 2013.
3. Idris Mootee "Design Thinking for Strategic Innovation", Adams Media publications, 2014.

Suggested Reading:

1. Bryan Lawson, “How Designer’s Think: The design process demystified”, Architectural Press, 2005.
2. Brown, Dan M, “Designing Together”, New Riders, 2013.

18ME H15

INNOVATION BY DESIGN

Instruction	3	Hour per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Find solutions to present day problems and challenges through innovation. (BL-4)
2. Formulate a design enabled by innovation. (BL-6)
3. Gain knowledge on the journey of a design idea from the identification of a problem to a final solution. (BL-2)
4. Learn the importance of innovation process requiring empathy, meticulous effort, constant user interaction and effective collaboration. (BL-1)
5. Apply innovation to have positive impact on a large community of users. (BL-3)

UNIT-I

Introduction: The seven concerns, design thinking & collaboration, challenges to innovation, understanding users, arriving at design insights, prototyping for user feedback.
First C:The cause: Crossing the first pitfall, trial and error, user feedback for development, new users, new needs to meet.

UNIT-II

Second C: The context: The basic need, ingenious attempts, further insights, the working rig, concepts generation, experiencing the product.
Third C: The comprehension: Understanding constraints, positioning the product, exploring possibilities, understanding the technology.

UNIT-III
Fourth C: The check: The check and the cause, the product, the users and the context, the prototyping, user needs.

UNIT-IV

Fifth C: The conception: Synchronic studies, one product, many problems, concept clusters, from idea to product, prototyping, materials and technologies, collaborative efforts.

UNIT-V

Sixth C: The drafting: Recap, the manufacturing challenge, the user feedback, the iterative Process.

Seventh C: The connection: The seed for innovation, pinnacle for innovation, the Innovation timeline, the innovation, champions, the Innovation templates, the Serial Innovation.

Suggested References:

4. 7C's Link: http://www.idc.iitb.ac.in/~chakku/chakku7Cs.pdf
5. Collaborative Model For Innovation Link: http://www.idc.iitb.ac.in/~chakku/collaborative_model_for_innovation.pdf
6. Pitfalls in the Innovation process Link: http://www.idc.iitb.ac.in/~chakku/Pitfalls_in_the_innovation_process.pdf
7. Innovation By Design – Collaboration is the key to cross the Pitsfalls in the Innovation Process Link: http://www.idc.iitb.ac.in/~chakku/Innovation_by_Design.pdf

18ME H16

UNDERSTANDING DESIGN

Instruction	3	Hour per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Understand the discipline of design and its multidisciplinary nature. (BL-2)
2. Translate ideas and needs into all the objects that surround us. (BL-2)
3. Understand the relevance and value of design and how it impacts society, industry and the environment. (BL-2)
4. Differentiate between good and bad design. (BL-4)
5. To analyze design as process and product. (BL-5)

UNIT-I

An introduction to design, users and context: The many notions of design, design as a process and a product, the evolution of design, design engages with many disciplines, design is concerned with the user, good design, bad design, users and contexts, multiple users, differing contexts, understanding user experience, design for a meaningful impact.

UNIT-II

Design and society: Community and collaboration, understanding contexts, knowledge and access, function, context and consequences.

UNIT-III

Design and sustainability: , , , e.

UNIT-IV

Design and industry and design and collaboration: Understanding varied user needs, pushing the boundaries of mass production, breaking familiar assumptions, design & collaboration, collaborating with unlikely partners, principles of collaboration, design thinking .

UNIT-V

Innovation by design: Facilitating the reach of a traditional craft, pitfalls of innovation, the seven concerns of innovation, a little design goes a long way.

Text Books:

1. Ansell, C & Torfing J, “Public Innovation through Collaboration and Design”, London and New York, Routledge, 2014.

2. Antonneli, Paola, “Humble Masterpieces: everyday marvels of Design”, Harper Collins Publishers, 2005.
3. Baxter, Mike, “Product Design”, London Glasgow New York, Chapman & Hall, 1995.

Suggested Reading:

1. Doordan, Dennis, “Design History: An Anthology”, Cambridge, London, MIT Press, 2000.
2. Heskett, John, “Design: a very short introduction” , Oxford University Press, 2002.

18ME H17

STRUCTURAL ANALYSIS OF NANO MATERIALS

Instruction	3	Hour per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, students are able to

1. Understand the properties of nano materials. (BL-2)
2. Study the crystal structure of materials and their defects. (BL-1)
3. Have a detailed knowledge of the structure from the atomic/molecular level. (BL-2)
4. Investigate the structure-property relationship of nano materials. (BL-4)
5. Achieve relevant improvements in current state-of-the art materials. (BL-3)

UNIT-I

Introduction: Fundamental concepts of atomic structure and interatomic bonding, structure of materials, defects in structure of materials.

UNIT-II

Phase diagram: Determination of phases, transformation of phases.

UNIT-III

Basic properties: Metals, ceramics, polymers, selection of nano materials, structure property relationship of advanced nano materials.

UNIT-IV

Qualitative analysis by diffraction, quantitative analysis by diffraction.

UNIT-V

Microscopic structural analysis of nano materials-I, microscopic structural analysis of nano materials-II.

Text Books:

1. Cullity, B.D., Stock, S.R. and Stock, S, "Elements of X-Ray diffraction", Prentice Hall, 3\e, New Jersey, 2013.
2. Phillips, R., "Crystal Defects and Microstructures", Cambridge university press, Cambridge, UK, 2015.
3. Wang, Z.L.," Characterization of Nano Phase Materials" , Wiley-VCH, Weinheim, Germany, 2008.

Suggested Reading:

1. Allen, S.M., Thomas, E.L., "The structure of materials", John Wiley & Sons, US, 2011.
2. Hideo Hosono, Yoshinao Mishima, "Nanomaterials: Research Towards Applications", Elsevier Science**,** 2006.

18ME H18

MECHANICAL MEASUREMENT SYSTEMS

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Understand the various characteristics of instrument. (BL-2)
2. Analyze the generalized model of a measuring system. (BL-4)
3. Understand the frequency response of a measuring system. (BL-2)
4. Evaluate measuring methods and devices for displacement, pressure and temperature measurement. (BL-5)
5. Understand the various thermo physical properties of measurement. (BL-2)

UNIT-I

Basic concepts of measurement, functional elements of instruments, classification of measuring instruments, methods of correction for interfering and modifying inputs.

UNIT-II

Static characteristics of measuring instruments, loading effect and impedance matching, statistical analysis, Chi-square test, least square method, uncertainty analysis, problem solving, generalized model of a measuring system, zero and first order system.

UNIT-III

First order system- ramp response, impulse response, frequency response, second order system- step response,ramp response, impulse and frequency response, higher order systems, compensation, transducers, flow measurement, temperature measurement.

UNIT-IV

Strain gauges, piezoelectric transducers pressure measurement, force and torque measurement, displacement and acceleration measurement.

UNIT-V

Sound measurement, thermophysical properties measurement, flow visualization, air pollution sampling and measurement, problem solving.

Text Books:

1. Venkateshan, S.P., “Mechanical measurements”, John Wiley & Sons, 2015.
2. Fridman, A.E., “The quality of measurements: a metrological reference”, Springer Science & Business Media, 2011.
3. Bewoor, A.K. and Kulkarni, V.A., “Metrology and measurement”, McGraw-Hill Education, 2009.

Suggested Reading:

1. R.K. Rajput, “Mechanical Measurements and Instrumentation”, S.K. Kataria & Sons, 2013.
2. Dr. D.S. Kumar, “Mechanical Measurements & Control”, Metropolitan Book Co. (P) Ltd, 2015.

18ME H19

PATENT DRAFTING FOR BEGINNERS

Instruction	3	Hour per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Understand the concept of various patent classification and the limits of patentability search. (BL-2)
2. Apply the various forms and punctuation of claim. (BL-3)
3. Analyze the claim with combo pen with marker. (BL-4)
4. Understand the various evolutions of patient specifications. (BL-2)
5. Apply the concept of amendments to claim. (BL-3)

UNIT- I

Invention as a solution to an unsolved problem: Patent classification, technical advance, getting working disclosure, searching with a disclosure, patentability search, reasons for ordering patentability search ,limits of patentability search, patentability search report, identifying the inventive concept.

UNIT- II

Drafting a claim: Problem solution statement, problem solution to claim, provisions relating to claim, structure of claims, form and punctuation of claim, omnibus claims, cooperation.

UNIT- III

Types and arrangement of claims: Dependent claims, apparatus claims, process claims, claim drafting best practices, amendment to claim, claim analysis combo pen with marker.

UNIT - IV

Structure of the patent specification: Introduction to specification drafting, enabling disclosure, best methods.

UNIT-V

Parts of the specifications, parts of the application, detailed description, evolution of patent specifications.

Text Books:

1. Jeffrey G. Sheldon, “How to Write a Patent Application”, Third Edition, Practicing Law Institute, 2016.
2. Richard Susskind, “Tomorrows Lawyers”, Oxford Publishers, 2013.
3. Nicholas J McBride, “Letters to a Law Student”, 3/e, Pearson publishers, 2013.

Suggested Reading:

1. Williams Glanville, “Learning the Law”, Indian Economy Reprint, 2013.
2. Pankaj Kumar Tripathi,” Law of Evidence”, PVP publications, 2019.

18ME H20

HEAT EXCHANGERS: FUNDAMENTALS AND DESIGN ANALYSIS

Instruction	3	Hour per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Evaluate the effectiveness of heat exchanger. (BL-5)
2. Discuss the tubular and compact heat exchangers. (BL-2)
3. Analyze the plate fin and direct contact heat exchangers. (BL-4)
4. Analyze the heat pipes and micro scale heat exchangers. (BL-4)
5. Understand the concept of phase change heat transfer. (BL-2)

UNIT-I

Background, application, classification, common terminologies introduction to thermal and hydraulic aspects, pressure drop and heat transfer, sizing and rating. F-LMTD and -NTU method.

UNIT-II

Tubular Heat Exchangers: Different designs, brief description of shell and tube heat exchangers, special types, compact heat exchangers, enhancement of heat transfer, extended surface or fin, fundamental of extended surface heat transfer, fin tube heat exchanger.

UNIT-III

Plate Fin Heat Exchangers (PFHE): Types, construction, fabrication, design, application, multi stream PFHE, multi stream PFHE continued, direct contact heat exchangers, types, application, simple analysis, regenerators, types of regenerators, construction, application, theory of regenerator, NTU and method.

UNIT-IV

Heat pipes: Construction, working principle, application, analysis, special heat pipes, micro scale heat exchangers and heat sinks, heat transfer and fluid flow through narrow conduits, special design considerations.

UNIT-V

Phase change HEX: Phase change heat transfer, introduction to evaporators and condensers, phase change HEX, phase change heat transfer, introduction to evaporators and condensers, heat exchanger testing, steady state and dynamic methods.

Text Books:

1. R. K. Shah, Dusan P. Sekulic, “Fundamentals of Heat Exchanger Design”, John Wiley & Sons, 2003.
2. Kuppan Thulukkanam, “Heat Exchanger Design Handbook” ,Taylor & Francis, 2000.

Suggested Reading:

1. Sadik Kakac, Hongtan Liu, “Heat Exchangers: Selection, Rating, and Thermal Design”, 3/e ,CRC-Press, 1998.
2. Randall F. Barron, Gregory F. Nellis, “Cryogenic Heat Transfer”, 2/e, CRC Press, 2016.

18ME H21

SOLAR ENERGY ENGINEERING AND TECHNOLOGY

Instruction	3	Hour per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the need of energy conversion and the energy measuring devices. (BL-2)
2. Estimate total solar radiation and maximum power generation from PV cells. (BL-5)
3. Design of grid-connected PV system. (BL-6)
4. Classify the solar collectors and evaluate their performance. (BL-2)
5. Explain the various methods of energy storage and applications of solar energy. (BL-2)

UNIT-I

Energy scenario, overview of solar energy conversion devices and applications, physics of propagation of solar radiation from the sun to earth.sun-earth geometry, extra-terrestrial and terrestrial radiation, solar energy measuring instruments.

UNIT-II

Estimation of solar radiation under different climatic conditions, estimation of total radiation, fundamentals of solar PV cells, principles and performance analysis, modules, arrays, theoretical maximum power generation from PV cells, PV standalone system components, standalone PV-system design.

UNIT-III

Components of grid-connected PV system, solar power plant design and performance analysis, fundamentals of solar collectors, Snails law, Bougers law, physical significance of transmissivity – absorptivity product.

UNIT-IV

Performance analysis of liquid flat plate collectors and testing, performance analysis of solar air heaters and testing, solar thermal power generation (Solar concentrators).

UNIT-V

Thermal energy storage (sensible, latent and thermochemical) and solar pond, applications, solar refrigeration, passive architecture, solar distillation, and emerging technologies.

Text Books:

1. G. N. Tiwari, "Solar Energy, Fundamentals, Design, Modeling and Applications", Narosa, 2002.
2. S. P. Sukhatme and J. K. Nayak, "Solar Energy: Principles of Thermal Collection and Storage", Tata McGraw Hill, 2006.
3. C. S. Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", Prentice Hall India, 2/e, 2011.

Suggested Reading:

1. J. A. Duffie and W. A. Beckman, "Solar Engineering of Thermal Processes", John Wiley, 2006.
2. D. Y. Goswami, F. Kreith and J. F. Kreider, "Principles of Solar Engineering", Taylor and Francis, 1999.

18ME H22 **ADVANCED FLUID MECHANICS**

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the concept of Kinematics and Dynamics of Fluid Mechanics. (BL-2)
2. Derive the Navier-stokes equation and apply it to steady flow problems. (BL-5)
3. Solve the Navier-stokes equation for the Unsteady Flows. (BL-3)
4. Understand the Concept of Boundary Layer theory in Turbulent cases. (BL-2)
5. Discuss the Compressible flows and potential flow, flow past immersed bodies. (BL-2)

UNIT-1.

Brief recapitulation of some preliminary concepts of Fluid Mechanics : Fluid Kinematics. Dynamics of Inviscid Flows and Reynolds Transport Theorem, Dynamics of viscous flows.

UNIT-2.

Derivation of Navier- Stokes equation. Some exact solutions of Navier-Stokes equation-Steady Flows, Practical Applications.

UNIT-3.

Some exact solutions of Navier-Stokes equation-Unsteady Flows.

UNIT-4.

Introduction to turbulence, Boundary Layer theory.

UNIT-5.

Potential flow and flow past immersed bodies,Compressible flows

Test Books:

1. Fluid Mechanics: by Pijush K. Kundu, Ira M. Cohen, David R Dowling, Academic Press.
2. Introduction to Fluid Mechanics and Fluid Machines: by S. K. Som, Gautam Biswas and Suman Chakraborty, McGraw-Hill Education.

Suggested Reading:

1. Fluid Mechanics: by F. M White, McGraw-Hill Education.
2. Introduction to Fluid Mechanics by R. Fox and A. MacDonald, John Wiley and Sons.

18ME H23

AIRCRAFT PROPULSION

Instruction	3	Hour per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Study of gas turbines and aircraft propulsion. (BL-2)
2. Compare the ideal and real cycle analysis. (BL-2)
3. Evaluate the performance of aircraft engine and study of engine components. (BL-5)
4. Study of different compressors and turbines. (BL-2)
5. Identify turbine cooling methods and study of blade and cascade theory. (BL-3)

UNIT-I

Introduction to gas turbines and aircraft propulsion: Turbomachines-Introduction, classification, components of gas turbine power plant, various aircraft engines, engine performance parameters.

UNIT-II

Ideal and real cycle analysis: Air standard ideal Brayton cycle, non-ideal Brayton cycle, Brayton cycle with reheater, Brayton cycle with intercooler, real Brayton cycle with stagnation conditions, polytropic efficiency of compressor and turbine, aircraft engine intake, intake efficiency, propelling nozzle, nozzle efficiency.

UNIT-III

Engine performance and engine components: Turbojet engine, turbofan engine, ramjet engine, thrust augmentation and engine parameters for aircrafts.

UNIT-IV

Centrifugal compressor: Velocity diagram, work done, thermodynamic analysis, stage efficiency and degree of reaction.

Axial flow compressor: Velocity diagram, work done, degree of reaction, free vortex condition.

Axial turbine: Velocity diagram, work done and degree of reaction.

Radial turbine: Velocity diagram, H-S diagram, stage efficiency, degree of reaction.

UNIT-V

Blade design, cascade theory and turbine cooling methods: Cascade theory and blade design, cascade variables and turbine cascade, velocity diagrams of turbine cascade, compressor cascade, turbine cooling methods.

Text Books:

1. G. F. C. Rogers and Y. R. Mayhew, “Engineering Thermodynamics Work and Heat Transfer”, 4/e., Pearson, 2001.
2. H. I. H Saravanamuttoo, G. F. C. Rogers and H. Cohen, “Gas Turbine Theory”, 4/e., Pearson, 2003.

18ME H24

ENERGY CONSERVATION AND WASTE HEAT RECOVERY

Instruction	3	Hour per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Define the waste heat and the importance of its recovery. (BL-1)
2. Explain different types of power cycles to extract waste heat. (BL-2)
3. Analyse heat exchanger with specialized heat exchange techniques for effective recovery. (BL-4)
4. Illustrate various techniques of direct energy conversion systems. (BL-2)
5. Discuss the various energy storage techniques. (BL-2)

UNIT-I

Introduction to waste heat, importance of waste heat recovery, review of thermodynamics – introduction to first and second laws, entropy, entropy generation, first and second law efficiency.

UNIT-II

Power plant cycles - energy cascading, Rankine cycle, modification of Rankine cycle, examples of gas turbine cycle, combined cycle, combined gas turbine-steam turbine power plant, heat recovery steam generators.

UNIT-III

Thermodynamic cycles for low temperature application, cogenerations, introduction to heat exchangers, analysis – LMTD and ε-NTU method, problem solving, special heat exchangers for waste heat recovery, synthesis of heat exchanger, network, heat pipes & vapour chambers.

UNIT-IV

Direct conversion technologies – thermoelectric generators, thermionic conversion, thermo-PV, magneto hydro dynamics, heat pump, heat recovery from incinerators.

UNIT-V

Energy storage – introduction, energy storage techniques – pumped hydro, compressed air, flywheel, superconducting magnetic storage, thermal storage (sensible & latent), battery, chemical energy storage, fuel cells, energy economics.

Reference Books:

1. Nikolai V. Khartchenko, “Advance Energy Systems”, Taylor and Francis Publishing,2000
2. M.M.El-Wakil, Powerplant Technology, Tata McGraw Hill ,2013
3. Rajmohan Gupta, “Steam Turbine”, Oxford & IBH Publishing Co. Pvt. Ltd.

Suggested Reading:

1. Ganesan, “Gas Turbine”, McGraw Hil,2013l
2. Practical Heat Recovery – Boyen J.L. John Wiley, New York, USA1976.

18ME H25

FLUIDIZATION ENGINEERING

Instruction	3	Hour per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the phenomenon of fluidization and characteristics of solids. (BL-2)
2. Analyse the fluidization parameters. (BL-4)
3. Measure the power consumption of gas pumping in fluidised beds and understand the concept of bubbling fluidization. (BL-5)
4. Understand the entrainment characteristics and attrition in fluidized beds. (BL-2)
5. Study the phenomena of mass transfer and heat transfer in fluidized bed. (BL-2)

UNIT-I

Introduction: The phenomenon of fluidization, advantages and disadvantages of fluidized beds, industrial applications of fluidized beds

Characteristics of solids: Classification of solids, flow characteristics and its outline in the different types of fluidization.

UNIT-II

Flow pattern of fluidization system: Flow pattern, flow pattern transition, flow pattern map, frictional pressure drop and its model to analyse, solid movement, mixing, segregation and staging.

UNIT-III

Gas distribution: Type of gas distributors in small and large scale industries, design of distributor.

Bubbling fluidized beds: Gas dispersion and gas interchange in bubbling beds, mixing characteristics.

UNIT-IV

Entrainment and elutriation from fluidized beds: Entrainment characteristics, fast fluidization condition, elutriation condition.

Attrition: Attrition mechanism and its analysis by model.

UNIT-V

Mass transfer phenomena: Particle to gas mass transfer phenomena and its analysis by model in two and three phase system and modelling.

Heat transfer phenomena: Heat transfer between fluidized beds, surfaces and modelling.

Design of fluidized bed reactors: Design for physical operation, catalytic and non-catalytic systems.

Text Books:

1. D. Kunii and O. Levenspiel, "Fluidization Engineering", Butterworth, 1991.
2. D. Gidaspow, "Multiphase Flow and Fluidization: Continuum and Kinetic Theory Description", Elsevier Science & Technology Books, 1993.

Suggested Reading:

1. L.G. Gibilaro, "Fluidization-Dynamics", Butterworth-Heinemann, 2001
2. S. K. Majumder, "Hydrodynamics and Transport Processes of Inverse Bubbly Flow", Elsevier,1/e, Amsterdam (2016).

18ME H26

COMPUTATIONAL FLUID DYNAMICS USING FINITE VOLUME METHOD

Instruction	3	Hour per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Describe and develop mathematical models for flow phenomena. (BL-1)
2. Classify PDE for fluid flow and heat transfer applications. (BL-2)
3. Apply Finite Volume Method for fluid flow and heat transfer problems. (BL-3)
4. Test the discretized equations for stability and solve the system of linear equations. (BL-4)
5. Implementation of different types of meshes. (BL-5)

UNIT-I

Review of governing equations: Continuity, momentum and energy equations, steady and unsteady flows,

classification of governing equations, elliptic, parabolic and hyperbolic equations, their significance.

UNIT-II

Overview of numerical solution methods: Finite difference, finite element and finite volume methods, their merits and demerits, steady diffusion equation on structured meshes.

UNIT-III

Structured and Unstructured meshes: Unsteady diffusion equation on structured meshes, diffusion in unstructured meshes.

UNIT-IV

Convection and diffusion: Mathematical formulation, discretization, various methods to solve them, higher-order schemes, their effect on convergence.

UNIT-V

Convection and diffusion on unstructured meshes: Their stability, linear system solvers, iterative methods.

Incompressible flow field calculation: SIMPLE algorithm, types of grids, staggered and co-located formulation, need of staggered grids.

Text Books:

1. Suhas V. Patankar, “Numerical Heat Transfer and Fluid Flow”, Hemisphere, New York, 1980.
2. H. K. Versteeg and W. Malalasekra,“An Introduction to Computational Fluid Dynamics - The Finite Volume Method”, Pearson Education, 2017.
3. T. J. Chung, “Computational Fluid Dynamics”, Cambridge University Press, 2010.

Suggested Reading:

1. F. Moukalled, L. Mangani, M. Darwish, "The Finite Volume Method in Computational Fluid Dynamics", Springer, 2015.
2. J. H. Ferziger and M. Peric, "Computational Methods for Fluid Dynamics", Springer, 2002.

18ME H27

FUNDAMENTALS OF CONVECTIVE HEAT TRANSFER

Instruction	3	Hour per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Derive the governing equations of incompressible fluid heat flow. (BL-5)
2. Study the different solutions and methods for the laminar external flow and heat transfer over a flat plate. (BL-2)
3. Understand the concepts of laminar fluid and heat transfer through the internal cross sections of different channels. (BL-1)
4. Understand the concepts of natural convective heat transfer on flow past vertical plate at different at conditions and positions. (BL-1)
5. Discuss the governing equations of turbulent convection of the heat and mass transfer and their analogies. (BL-2)

UNIT-I

Governing equations: Continuity, momentum and energy equations and their derivations in different coordinate systems, boundary layer approximations to momentum and energy.

UNIT-II

Laminar external flow and heat transfer: Similarity solutions for flat plate (Blasius solution), flows with pressure gradient (Falkner-Skan and Eckert solutions), flow with transpiration, integral method solutions for flow over an isothermal flat plate, flat plate with constant heat flux and with varying surface temperature (Duhamel’s method), flows with pressure gradient (von Karman-Pohlhausen method).

UNIT-III

Laminar internal flow and heat transfer: Exact solutions to N-S equations for flow through channels and circular pipe, fully developed forced convection in pipes with different wall boundary conditions, forced convection in the thermal entrance region of ducts and channels (Graetz solution), heat transfer in the combined entrance region, integral method

for internal flows with different wall boundary conditions.

UNIT-IV

Natural convection heat transfer: Governing equations for natural convection, Boussinesq approximation, dimensional analysis, similarity solutions for laminar flow past a vertical plate with constant wall temperature and heat flux conditions, integral method for natural convection flow past vertical plate, effects of inclination, natural convection in enclosures, mixed convection heat transfer past vertical plate and in enclosures.

UNIT-V

Turbulent convection: Governing equations for averaged turbulent flow field (RANS), analogies between heat and Mass transfer (Reynolds, Prandtl-Taylor and von Karman Analogies),turbulence models (Zero, one and two equation models), turbulent flow and heat transfer across flat plate and circular tube, turbulent natural convection heat transfer, empirical correlations for different configurations.

Text Books:

1. W.Kays, M. Crawford and B. Weigand, “Convective Heat and Mass Transfer”, 4/e, McGraw Hill International, 2005.
2. S. Kakac and Y.Yener, “Convective Heat Transfer”, 2/e, CRC Press, 1995.
3. A. Bejan, “Convection Heat Transfer”, 3/e, John Wiley, 2004.

Suggested Readings:

1. F.P. Incropera and D. Dewitt, “Fundamentals of Heat and Mass Transfer”, 7/e, John Wiley, 2011.
2. H. Schlichting and K. Gersten, “Boundary Layer Theory”, 8/e, Springer-Verlag, 2000.

18ME H28

DYNAMIC BEHAVIOR OF MATERIALS

Instruction	3 Hours per week
Course Duration	12 Weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Understand about dynamic deformation, failure, and elastic waves. (BL-2)
2. Differentiate plastic waves and shockwaves due to uniaxial and combined stress. (BL-4)
3. Apply experimental techniques for dynamic deformation in metals. (BL-3)
4. Analyze plastic deformation of metals at high strain rates. (BL-4)
5. Assess dynamic fracture. (BL-5)

UNIT-I

Introduction: Dynamic deformation and failure, Introduction to waves: elastic waves, types of elastic waves, reflection, refraction and interaction of waves.

UNIT-II

Plastic waves and shock waves: Plastic waves of uniaxial stress, uniaxial strain and combined stress, Taylor's experiments, shock waves, shock wave induced phase transformation, explosive-material interaction and detonation.

UNIT-III

Experimental techniques for dynamic deformation: Intermediate strain rate tests, split Hopkinson pressure bar, expanding ring test, gun systems, Review of mechanical behavior of materials (especially metals), elastic and plastic deformation of metals, dislocation mechanics.

UNIT-IV

Plastic deformation of metals at high strain rates: Empirical constitutive equations, relationship between dislocation velocity and applied stress, physically based constitute equations, Plastic deformation in shock waves, strengthening due to shock wave propagation, dislocation generation, point defect generation and deformation twinning, strain localization/shear bands, constitutive models, metallurgical aspects.

UNIT-V

Dynamic fracture: Fundamentals of fracture mechanics, limiting crack speed, crack branching and dynamic fracture toughness, spalling and fragmentation, dynamic deformation of materials other than metals, polymers, ceramics, composites, applications, armor applications, explosive welding and forming.

Textbooks:

1. Marc A. Meyers, “Dynamic Behavior of Materials”, John Wiley & Sons, New York, 1994 .
2. L.B. Freund, “Dynamic Fracture Mechanics”, Cambridge, 1990.
3. Y. Bai B. Dodd, “Adiabatic Shear Localization”, Pergamon, Oxford, UK, 1992.

Suggested Reading:

1. G.E. Dieter, “Mechanical Metallurgy”, Mc Graw Hill, 1986

2. J.W. Swegle, D.E. Grady, in Shock Waves in Condensed Matter, Springer, 1985,

18ME H29

SYSTEM DESIGN FOR SUSTAINABILITY

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand sustainability, its development and evolution. (BL-2)
2. Identify the strategies and software tools for product life cycle design. (BL-2)
3. Understand the transition path and challenges in sustainable product service system. (BL-2)
4. Use the tools for designing product-service system for eco-efficiency. (BL-3)
5. Design for social equity and cohesion by following design criteria and guidelines. (BL-6)

UNIT-I
Sustainability: Definition of sustainability, the need for sustainable development, evolution of sustainability within design.

UNIT-II
Product life cycle design: Methods, strategies and software tools.

UNIT-III
Sustainable product: Service system design: Definition, types, examples, Sustainable product service system – transition path and challenges.

UNIT-IV
Designing for sustainable product-service system: Methods and tools, other design for sustainability, tools and approaches .

UNIT-V
Design for sustainability: Engineering design criteria and guidelines.

Text Books:

1. Vezzoli, C., Kohtala, C., Srinivasan, A., Xin, L., Fusakul, M., Sateesh, D. and Diehl,. “Product-service system design for sustainability”. J.C.Routledge,2017
2. Peter Stansinoupolos (Author), Michael H Smith (Author), Karlson Hargroves (Author), ” Whole System Design: An Integrated Approach to Sustainable Engineering”: Paperback ,2008.
3. Jane Penty. “Product Design and Sustainability: Strategies, Tools and Practice” Routledg, 1/e, 2019.

18ME H30

COMPUTATIONAL CONTINUUM MECHANICS

Instruction	3Hours per week
Course Duration	12Weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Summarize the concepts of tensors, kinematics and kinetics. (BL-2)
2. Apply concepts of tensors to set up the constitutive relations for nonlinear finite element analysis of a simple hyperelastic material. (BL-3)
3. Analyze linearization of the weak form of the equilibrium equations. (BL-4)
4. Discuss discretization to obtain the finite element equations, in particular, the tangent matrices and residual vectors. (BL-2)
5. Compare the Newton-Raphson solution procedure along with line search and arc length methods to enhance the solution procedure. (BL-5)

UNIT-I

Introduction - Origins of nonlinearity.

Mathematical preliminaries -1: Tensors and tensor algebra.

Mathematical preliminaries -2: Linearization and directional derivative, tensor analysis.

UNIT-II

Kinematics - 1: Deformation gradient, polar decomposition, area and volume change.

Kinematics - 2: Linearized kinematics, material time derivative, rate of deformation and spin tensor.

UNIT-III

Kinetics - 1: Cauchy stress tensor, equilibrium equations, principle of virtual work.

Kinetics - 2: Work conjugacy, different stress tensors, stress rates.

UNIT-IV

Hyperelasticity - 1: Lagrangian and Eulerian elasticity tensor.

Hyperelasticity - 2: Isotropic hyperelasticity, compressible Neo-Hookean material.

UNIT-V

Linearization: Lineation of internal virtual work, linearization of external virtual work.

Discretization: Discretization of linearized equilibrium equations - material and geometric tangent matrices.

Solution Procedure: Newton-Raphson procedure, line search and arc length method.

Text Books:

1. J, Bonet A. J. Gil and R. D. Wood, "Nonlinear Solid Mechanics for Finite Element Analysis: Statics" ,Cambridge University Press, 2016.
2. K.-J. Bathe ,"Finite Element Procedures", Prentice-Hall India, New Delhi, 1996.
3. A. F. Bower, "Applied Mechanics of Solids , CRC Press, Boca Raton, 2010. (Also accessible through authors website: http://solidmechanics.org/)

Suggested Readings:

1. Ahmed A. Shabana , "Computational Continuum Mechanics" , Wiley 2018.
2. FY Cheng, FZizhi,"Computational Mechanics in Structural Engineering: Recent Developments", Elsevier Science; 2/e,1999.

18ME H31

ENGINEERING FRACTURE MECHANICS

Instruction	3Hours per week
Course Duration	12Weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Understand the concepts of fracture mechanics. (BL-2)
2. Analyze different modes of failure under the presence of crack. (BL-4)
3. Develop crack growth models. (BL-3)
4. Identify the relationship between crack propagation and stress intensity factor systems. (BL-3)
5. Examine advanced Fracture mechanics. (BL-4)

UNIT-I

Introduction to fracture mechanics: LEFM and EPFM, fatigue crack growth model, crack growth and fracture mechanisms, energy release rate, elastic strain energy, fracture strength by Griffith, energy release rate, utility of energy release rate

UNIT-II

Crack-tip stress and displacement fields: Review of theory of elasticity, Airy's stress function for mode-I, Westergaard solution of stress field for mode-I ,displacement field for mode-I ,relation between KI and G_I, stress field in mode-II, generalized Westergaard approach ,William's Eigen function approach, multi-parameter stress field equations and validation.

UNIT-III

SIF's, plastic zone modeling, fracture toughness testing : Evaluation of SIF for various geometries ,SIF for embedded cracks ,SIF for surface cracks, modeling of plastic deformation ,Irwin's model , Dugdale model , fracture toughness testing, plane strain fracture toughness testing ,plane stress fracture toughness testing.

UNIT-IV

Crack initiation and life estimation: Paris law and Sigmoidal curve, crack closure, crack growth models.

UNIT-V

Advanced fracture mechanics: J-Integral, HRR field and CTOD, FAD and mixed mode fracture, crack arrest and repair methodologies.

Text Books:

1. David Broek , "Elementary Engineering Fracture Mechanics", Kluwer Academic Publishers , The Hague – 1984.
2. Prashant Kumar., "Elements of fracture mechanics", Mc Graw Hill Education (India) Private Limited, New Delhi - 2014.
3. T.L. Anderson, "Fracture Mechanics - Fundamentals and Applications", 3/e, Taylor and Francis Group, 2005.

Suggested reading:

1. R.N.L.Smith, "Basic Fracture Mechanics", Butterworth Heinemann Publications, 1991.
2. K. Ramesh," e-Book on Engineering Fracture Mechanics", IIT Madras, 2007.
   URL: http://apm.iitm.ac.in/smlab/kramesh/book_4.htm

18ME H32

NUMERICAL METHODS FOR ENGINEERS

Instruction	3 hours per week
Course Duration	12 weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Understand the of calculation and interpretation of errors in numerical method. (BL-2)
2. Analyze numerical solution of a system of linear equations . (BL-4)
3. Examine the roots of polynomial equations using numerical analysis . (BL-4)
4. Apply numerical differentiation, integration and regression methods. (BL-3)
5. Solve numerically on the ordinary differential equations using different methods . (BL-3)

UNIT-I

Introduction : Motivation and applications computation and error analysis accuracy and precision, truncation and round-off errors, binary number system, error propagation

UNIT-II

Linear systems and equations: Matrix representation, Cramer's rule, Gauss Elimination, Matrix Inversion, LU decomposition, iterative methods, relaxation methods, Eigen values.

UNIT-III

Algebraic equations: Bracketing methods, bisection, Reguli-Falsi, open methods and optimization open methods, secant, fixed point iteration, Newton-Raphson, multivariate Newton's method.

UNIT-IV

Numerical differentiation ,integration, regression and curve fitting : Numerical differentiation, higher order formulae , integration and integral equations trapezoidal rules, Simpson's rules, quadrature regression linear regression, least squares, total least squares, interpolation and curve fitting interpolation, Newton's difference formulae, cubic splines.

UNIT-V

ODEs initial value problems and boundary value problems: Euler's methods, Runge-Kutta methods, predictor-corrector methods, extension to multi-variable systems, adaptive step size, stiff ODEs, boundary value problems shooting method, finite differences, over/under relaxation(SOR).

Text Books:

1. Gupta S.K , "Numerical Methods for Engineers", New Age International, 1995.
2. Chapra S.C. and Canale R.P, "Numerical Methods for Engineers", 5/e., McGraw Hill, 2006.
3. Froberg C. E., "Introduction to Numerical Analysis", 2/e, Addison Wesley, 1970.

Suggested Reading:

1. Jain M.K., IyengarS.R.K., "Numerical methods for Scientific and Engineering Computation", 3/e, New Age International (P) Ltd, 1996.
2. Phillips G.M., Taylor P.J., "Theory and Applications of Numerical Analysis", 2/e, Academic Press, 1996.

18ME H33

ROBOTICS AND CONTROL : THEORY AND PRACTICE

Instruction	3 hours per week
Course Duration	8 weeks
Credits	2

Outcomes: At the end of the course, the students are able to

1. Understand the spatial transformations associated with rigid body motions. (BL-2)
2. Develop skill in performing kinematics and dynamic analysis of robot systems. (BL-3)
3. Analyze different robot manipulators. (BL-4)
4. Understand the concept of robot exoskeleton. (BL-2)
5. Examine the robot assisted percutaneous interventions. (BL-4)

UNIT-I

Introduction: Coordinate frames and homogeneous transformations-I, coordinate frames and homogeneous frames-II, differential transformations, transforming differential changes between coordinate frames.

UNIT-II

Robot kinematics: Manipulator model, direct kinematics, inverse kinematics, manipulator Jacobian.
Robot dynamics: Trajectory planning, dynamics of manipulator, manipulator dynamics multiple degree of freedom ,stability of dynamical system.

UNIT-III

Manipulator control and neural networks: Biped robot basics and flat foot biped model, biped robot flat foot and toe foot model, artificial neural network, neural network based control for robot manipulator.

UNIT-IV

Robotic exoskeletons: Introduction, force control of an index finger exoskeleton, neural control of a hand exoskeleton, neural control of a hand exoskeleton based on human subjects intention, redundancy resolution of human fingers using robotic principles, manipulability analysis of human fingers during coordinated object rotation ,kinematics of flexible link robots.

UNIT-V

Robot assisted percutaneous interventions : Experiments on robot assisted percutaneous interventions, sliding mode control, higher order sliding mode control, smart needles for percutaneous interventions-I , smart needles for percutaneous interventions-II.

Text Books:

1. Mittal & Nagrath, "Robotics and Control", Tata McGraw-Hill Education, 2003.
2. Schilling Robert J, "Fundamentals of Robotics: Analysis and Control", Prentice-Hall, 1990. (TJ211.S334)
3. Niku Saeed B, "An Introduction to Robotics Analysis, Systems, Applications", Prentice-Hall, 2001.

Suggested Reading:

1 Niku Saeed B, "An Introduction to Robotics Analysis, Systems, Applications", Prentice-Hall, 2001.
2 K S Fu,Ralph Gonzalez,C S G Lee, "Robotics: Control Sensing. Vision and Intelligence", Tata McGraw-Hill Education, 1987.

18ME H34

ACOUSTIC MATERIALS AND METAMATERIALS

Instruction	2 Hours per week
Course Duration	8 Weeks
Credits	2

Outcomes: At the end of the course, the students are able to

1. Understand the concepts of acoustic propagation and signal analysis. (BL-2)
2. Analyze principles of acoustic barrier materials, sound absorbing materials, acoustic metamaterials. (BL-4)
3. Differentiate conventional and acoustic metamaterials. (BL-2)
4. Design of membrane type metamaterials of sonic crystals . (BL-6)
5. Recommend suitable acoustic materials. (BL-5)

UNIT-I

Acoustics fundamentals: Sound propagation in fluids, advanced concepts in acoustics: introduction, sound wave propagation in fluid, sound propagation at medium boundaries, standing waves and modes, sound signal analysis, principles of noise control.

UNIT-II

Acoustic materials: Acoustic materials, enclosures, barriers, enclosures and barriers-tutorial, sound absorbing materials, porous-fibrous sound absorbers, panel sound absorbers, Helmholtz resonators, tutorial on sound absorbers, perforated panel absorbers.

UNIT-III

Micro-perforated panel absorbers: Limitations of conventional acoustic materials, micro perforated panel absorbers, introduction to acoustic metamaterials.

UNIT-IV

Acoustic metamaterials: History of acoustic metamaterials, applications of acoustic metamaterials, membrane type acoustic metamaterials, introduction to sonic crystals, advantages and applications of membrane type AMM, tutorial on membrane type AMM.

UNIT-V

Guidelines for material selection: Introduction to sonic crystals, fundamentals of crystals principle of working of sonic crystals, tutorial on sonic crystals, more on sonic crystals and conclusions.

Text Books:

1. David A. Bies, and Colin H. Hansen, “Engineering Noise Control: Theory and practice”, Spon Press, 2009.
2. M. J. Crocker ,“Introduction to Principles of Noise and Vibration Control”, in Handbook of Noise and Vibration Control, John Wiley and Sons Inc, 2007.
3. Richard V. Craster and Sébastien Guenneau, “Acoustic Metamaterials” Springer, 2013.

Suggested Readings:

1. Perngjin Frank Pai ,“Theory and Design of Acoustic Metamaterials” SPIE-International Society for Optical Engineering, 2014.
2. Vakakis Alexander F ,“Fundamentals and Applications of Acoustic Metamaterials” World Scientific, 2014.

18ME H35

MATLAB PROGRAMMING FOR NUMERICAL COMPUTATION

Instruction	3 Hours per week
Course Duration	8 Weeks
Credits	2

Outcomes: At the end of the course, the students are able to

1. Understand the concepts of MATLAB programming , error approximation. (BL-2)
2. Apply MATLAB functions for integration. (BL-3)
3. Make use of MATLAB functions for linear and nonlinear problems. (BL-3)
4. Identify ways of using linear and nonlinear regression and interpolation functions in MATLAB (BL-3)
5. Choose explicit ODE solving techniques in single and multiple variables. (BL-5)

UNIT-I

Introduction to MATLAB programming, approximations and errors: Basics of MATLAB programming, array operations in MATLAB, loops and execution control, working with files: scripts and functions, plotting and program output, defining errors and precision in numerical methods, truncation and round-off errors, error propagation, global and local truncation errors.

UNIT-II

Numerical differentiation and integration: Numerical differentiation in single variable, numerical differentiation: higher derivatives , differentiation in multiple variables , Newton-cotes integration formulae , multi-step application of trapezoidal rule ,MATLAB functions for integration.

UNIT-III

Linear equations.: Linear algebra in MATLAB lecture, Gauss elimination, LU decomposition and partial pivoting, iterative methods, Gauss Siedel , special matrices, tri-diagonal matrix algorithm.

Nonlinear equations: Nonlinear equations in single variable, MATLAB function fzero in single variable, fixed-point iteration in single variable, Newton-Raphson in single variable, MATLAB function fsolve in single and multiple variables , Newton-Raphson in multiple variables.

UNIT-IV

Regression and interpolation: Introduction, linear least squares regression (including lsqcurvefit function), functional and nonlinear regression (including lsqnonlin function) , interpolation in MATLAB using spline and pchip.

UNIT-V

Ordinary differential equations (ODE) and practical aspects: Introduction, implicit and explicit Euler's methods,second-order Runge-Kutta methods, MATLAB ode45 algorithm in single variable,higher order Runge-Kutta methods, error analysis of Runge-Kutta method, MATLAB ode45 algorithm in multiple variables ,stiff ODEs and MATLAB ode15s algorithm , practical example for ODE-IVP , solving transient PDE using method of lines.

Text Books:

1. Fausett L.V, “Applied NumericalAnalysis Using MATLAB”, 2/e, Pearson Education,2007.
2. Chapra S.C. and Canale R.P, “Numerical Methods for Engineers”, 5/e., McGraw Hill,2006.
3. Rudra Pratap, “Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers”, Oxford Edition , 2010.

Suggested Reading:

1. Rao V Dukkipati, “MATLAB for Mechanical Engineers”, New Age Science Limited, 2009.
2. Bober, W., “Numerical and analytical methods with MATLAB”, Boca Raton: CRC Press,2009.

18ME H36

ERGONOMICS IN AUTOMOTIVE DESIGN

Instruction	3 Hours per week
Course Duration	4 weeks
Credits	1

Outcomes: At the end of the course, the students are able to

1. Understandanthropometric and biomechanical data. (BL-2)
2. Understand occupant packaging and visibility aspects of the driver. (BL-2)
3. Analyze driving performance and driver workload measurement. (BL-4)
4. Apply virtual ergonomics evaluation technique and automotive craftsmanship. (BL-3)

UNIT-I

Introduction to automotive ergonomics: Driver information acquisition and processing, anthropometric and biomechanical data in automotive design.

UNIT-II

Occupant packaging: Basics and details, principle of control and display design, usability evaluation of in-vehicle control and displays, human fields of view and driver's fields of view, in vehicle and external visibility of the driver.

UNIT-III

Entry and exit by drivers and passengers: Basics and details, driver distraction and driving performance measurement, driver workload measurement.

UNIT-IV

Virtual ergonomics: Evaluation technique and its application in automotive design, automotive craftsmanship.

Text Books:

1.Bhise,V.D., "Ergonomics in the automotive design process" ,CRC Press, 2016.
2.Harvey, C and Stanton,N.A , "Usability analysis for in-vehicle systems", CRC Press, 2016.
3. Gkikas, N, "Auto Ergonomics Driver -Vehicle Interaction", CRC Press, 2016.

Suggested Reading:

1.Happian -Smith, J .ed. ,"An introduction to modern vehicle design" ,Elsevier, 2001.
2.Castro, C., "Human factors of visual and cognitive performance in driving" CRC Press, 2008.

18ME H37

FOUNDATIONS OF COGNITIVE ROBOTICS

Instruction	3 Hours per Week
Course Duration	4 Weeks
Credits	1

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

1. Understand importance of cognitive robot and smart materials. (BL-2)
2. Explain about intelligence, thinking. (BL-2)
3. Develop knowledge of artificial intelligence related to robots . (BL-3)
4. Design intelligent systems. (BL-6)
5. Apply AI based approach to various systems. (BL-3)

UNIT-I

Introduction: Introduction to cognitive robotics and human robot interaction, smart materials I, II, III.

UNIT-II

Intelligence thinking: Thinking, cognition, and intelligence, defining intelligence - embodiment and its implications.

UNIT-III

Artificial intelligence and theory of intelligence: Role of neuroscience and bio robotics, synthetic methodology for intelligence.

UNIT-IV

Intelligent system design and cognition development: Properties of complete agents, agent design principle, developmental robot design, matching brain and body dynamics.

UNIT-V

Control of intelligent systems- ai based approach: Artificial neural networks (ANN), fuzzy logic, genetic algorithms and other nature inspired methods, optimal control using ANN.

Text Book

1. Dale Purves "Neuroscience", Sinauer Associates, 5th Ed., 2011
2. Rolf Pfeifer and Josh Bongard, "How the body shapes the way we think-A New View of Intelligence", MIT Press,2007
3. Jitendra R. Raol, Ramakalyan Ayyagari, "Control Systems: Classical, Modern, and AI-Based Approaches", CRC Press,2019.

18ME H38

THEORY OF RECTANGULAR PLATES

Instruction	3 Hours per Week
Course Duration	4 Weeks
Credits	1

Outcomes: At the end of the course, the students are able to

1. Examine systematic development of plate governing equations using the variational calculus. (BL-3)
2. Discuss the basic analytical solutions techniques for bending, free vibration and buckling cases. (BL-2)
3. Apply to develop governing equation and solutions for functionally graded plate, piezoelectric plates (current research topics). (BL-4)
4. Apply MATLAB functions to simulate vibration of rectangular plates. (BL-4)

UNIT-I

Basic terminology, equations and methods: Basic of solid mechanics, energy principles, classification of plate theories and some basics. Tutorial: Transformation of tensors.

UNIT-II

Derivation of classical plate equations: Kinematic assumptions for various theories, development of governing equations, boundary conditions and plate constitutive relations, governing equation for plate. Tutorial: Reduced stiffness & plate stiffness.

UNIT-III

Analytical solution : Navier and levy for bending case, Navier solution + levy solution, levy solution.Tutorial: Load matrices calculation.

UNIT-IV

Apprpoximte solution: Apprpoximte solution techniques and 3D solution, extended Kantorovich method and buckling of plates, 3D solutions, MATLAB coding + Abaqus. Tutorial: Levy solutions.

Text Books:

1. J. N. Reddy, “Theory and Analysis of Elastic Plates and Shells”, CRC Press, 2006.
2. K. Bhaskarand T.K. Varadan, “Plates: Theories and Applications”, Wiley, 2014.
3. K. Chandrashekhara, “Theory of Plates”, University Press (India) Limited, 2001.

Suggested Reading:

1. Stephan P. Timoshenko, “Theory of Plates and Shells”, McGraw-Hill, Import, 1964.
2. L. G. Jaeger, Elementary “Theory of Elastic Plates”, 1/e, Pergamon 1964.

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

AICTE MODEL CURRICULUM

MECHANICAL ENGINEERING

B.E: MINOR ENGINEERING (3-D Printing and Design)

Sl. No.	Course Code	Title of the Course	Credits
1	18ME M03	Rapid Manufacturing	3
2	18ME M04	Manufacturing Systems Technology	3
3	18ME M05	Introduction to robotics	3
4	18ME M11	Principles of Industrial Engineering	3
5	18ME M15	Additive Manufacturing Technologies	2
6	18ME M16	Product Design and Development	1
7	18ME M17	Basics Of Finite Element Analysis	2
8	18ME M18	Electronics equipment integration and Prototype building	2
9	18ME M19	Design Practice	2
10	18ME M20	Computer Aided Design / Computer Aided Manufacturing	1
11	18ME M21	Basics of Materials Engineering	3
12	18ME M22	Computer numerical control of machine tools and processes	1
13	18ME M23	Processing of Polymers and Polymer Composites	2
14	18ME H01	Automation in Manufacturing	3
15	18ME H03	Industrial Safety Engineering	3
16	18ME H08	Functional and Conceptual Design	3
17	18ME H10	Design for Quality, Manufacturing and Assembly	2
18	18ME H14	Design Thinking - A Primer	1
19	18ME H15	Innovation by Design	1
20	18ME H33	Robotics and Control: Theory and Practice	2
21	18ME H37	Foundations of Cognitive Robotics	1

18ME M03

RAPID MANUFACTURING

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Define Rapid Manufacturing. (BL-1)
2. Understand Design for Modularity and the Reverse Engineering (BL-2)
3. Analyze and select a Rapid manufacturing technology for a given component. (BL- 4)
4. Describe the materials used and Post-processing techniques in Rapid Manufacturing.(BL-2)
5. Illustrate the significance of Rapid Product development. (BL-3)

UNIT- I
Introduction to Rapid Manufacturing (RM), Product Design Process

UNIT- II
Design for Modularity, Reverse Engineering, 3D measurement: laboratory demonstration

UNIT- III
Polymerization and Powder based RM processes, Liquid based, and Sheet stacking RM processes, 3D printing RM processes and laboratory demonstration

UNIT - IV
Beam Deposition RM processes, and materials in RM, Post-processing and costing in RM

UNIT –V
Rapid Product Development (CAD/CAE/CIM), Rapid Product Development (Software demonstration), and case studies on RM

Text Books:

1. Kamrani, A.K. and Nasr, E.A., 2010. Engineering design and rapid prototyping. Springer Science & Business Media.Groover, M. P., Automation, Production Systems, and Computer-Integrated Manufacturing, Prentice Hall, 2001.
2. Gebhardt, A., 2011. Understanding additive manufacturing.
3. Gibson, I., Rosen, D.W. and Stucker, B., 2014. Additive manufacturing technologies (Vol. 17). New York: Springer.

Suggested Reading:

1. Hopkinson, N., Hague, R. and Dickens, P. eds., 2006. Rapid manufacturing: an industrial revolution for the digital age. John Wiley & Sons.
2. Pham, D. and Dimov, S.S., 2012. Rapid manufacturing: the technologies and applications of rapid prototyping and rapid tooling. Springer Science & Business Media.

18ME M04

MANUFACTURING SYSTEMS TECHNOLOGY

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the concepts of computer aided designing. (BL-2)
2. Apply the principles in process planning. (BL-3)
3. Gain knowledge on computer numerical control systems. (BL-1)
4. Distinguish between quality improvement methods. (BL-4)
5. Understand the dynamic changes that are taking place in business environment. (BL-2)

UNIT- I
Introduction: Manufacturing properties of materials

Integrated product designing: Manufacturing systems approach, historical perspective of design, material handling systems.

Computer aided designing: Introduction, homogeneous transformation, 3-D transformations, parametric and non-parametric equations, hermite cubic spline fit, Bezier curves, introduction to manufacturing processes,

UNIT- II
Principles and process planning of basic machining processes, machine tools design.

Computer aided process planning: Developing a process plan, determining machining conditions and machining time, machining cost evaluation, estimation of tool life, generative CAPP method and knowledge based process planning.

UNIT- III
Introduction to CNC part programming, motion control of NC machines, preparatory functions used in NC programming, G codes, M codes and canned cycles.

UNIT - IV
Quality systems engineering: Introduction to quality engineering, Just-in-time manufacturing, toyta production system, pull systems, kanban systems. quality costs, product design, design of experiments, applications of quality loss function, product selection strategies.

UNIT –V
Cost of quality and statistical quality control: Robust design approaches, taguchi's method, failure mode and effects analysis, product quality improvement methods, quality tools, quality charts, X-bar chart, R-chart.

Robotic systems planning and designing: Six sigma, theory of probability, determining the defective products using probability, sampling based on permutations and combinations, bionomial distributions, poisson distribution, normal distribution, fundamental of robotics and its application in automated systems, joint configuration systems of robot.

Text Books:

1. R. Thomas Wright, “Manufacturing systems”, Goodheart-Willcox Company, 1990.
2. Katsundo Mitomi , “Manufacturing Systems Engineering: A Unified Approach to Manufacturing Technology, Production Management and Industrial Economics”, second edition, CRC press, 1996.
3. Yoram Koren , “Computer control of manufacturing systems”, McGraw Hill ,2017

Suggested Reading:

1. Rao, Kundra, and Tewari, “Numerical Control and computer aided manufacturing”, Mc Graw Hill ,2017

18ME M05

INTRODUCTION TO ROBOTICS

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Describe the basic components, specifications and applications of the Robots (BL-1)
2. Understand transformations, direct and inverse kinematics of robots (BL-2)
3. Calculate forces in links and joints of a robot and find the singularities, Jacobian and trajectory planning of a robot for various tasks (BL-3)
4. Classify drives, sensors and grippers for various applications (BL-4)
5. Programme a robot for a given task with machine vision and sensors (BL-5)

Unit I

Introduction to robotics- History, growth; Robot applications- Manufacturing industry, defence, rehabilitation, medical etc., Laws of Robotics.

Unit II

Robot mechanisms; Kinematics- coordinate transformations, DH parameters Forward kinematics, Inverse Kinematics

Unit III

Jacobians, Statics, Trajectory Planning, Computed torque control, Actuators (electrical)- DC motors, BLDC servo motors.

Unit IV

Control – PWM, joint motion control, feedback control, Probabilistic robotics, Path planning, BFS; DFS; Dijkstra; A-star; D-star; Voronoi; Potential Field; Hybrid approaches

Unit V

Sensors , sensor integration.Perception, Localisation and mapping, Simultaneous Localization and Mapping. Introduction to Reinforcement Learning

Text Books:

1. Robert J Schilling, Fundamentals of Robotics, Prentice Hall India, 2000
2. John J Craig, Introduction to Robotics, Prentice Hall International, 2005
3. Groover, “Industrial Robotics”, Mcgraw-Hill Publishing Company Ltd. 2003

Suggested Reading:

1. Asada and Slotine, “Robot analysis and Intelligence”, Wiley Interscience, 1986
2. K.S. Fu Gon ZalezRC., lEEc.S.G., “Robotics, Control Sensing Vision and Intelligence”, McGraw Hill, Int. Ed., 1987

18ME M11

PRINCIPLES OF INDUSTRIAL ENGINEERING

Instruction	3 Hours per week
Course Duration	12 weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Understand the various concepts of organizational structure. (BL-2)
2. Analyze the process layout design. (BL-4)
3. Apply the network techniques in the project management. (BL-3)
4. Apply forecasting techniques for predicting demand. (BL-3)
5. Apply the quality control tools to improve performance of production system. (BL-3)

Unit -I

Introduction: Developments, objectives, functions and tools.

Organizational structure: Roles,Types, product strategies, principles, process and product organization.

Unit-II

Plant Location and Plant Layout: Selection of site, Factor Affecting Selection of Site, Purpose and Types of Layout, Process Layout Design, Product Layout Design.

Material Handling: Scope, Capacity Planning &Scheduling, Sequencing, Relative Performance of Priority Sequencing Rules.

Unit-III

Inventory: Fundamentals, Models I, Models II, Wilson Model, Gradual Replenishment Model.

Project Management & Network Modeling: Introduction, Network Modeling, Network Analysis.

Unit-IV

Forecasting: Introduction, Methods I, Methods II, Methods III, Methods IV, Methods V.

Unit -V

Quality Control: Introduction, Fundamentals, Control Charts for variables, Control Charts for Attributes, Productivity & Work Study.

Text Books:

1. Russel, R S, Taylor BW, “Operations Management”, Pearson education, 2003.
2. Jocobs C A ,”Production and operations management”, TMH, 1999.
3. Mitra, A “Fundamentals of Quality control and improvement”, John Willey & Sons, 2008.

Suggested Reading:

1. Besterfield DH, “Total Quality Management”, Pearson education, 1999.
2. S.N. Chary, “Production and Operations Management”, 3rd edition, Tata McGraw

18ME M15

ADDITIVE MANUFACTURING TECHNOLOGIES

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Define Significance of manufacturing and Advances in Manufacturing (BL-1)
2. Explain various Additive Manufacturing Technologies and Industrial Applications. (BL-2)
3. Illustrate about different AM materials and Business Functionalities. (BL-3)
4. Identify Quality of parts and challenges in certification. (BL-3)
5. Interpret the impact of additive manufacturing on firms and market. (BL-2)

UNIT- I

Manufacturing Paradigms: Significance of manufacturing. Different manufacturing paradigms, craft production, mass production, mass customization, distributed manufacturing, servitisation. Technology and manufacturing.Laws of manufacturing.

Advances in Manufacturing and SCM: Additive manufacturing, and its impact over the product development cycles. Reconfiguring of supply chain models. Contemporary initiatives in manufacturing: Advanced Manufacturing (US), e-factory (Japan), Industrie 4.0 (Germany), Intelligent Manufacturing (China) and Make in India (India).

UNIT- II

Economics of Manufacturing: Firms' market microstructure for manufacturing. Economies of scale, unscale, and scope. Manufacturing production functions. Mathematics of complementarities.Complementarities in production.
Additive Manufacturing Technologies: Technology basics and classification. Metal additive manufacturing and significance of laser powder bed fusion. Challenges in realization of metal additive manufactured parts with adequate strength and integrity. Input data formats and data generation from physical artefacts. Build environment and concept of process window. Typical pitfalls and corrective measures.
Industrial Applications: Part Substitution, Prototyping, Tooling and Reengineering. Product Design and Development Models based on Metal Additive Manufacturing. Spare part management for engineering conglomerates and users of legacy systems. MRO and refurbishment models based on metal additive manufacturing.

UNIT- III

AM Materials: Functionalities of AM materials – metals, plastics, ceramics and composites.Use of certified Materials and challenges in adapting new materials. Comparisons of AM materials with cast or forged structural alloys. Common Defects in AM Parts and their implications

AM Business Functionalities: Essentials of AM plant infrastructure. Importance of post processing. Dimensional accuracy, surface finish and strength aspects.Powder handling and recycling.
Opportunities for Value Addition: Light Weighting, Part Consolidation and Topology Optimisation. Functional integration.

UNIT- IV

Quality: Process Certification, General Approach to Part Certification, Process Monitoring| Industry Certifications: AS, LR. Challenges in Certification and Prove Out Repeatability, Reliability and Predictability, Control Measures.

Opportunity Identification: Selection of Right Parts, Assessment of Shortlisted Components, Use Cases and Business Cases based on Techno-Commercials, Impact on Sub-systems and Systems

UNIT- V

Road Mapping: Challenges in AM Adoption and Change Management Approach, Wipro3D Adoption Approach, Benchmarking organizational Goals with reference to AM. Value Estimation. Economic characteristics of additive manufacturing.Impact of additive manufacturing on firms' payoff functions and market microstructure.

Manufacturing Architecture and Business Models for Manufacturing: Cloud manufacturing. Cooperative and responsive manufacturing.Data-driven manufacturing and digital factory. Human-centered manufacturing. Introduction to business models. Manufacturing-as-a-Service (MaaS).Anything-as-a-Service (XaaS).

Text Books:

1. Y. Koren, "The Global Manufacturing Revolution", John Wiley & Sons, 2010.
2. Richard D'Aveni, "The 3-D Printing Revolution", Harvard Business Review, May 2015.
3. John O. Milewski, "Additive Manufacturing Technologies", Springer, 2017

Suggested Reading:

1. Regtien, P. P. L., Sensors for mechatronics, Elesevier, USA, 2012.
2. Parr, A. A., Hydraulics and pneumatics, Elsevier, 1999.

18ME M16

PRODUCT DESIGN AND DEVLOPMENT

Instruction	3	Hours per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Define the needs of the customer while designing a new product or modifying existing product in the competitive environment. (BL-1)
2. Understand Product life cycle and value engineering. (BL- 2)
3. Make use of Ergonomic concepts in product design (BL- 3)
4. Understand design for manufacturability and assembly concepts in product design . (BL- 2)
5. Identify appropriate manufacturing technique . (BL-3)

UNIT- I

Product Design: Introduction to course, Need analysis, Product policy of an organization. Selection of a profitable product, Product design process, Product analysis.

UNIT- II

New Product Planning: Applications in product design, Problem identification and selection, Analysis of functions, Anatomy of function. Primary versus secondary versus tertiary/unnecessary functions, Functional analysis: Functional Analysis System Technique (FAST), Case studies. Product life-cycle, Value engineering in product design.

UNIT- III

Industrial Ergonomics: Introduction to product design tools, Quality Function Deployment, Computer Aided Design, Robust design, Design For Manufacturing, Design For Assembly, Ergonomics in product design.

UNIT - IV

Design for Manufacturability and Assembly: guidelines, Product design for manual assembly, Design guidelines for metallic and non-metallic products to be manufactured by different processes

UNIT –V

Process Selection: casting, machining, injection molding. Rapid prototyping, needs, advantages, working principle of Stereo lithography (SLA),Selective Laser Sintering (SLS),

Text Books:

1. B.W.Niebel &A.B.Draper, “Production Design & Process Engg”, McGraw Hill, Kogakusha, 1974.
2. A.K. Chitale& R.C. Gupta, “Product Design & Manufacturing”, PHI, 1997.
3. K. G. Swift & J. D. Booker, “Process Selection: From Design to Manufacture”, Butterworth-Heinemann Ltd; Revised 2/e, 2003.

Suggested Reading:

1. Brain Twiss, “Managing Technological Innovation”, Pittrnan Publications, 1992.

2. Karl T. Ulrich, Stephen Eppinger, “Product Design and Development”,McGrawHill Publication, 2012

18ME M17

BASICS OF FINITE ELEMENT ANALYSIS

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

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

1. Analyze FEA models correct or not for 1D problems. (BL-4)
2. Apply FE method for solving field problems using Virtual work and Potential energy formulation (BL-3)
3. Solve radially symmetric problems. (BL-3)
4. Solve 1-D conduction and convection heat transfer problems and shear deformable beams (BL-3)
5. Solve time dependent problems, estimate natural frequencies for stepped bar, beam (BL-3)

UNIT- I

Finite element analysis (FEA): Introduction to FEA, philosophy of FEA, nodes, elements, shape functions, polynomials as shape functions, weighted residuals, elements and assembly equations, types of errors in FEA, overall FEA process, convergence, strengths of FE method, continuity conditions at interfaces.

UNIT- II

Mathematical Concepts and: Weighted integral statements, Gradient and Divergence theorems, functionals, variational operator, weighted integral & weak formulation: principle of minimum potential energy, variational method: Rayleigh Ritz method, weighted residual methods,

UNIT- III

1-D boundary value problems:FEA formulation for 2^{nd} order BVP, element level equations, Assembly of element equations, radially symmetric problems.

UNIT- IV

Heat transfer problems and Beams: 1-D heat transfer, 1-D heat conduction with convective effects, FE formulations of Euler Bernoulli beam, FE formulations of shear deformable beams, equal interpolation but reduced integration element.

UNIT -V

Time dependent and Eigen value problems: Introduction to time dependent problems, explicit and implicit method, diagonalization of mass matrix, spatial approximation, temporal approximation for parabolic and hyperbolic problems, FE formulations of dynamic systems, element mass matrices, Eigen value problems.

Text Books:

1. J.N.Reddy,"An Introduction to the finite element method" , Mc Graw Hill series in mechanical engineering, Hardcover – Import, 16 January 2005.
2. Tirupathi R Chandraputla and Ashok D Belagundu, "Introduction to Finite Elements in Engineering", Prentice Hall of India, 1997
3. Daryl L. Logan, "A First Course in the Finite Element Method", Cengage Learning, 2011.

Suggested Reading:

1. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt., “Concepts and Applications of Finite Element Analysis”, 4/e, Wiley.
2. L. J. Segerlind, “Applied Finite Element Analysis”, Wiley Eastern, 1984.

18ME M18

ELECTRONICS EQUIPMENT INTEGRATION AND PROTOTYPE BUILDING

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Course objectives

1. Define the concepts of prototyping (BL-1)
2. Identify the concepts of solid modeling and 3D printing (BL-3)
3. Illustrate the hardware integration of electronic components (BL-2)
4. Identify the Fabrication and fastenings of components (BL-3)
5. Examine the Assembly and Finishing techniques (BL-4)

Unit 1

Product Concepts and Prototyping, Sample product concept and project

Unit 2

Solid Modelling and 3D printing

Unit 3

Detailing and design for 3D printing, Components and hardware integration

Unit 4

Fabrication and fastenings, Creative design of products

Unit 5

Assembly, Integration and Finishing techniques

Text books:

1. Eugene R. Hnatek, "Practical Reliability Of Electronic Equipment And Products", Qualcomm Incorporated, san Diege, California

18MEM19

DESIGN PRACTICE

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Demonstrate the concepts of Product design (BL-3)
2. Apply the concepts of Concurrent Engineering (BL- 3)
3. Develop the Visualization of the Product Design (BL- 6)
4. Summarize the concepts of Group technology (BL- 2)
5. Select the material and ergonomics in design (BL- 4)

UNIT- I

Introduction to design /product design. Stanford model of Design thinking/ Stages of engineering design of products

UNIT- II

Introduction to Concurrent Engineering. Concurrent engineering in Practice

UNIT- III

Product embodiment design (robustness of design/FMEA techniques). House of quality, Specifications (Fits and Tolerances)

UNIT - IV

Axiomatic Design, Introduction to Group Technology, Creating forms and shapes, Geometric transformation models, Introduction to electronics.

UNIT –V

Material selection process in design, Applied Ergonomics (work systems design, Introduction to bio-mechanics)

Text Books:

1. Nanua Singh, “Systems approach to computer integrated design and manufacturing”, Wiley India Pvt. Ltd.1996
2. Karl T. Ulrich, Steven. D. Eppinger, “Product design and development”, Mcgraw hill publications.5th Edition,2011

18ME M20

COMPUTER AIDED DESIGN / COMPUTER AIDED MANUFACTURING

Instruction	3	Hours per week
Course Duration	4	Weeks
Credits	1	

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

1. Understand CAD for drafting, modelling of curves. (BL-2)
2. Understand display devices and modelling techniques. (BL-2)
3. Demonstrate Numerical Control machines. (BL-2)
4. Develop programs using G and M codes for lathe and milling operations. (BL-3)
5. Describe various advanced manufacturing systems (BL-1)

UNIT- I

Introduction to Computer Aided Design (CAD): 2 D &3 D drafting, 3D modelling and CAD functions, applications, modelling of Curves, solids, mechanisms and assemblies.

UNIT- II

Display Devices, Working Principles and its various Techniques: Hardware and software of CAD, principles and techniques of CAD display devices, input and output devices, wireframe & solid modelling and its techniques, operations, comparison of wireframe & solid modelling.

UNIT- III

Introduction to CAM: Numerical control (NC), features and elements of NC, types of NC systems: PTP, straight cut and contouring.

UNIT- IV

Working principle of CNC machine: Computer numerical control machines (CNC), principles of CNC and coordinate systems, motion control, working and operation of CNC, advantages and disadvantages of CNC machines.

UNIT -V

Advanced manufacturing system: Position and flexible manufacturing systems (FMS), components and types, approaches, layouts, problems, advantages and disadvantages, automated guided vehicle systems (AGVS), types and control systems, charging and guidance methods, safety elements and task allocation and computer inventory control, management information systems (MIS), functions, storages and decision support systems (DSS) components and benefits, robotics, types of robots and features, robot anatomy, defining parameter, control systems and robot applications.

Text Books:

1. Groover, Mikell P and Zimmer’s Emory W, “CAD/CAM”, Prentice Hall India (P) Ltd, 2001.
2. Rao P N, “CAD/CAM: Principles and Applications”, Tata McGraw Hill Higher Education P Ltd 2002.
3. Ibrahim Zeid, “Mastering CAD/CAM”, Tata McGraw Hill Higher Education P Ltd 2004

Suggested Reading:

1. Radhakrishnan P, “CAD/CAM/CIM”, New Age International Publishers 1994.
2. Groover, “Industrial Robotics”, Mc Graw-Hill Publishing Company Ltd. 2003.

18ME M21

BASICS OF MATERIALS ENGINEERING

Instruction	3 Hours per week
Course Duration	12 weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Describe the relationship between structure and properties of materials. (BL-2)
2. Understand the mechanical behaviour of materials (BL-2)
3. Demonstrate knowledge relating to composition, structure and processing of materials. (BL-2)
4. Distinguish between plastic deformation and its different modes. (BL-4)
5. Apply the concepts of heat treatments to alter the structure and properties of materials. (BL-3)

UNIT-I

Crystal Structure: Introduction, Unit cells and Crystal Systems, Types of unit cells-ordination number, atomic packing factor and density computations, Single crystals, Polycrystalline materials-Ray diffraction – determination of crystal structure.

Imperfections in solids: Point defects,Impurities,Dislocations,Bulk or volume defects, Dislocations and strengthening mechanisms, slip in single crystals, critically resolved shear stress, Plastic deformation in polycrystalline materials, Deformation by twinning, Strengthening mechanisms.

UNIT-II

Mechanical properties of metals: Tensile test, compression test, shear and torsion test, Elastic deformation, Stress-strain plot, engineering and true stress-strain plots, relations between true and engineering values, Young's modulus, relation between elastic constants, Hooke's law. Plastic deformation, yielding and yield strength, tensile strength, ductility, resilience and toughness, elastic recovery, Hardness, Brinell, Rockwell and Vickers's hardness.

UNIT-III

Failure of materials: Introduction,Stress concentration factors, Stress tensor and its invariants, Static failure theories, Application of failure theories, Fracture mechanics, Griffith criterion. Fatigue failure theories, Low cycle and high cycle fatigue.

UNIT-IV

Phase diagrams: Introduction,solidus line, liquidus line, components of a typical phase diagram, Interpretation of binary phase diagrams of simple alloy systems, Determination of phases, amounts and composition of each phase, Iron-Iron Carbide (Fe-Fe_3C) Phase diagram, Influence of alloying elements like (Chromium, Nickel and Titanium) on the Iron-Iron carbide phase diagram.

UNIT -V

Heat treatment of Steel: Isothermal transformation diagram, Microstructural changes during phase transformation, Different types of microstructures formed during heat treatment and their relative hardness and mechanical properties: Fine Pearlite, Coarse Pearlite, Bainite, Martensite, Tempered Martensite

Continuous cooling transformation diagram, Types of heat treatment and associates microstructure,

Annealing, Tempering, Normalizing, Quenching, Spheroidizing.

Text Books

1. William D Callister Jr. and David G. Rethwisch, “Materials Science and Engineering:”, 8^{th} Edn ,2009.

2. S.H. Avner, “Introduction to Physical Metallurgy”, Tata McGraw Hill Publishers, 2nd Edn, 2005.

3. V. Raghavan, “Materials Science and Engineering”, Prentice Hall of India Ltd, 4th Edn, 2005.

Suggested Readings

1. E. Dieter, “Mechanical Metallurgy”, Metric Edition, Tata McGraw Hill, 3rd Edn, 2005.2 2.K.L. 2. Kakani,” Material Science”, New Age Publications (P) Ltd, 2008.
2. Kakani, “Material Science”, New Age Publications(p) Ltd, 2008.

18ME M22

COMPUTER NUMERICAL CONTROL OF MACHINE TOOLS AND PROCESSES

Instruction	3	Hours per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Demonstrate computer numerical control machines. (BL-2)
2. solve the problems on CNC controls (BL-3)
3. Develop programs using G and M codes for lathe and milling operations. (BL-3)
4. Develop programs on interpolations. (BL-3)
5. Describe methods for cutter path generation of curved surfaces. (BL-1)

UNIT- I

Computer Numerical Control Machines: Introduction to computer control-role of computers in automation, binary logic and logic gates, classification of CNC machine tools, point to point control, continuous control, closed loop and open loop control, problems CNC on controls.

UNIT- II

Technologies and devices employed in CNC machines: Stepper motors, permanent magnet DC motors, binary circuits, decoders, tachogenerator, printed circuit motors, encoders, programs using G codes and M codes.

UNIT- III

2-D Programming and Interpolation: Computer aided offline programming, linear interpolations, curvilinear interpolations, programming on interpolation.

UNIT - IV

3-D programming: 3-D machining, basic concepts, curved surface geometry.

UNIT –V

Cutter path generation methods for curved surfaces: Iso parametric method, iso planar method, iso scallop method

Text Books:

1. Yoram Koren , “Computer control of manufacturing systems”, McGraw Hill ,2017.
2. Rao, Kundra, and Tewari, “Numerical Control and computer aided manufacturing”, Mc Graw Hill ,2017.
3. Albert Malvino, “Digital computer electronics”, 3rd edition, Tata McGraw Hill, 1992.

Suggested Reading:

1. D. Rogers and R. Adams, “Mathematical elements in computer graphics”, Mc Graw Hill ,2017.
2. Yoramkoren, “Computer Control of Manufacturing Systems” McGraw Hill Int, New York, 1994.

18ME M23

PROCESSING OF POLYMERS AND POLYMER COMPOSITES

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Understand the classification of engineering materials, structure and mechanical properties of thermoplastics and thermosets. (BL- 2)
2. Select suitable method for manufacturing a plastic component (BL- 5)
3. Understand the basic concepts of composites and their classification (BL- 2)
4. Describe and differentiate various processing techniques used for polymer composites (BL-2)
5. Outline some important secondary processes used in the manufacturing of polymer composites (BL-4)

UNIT- I

Introduction: Engineering materials and processing techniques, thermoplastics and thermosets

Processing of polymers: Introduction and classification**,** thermoforming process, extrusion and compression molding

UNIT- II

Processing of Polymers: Injection molding, transfer molding, rotational molding and blow molding,

Composite materials: Basic concepts and classification of composite materials

UNIT- III

Processing of polymer composites: Hand-layup, spray-layup, compression molding, injection molding. reaction injection molding, autoclaving, resin transfer molding, filament winding, pultrusion

UNIT - IV

Processing of polymer composites: Sheet molding, pre-pegging and challenges in primary processing of composites,

Secondary processing of polymer composites: Joining of polymer composites, Adhesive joining. Mechanical joining, Microwave joining, Induction and resistance welding

UNIT –V

Drilling of polymer composites: conventional v ultrasonic drilling, remedies for reducing drilling induced damages, research tools for secondary processing, numerical problems and case studies

Text Books:

1. Mikell P. Groover, “Fundamentals of Modern Manufacturing: Materials, Processes, and Systems”, Wiley publications, 6th edition 2015.
2. Kalpakjian, “Manufacturing Engineering and Technology”, Pearson publications, 7th edition 2013.
3. P.N. Rao, “Manufacturing Technology”, Vol.-1, McGraw Hills Publication, 4th Edition 2016.

Suggested Reading:

1. R.K.Rajput, “A text book of Manufacturing Technology”, Vol-I, Laxmi Pub., 2007.
2. P.C. Sharma, “A Text book of Production Technology”, 8/e, S. Chand & Co., Pvt.Ltd., 2014.

18ME H01

AUTOMATION IN MANUFACTURING

Instruction	3 Hours per week
Course Duration	12 Weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Explain the design and development of automated systems in the manufacturing. (BL-2)
2. Describe working of various blocks of automated system. (BL-2)
3. Illustrate the principle of operation and construction details of sensors/transducers, actuators, drives and mechanisms, hydraulic and pneumatic systems for automation. (BL-3)
4. Summarize the microprocessor technology, programming and CNC technology. (BL-2)
5. Use automation principles for manufacturing industrial applications. (BL-3)

UNIT- I

Introduction: Importance of automation in the manufacturing industry. Use of mechatronics, systems required.

Design of an automated system: Building blocks of an automated system, working principle and examples.

UNIT- II

Fabrication: Fabrication or selection of various components of an automated system, specifications of various elements, use of design data books and catalogues.

Sensors: Study of various sensors required in a typical automated system for manufacturing, construction and principle of operation of sensors.

UNIT- III

Microprocessor technology: Signal conditioning and data acquisition, use of microprocessor or micro controllers, configurations, working.

Drives: Electrical drives, types, selection criteria, construction and operating principle.

UNIT - IV

Mechanisms: Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, and transfer systems.

Hydraulic systems: Hydraulic power pack, pumps, valves, designing of hydraulic circuits.

UNIT –V

Pneumatic systems: Configurations, compressors, valves, distribution and conditioning.

CNC technology: Basic elements, interpolators and programming.

Text Books:

1. Boltan, W., “Mechatronics: electronic control systems in mechanical and electrical engineering”, Longman, Singapore, 1999.
2. Groover, M.P., “Automation, Production Systems, and Computer-Integrated Manufacturing”, Prentice Hall, 2001.
3. Gaonkar, R.S., “Microprocessor architecture, programming, and applications with the 8085”, Penram International Publishing (India), Delhi, 2000.

Suggested Reading:

1. Regtien, P. P. L., “Sensors for mechatronics”, Elsevier, USA, 2012.
2. Parr, A. A., “Hydraulics and pneumatics”, Elsevier, 1999.

Handbooks:

1. Smid, P., “CNC Programming Handbook”, Industrial Press, New York, USA, 2008.
2. Rothbart, H. A., “CAM Design Handbook”, McGraw-Hill, 2004.
3. Norton, R. L., “Cam Design and Manufacturing Handbook”, Industrial press Inc, 2002.

18 ME H03

INDUSTRIAL SAFETY ENGINEERING

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Identify the causes for industrial accidents and suggest preventive measures for safety. (BL-2)
2. Use the concepts of engineering systems safety, dimensions of engineering systems safety.(BL-3)
3. Apply the principles of safety design and carry out analysis. (BL-3)
4. Design for engineering systems safety and control for safety. (BL-3)
5. Integrate safety with other operational goals such as quality and reliability. (BL-5)

UNIT - I

Introduction: key concepts, terminologies, and safety quantification, safety by design, hazard identification techniques (e.g., HAZOP, FMEA, etc.) .

UNIT - II

Fault tree and event tree analysis (qualitative & quantitative)andBow-tie and quantitative risk assessment (QRA) .

UNIT - III

Safety function deployment, safety vs reliability, quantification of basic events (repair to failure, repair-failure-repair, and combined processes).

UNIT - IV

Systems safety quantification (e.g., truth tables, structure functions, minimal cut sets), human error analysis and safety.

UNIT – V

Accident investigation and analysis, application of virtual reality, OSHAS 18001 and OSHMS.

Text Books:

1. Komamoto and Henley, “Probabilistic Risk Assessment for Engineering and Scientists”, IEEE Press, 1995.
2. Heinrich et al., “Industrial Accident Prevention”, McGraw Hill, 1980.
3. Petersen D, “Techniques for safety management - A systems approach”, ASSE 1998.

Suggested Reading:

1. H. P. Garg, “Maintenance Engineering”, S. Chand and Company, Year 2010.
2. Tyler G. Hicks and T. W. Edwards, “Pump Application Engineering", McGraw-Hill, 1971.

18ME H08

FUNCTIONAL AND CONCEPTUAL DESIGN

Instruction	3 Hours per week
Course Duration	12 Weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Learn the importance of system design process in product design. (BL-1)
2. Identify various steps involved in the design process. (BL-2)
3. Learn the importance of function and form in the design process. (BL-1)
4. Apply the systematic design process for product development. (BL-3)
5. Apply the concept development tools in the design process. (BL-3)

UNIT - I

Overview of the design process: How engineering design is different from conventional design.

Steps in design process: Understanding the opportunity, mission statement.

UNIT - II

Customer need identification: Like/Dislike method, affinity diagram.

Product specifications: Design metrics, bench marking, QFD, HOQ and examples.

UNIT - III

Functional design: Functional decomposition, FAST, function structure, function tree, functional decomposition, examples.

UNIT - IV

Product architecture: Portfolio architecture, unshared, modular, customizable architectures, choosing portfolio architecture, module heuristics.

UNIT - V

Concept development: Converting functions to concepts, concept development tools- intuitive and logical methods, brainstorming, 6-3-5, TRIZ.

Concept selection: Concept screening, scoring and ranking.

Text Books:

1. Kevin Otto & Krisitn Wood, “Product Design”, Pearson Education, 2010.
2. D.G. Ullman, “The Mechanical Design Process”, McGraw- Hill, 2015.
3. G. Pahl and W.Beitz, “Engineering Design- A systematic Approach”, Springer, 2007.

Suggested Reading:

1. Michael Joseph French, “Conceptual Design for Engineers”, Springer; 3rd edition, 2013.
2. Clive L. Dym, “Engineering Design: A Project-Based Introduction”, Wiley; 4th edition, 2013.

18ME H10

DESIGN FOR QUALITY, MANUFACTURING AND ASSEMBLY.

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

.**Outcomes:** At the end of the course, the students are able to

1. Recall the concepts such as quality, robustness, six sigma and orthogonal array. (BL-1)
2. Understand the limitations of a design from manufacturing and assembly perspective. (BL-2)
3. Suggest techniques to produce high quality products at low cost. (BL-4)
4. Design teams in simplifying product structure to reduce manufacturing & assembly costs and quantify improvements. (BL-4)
5. Interpret the reasons for variability, mathematically represent, formulate and control it. (BL-6)

UNIT - I

Introduction: Discussion on quality**,** measuring quality, quality loss function, discussion on robustness, six sigma concepts.

UNIT - II

Quantifying robustness: Signal to noise ratio, problem formulation using SNR, design of experiment discussions, orthogonal array, linear graphs, triangular tables, finding optimum combinations, case studies.

UNIT – III

Design for manufacturing: Over the wall design, most influential phase in design, best practices in injection molding and sheet metal working, design for additive manufacturing, single point and multipoint tools.

UNIT – IV

Design for assembly: Boothroyd Dewhurst method, theoretical minimum number of parts, Xerox producibility index (XPI) method.

UNIT – V

Do’s and dont’s in manual assembly, assembly time estimation, design for robotic assembly considerations, design for sustainability.

Text Books:

1. J. M. Juran, “Juran on Quality by Design: The New Steps for Planning Quality into Goods and Services”, McGraw-Hill Education,1992.
2. Daniel E. Whitney, "Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development”, Oxford University Press, 2004.
3. Geoffrey Boothroyd, Peter Dewhurst, “Product Design for Manufacture and Assembly (Manufacturing Engineering and Materials Processing)”, CRC Press, 3/e , 2010.

Suggested Reading:

1. James Bralla, “Design for Manufacturability Handbook”, McGraw-Hill Education, 2/ e,1998
2. David M. Anderson , “Design for Manufacturability: How to Use Concurrent Engineering to Rapidly Develop Low-Cost, High-Quality Products for Lean Production”, Productivity Press, 1/e, 2014.

18ME H14

DESIGN THINKING - A PRIMER

Instruction	3	Hour per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Understand the basic concept of design thinking. (BL-2)
2. Recall the step involved in design thinking. (BL-1)
3. Apply the principles of design thinking by observing, interviewing or just experiencing a situation. (BL-3)
4. Improve the situation of the humans by solving problems facing them. (BL-5)
5. Analyze problems using brain storming, 5 why's. (BL-3)

UNIT-I

Design thinking: Introduction, history, discussion and case study.

UNIT-II
Empathize phase: Customer journey mapping.

UNIT-III
Analyze phase: 5-Whys, 5 whys-IIT stadium levels and solve-workshop I & II.

UNIT-IV
Solve phase: Ideation, free brainstorming.

UNIT-V
Make/Test phase: Customer reactions to prototype, finale and appeal for proposals.

Text Books:

1. Prof. Karl Ulrich, "Design: Creation of Artifacts in Society", University of Pennsylvania, 2011.
2. Tim Brown, "Change by Design" Harper Business Publication, 2013.
3. Idris Mootee "Design Thinking for Strategic Innovation", Adams Media publications, 2014.

Suggested Reading:

1. Bryan Lawson, "How Designer's Think: The design process demystified", Architectural Press, 2005.
2. Brown, Dan M, "Designing Together", New Riders, 2013.

18ME H15

INNOVATION BY DESIGN

Instruction	3	Hour per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Find solutions to present day problems and challenges through innovation. (BL-4)
2. Formulate a design enabled by innovation. (BL-6)
3. Gain knowledge on the journey of a design idea from the identification of a problem to a final solution. (BL-2)
4. Learn the importance of innovation process requiring empathy, meticulous effort, constant user interaction and effective collaboration. (BL-1)
5. apply innovation to have positive impact on a large community of users. (BL-3)

UNIT-I

Introduction: The seven concerns, design thinking & collaboration, challenges to innovation, understanding users, arriving at design insights, prototyping for user feedback.
First C:The cause: Crossing the first pitfall, trial and error, user feedback for development, new users, new needs to meet.

UNIT-II

Second C: The context: The basic need, ingenious attempts, further insights, the working rig, concepts generation, experiencing the product.
Third C: The comprehension: Understanding constraints, positioning the product, exploring possibilities, .

UNIT-III
Fourth C: The check: The check and the cause, the product, the users and the context, the prototyping, user needs.

UNIT-IV

Fifth C: The conception: Synchronic studies, one product, many problems, concept clusters, from idea to product, prototyping, materials and technologies, collaborative efforts.

UNIT-V

Sixth C: The drafting: Recap, the manufacturing challenge, the user feedback, the iterative Process.
Seventh C: The connection: The seed for innovation, pinnacle for innovation, the Innovation timeline, the innovation, champions, the Innovation templates, the Serial Innovation.

Suggested References:

1. 7C's Link: http://www.idc.iitb.ac.in/~chakku/chakku7Cs.pdf
2. Collaborative Model For Innovation Link: http://www.idc.iitb.ac.in/~chakku/collaborative_model_for_innovation.pdf
3. Pitfalls in the Innovation process Link: http://www.idc.iitb.ac.in/~chakku/Pitfalls_in_the_innovation_process.pdf
4. Innovation By Design – Collaboration is the key to cross the Pitsfalls in the Innovation Process Link: http://www.idc.iitb.ac.in/~chakku/Innovation_by_Design.pdf

18ME H33

ROBOTICS AND CONTROL : THEORY AND PRACTICE

Instruction	3 hours per week
Course Duration	8 weeks
Credits	2

Outcomes: At the end of the course, the students are able to

1. Understand the spatial transformations associated with rigid body motions. (BL-2)
2. Develop skill in performing kinematics and dynamic analysis of robot systems. (BL-3)
3. Analyze different robot manipulators. (BL-4)
4. Understand the concept of robot exoskeleton. (BL-2)
5. Examine the robot assisted percutaneous interventions. (BL-4)

UNIT-I

Introduction: Coordinate frames and homogeneous transformations-I, coordinate frames and homogeneous frames-II, differential transformations, transforming differential changes between coordinate frames.

UNIT-II

Robot kinematics: Manipulator model, direct kinematics, inverse kinematics, manipulator Jacobian.

Robot dynamics: Trajectory planning, dynamics of manipulator, manipulator dynamics multiple degree of freedom ,stability of dynamical system.

UNIT-III

Manipulator control and neural networks: Biped robot basics and flat foot biped model, biped robot flat foot and toe foot model, artificial neural network, neural network based control for robot manipulator.

UNIT-IV

Robotic exoskeletons: Introduction, force control of an index finger exoskeleton, neural control of a hand exoskeleton, neural control of a hand exoskeleton based on human subjects intention, redundancy resolution of human fingers using robotic principles, manipulability analysis of human fingers during coordinated object rotation ,kinematics of flexible link robots.

UNIT-V

Robot assisted percutaneous interventions : Experiments on robot assisted percutaneous interventions, sliding mode control, higher order sliding mode control, smart needles for percutaneous interventions-I , smart needles for percutaneous interventions-II.

Text Books:

1. Mittal & Nagrath, "Robotics and Control", Tata McGraw-Hill Education, 2003.
2. Schilling Robert J, "Fundamentals of Robotics: Analysis and Control", Prentice-Hall, 1990. (TJ211.S334)
3 Niku Saeed B, "An Introduction to Robotics Analysis, Systems, Applications", Prentice-Hall, 2001.

Suggested Reading:

1 Niku Saeed B, "An Introduction to Robotics Analysis, Systems, Applications", Prentice-Hall, 2001.
2 K S Fu,Ralph Gonzalez,C S G Lee, "Robotics: Control Sensing. Vision and Intelligence", Tata McGraw-Hill Education, 1987.

18ME H37

FOUNDATIONS OF COGNITIVE ROBOTICS

Instruction	3 Hours per Week
Course Duration	4 Weeks
Credits	1

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

1. Understand importance of cognitive robot and smart materials. (BL-2)
2. Explain about intelligence, thinking. (BL-2)
3. Develop knowledge of artificial intelligence related to robots . (BL-3)
4. Design intelligent systems. (BL-6)
5. Apply AI based approach to various systems . (BL-3)

UNIT-I

Introduction: Introduction to cognitive robotics and human robot interaction, smart materials I, II, III.

UNIT-II

Intelligence thinking: Thinking, cognition, and intelligence, defining intelligence - embodiment and its implications.

UNIT-III

Artificial intelligence and theory of intelligence: Role of neuroscience and bio robotics, synthetic methodology for intelligence.

UNIT-IV

Intelligent system design and cognition development: Properties of complete agents, agent design principle, developmental robot design, matching brain and body dynamics.

UNIT-V

Control of intelligent systems- ai based approach: Artificial neural networks (ANN), fuzzy logic, genetic algorithms and other nature inspired methods, optimal control using ANN.

Text Book

1. "Neuroscience", edited by Dale Purves, et al., published by Sinauer Associates.
2. Rolf Pfeifer and Josh Bongard, "How the body shapes the way we think-A New View of Intelligence", MIT Press.
3. Jitendra R. Raol, Ramakalyan Ayyagari, "Control Systems: Classical, Modern, and AI-Based Approaches", CRC Press.

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

AICTE MODEL CURRICULUM

MECHANICAL ENGINEERING

B.E: MINOR ENGINEERING (Manufacturing and Robotics)

Sl. No.	Course Code	Title of the Course	Credits
1	18ME M01	Fundamentals of manufacturing processes	3
2	18ME M02	Mechanism And Robot Kinematics	2
3	18ME M03	Rapid Manufacturing	3
4	18ME M04	Manufacturing Systems Technology	3
5	18ME M05	Introduction to robotics	3
6	18ME M06	Fundamentals of electronic device fabrication	1
7	18ME M07	Principles of Metal Forming Technology	2
8	18ME M08	Fundamentals Of Artificial Intelligence	3
9	18ME M09	Theory and Practice of Non Destructive Testing	2
10	18ME M10	Computer Integrated Manufacturing	3
11	18ME M11	Principles of Industrial Engineering.	3
12	18ME M12	Advances in welding and joining Technologies.	2
13	18ME M13	Advanced Machining Processes	2
14	18ME M14	Material Science and Engineering	2
15	18ME H01	Automation in Manufacturing	3
16	18ME H03	Industrial Safety Engineering	3
17	18ME H05	Mathematical Modeling Of Manufacturing Processes	3
18	18ME H12	Manufacturing Strategy	2
19	18ME H33	Robotics And Control: Theory And Practice	2
20	18ME H37	Foundations of Cognitive Robotics	1

18ME M01

FUNDAMENTALS OF MANUFACTURING PROCESSES

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the concepts of manufacturing, need, scope, advantages, limitation, and application. (BL-2)
2. Demonstrate the understanding of various manufacturing processes. (BL-2)
3. Solve simple problems such as riser design and sheet metal calculations. (BL-3)
4. Compare various Manufacturing processes. (BL-4)
5. Choose suitable manufacturing process for a given component. (BL-5)

UNIT- I

Understanding Manufacturing, Fundamental Approaches of Manufacturing, Manufacturing Process Specific Advantages and Limitations, Material and Manufacturing Processes, Classification of Manufacturing Processes, Selection of Manufacturing Processes, Applications of Manufacturing Processes, Effect of Manufacturing Processes on Mechanical Properties, Break Even Analysis in Manufacturing Processes.

UNIT- II

Casting: Introduction and Suitability, Steps of Casting Processes, Casting: Terminology, Types of Pattern Allowances, Sand Moulding, Core and Core Prints, melt treatment, solidification.

Gating System: Elements of gating system, Yield and Riser Design. Cleaning of Castings, Casting Defects and their Preventions, Shell Mould Casting, Investment and Permanent Mould Casting.

UNIT- III

Metal Working Processes: Hot & Cold Working, Rolling, Forging, Extrusion, Wire Drawing.
Sheet Metal Operations: Types of Presses, Shearing, punching, blanking, notching, nibbling drawing, Types of Dies and Die sets

UNIT - IV

Material Removal Processes: Machining, Mechanism of Metal Cutting and Chip Formation, classification, Material Removal Processes, Types of Chips and Power Consumption, Heat Generation, Tool Failure and Tool Life, Tool materials, Cutting fluids, Grinding, internal and external surface grinding, centerless grinding designation and selection of grinding wheel, trueing and balancing, honing, reaming, lapping, polishing etc

Improving surface properties: Introduction, Surface modification processes, surface modification methods namely without change chemistry, changing chemical composition and development of coating and cladding.

UNIT –V

Joining of metals: Joining: approach, need, principle of fusion welding, gas welding, thermit welding, arc welding, common arc welding processes, resistance welding, Brazing, soldering , Weldability and welding defects, solidification of weld, weld discontinuities and their remedy.

Heat treatment processes : Heat treatment of steel and Aluminum alloys, Fe-C diagram, TTT diagram, and CCT diagram, heat treatment processes annealing, normalizing, quenching ,hardening and tempering,

Text Books:

1. P.N.Rao, “Manufacturing Technology”, Vol.1, 3/e, Tata McGraw HillPubl., 2011.
2. Amitabh Ghosh and Mallick, “Manufacturing Science”, 4/e, Assoc.East West Press Pvt. Ltd., 2011.
3. MikellP.Grover, “Fundamentals of Modern Manufacturing Materials, Processes and Systems”, 3/e, Willey A

Suggested Reading:

1. G.K.Lal and S.K.Choudhury," Fundamentals of Manufacturing Processes" Alpha science international ltd., 2005.
2. Schey, "Introduction To Manufacturing Processes", 2/e, McGraw -hill Education. 2015.

18ME M02

MECHANISM AND ROBOT KINEMATICS

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Identify the mechanisms of the robots (BL-1)
2. Analyze the displacement analysis of Robots -1 and Robots-II (BL-4)
3. Solve the displacement and velocity analysis of different robotics (BL-3)
4. Estimate the constrained mechanisms of different robots (BL-5)
5. Assess the Acceleration Analysis and do the force analysis (BL-5)

Unit 1

Introduction to Mechanisms and Robotics, Mobility Analysis-I, Mobility Analysis-II

Unit 2

Displacement Analysis: constrained mechanisms and robots-I, constrained mechanisms and robots-II

Unit 3

Displacement Analysis: constrained mechanisms and robots- III, Velocity Analysis: constrained mechanisms and robots-I

Unit 4

Velocity Analysis: constrained mechanisms and robots-II, constrained mechanisms and robots-III

Unit 5

Velocity Analysis: singularity and path generation, Acceleration Analysis, Force Analysis-I, Force Analysis-II, Coordinate Transformations and kinematics of serial robots

Text books

1. Jadran Lenarcic, Vincenzo Parenti-Castelli, “Advances in robotic kinematics 2018” springer proceedings in advanced robotics
2. Carl D. Crane, III, Joseph Duffy, “Kinematic Analysis of Robot Manipulators” cambridge university press, 2008
3. Xilun Ding, Xianwen Kong, Jian S. Dai, “Advances in Reconfigurable Mechanisms and Robots II” springer , 2015

18ME M03

RAPID MANUFACTURING

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Define Rapid Manufacturing. (BL-1)
2. Understand Design for Modularity and the Reverse Engineering (BL-2)
3. Analyze and select a Rapid manufacturing technology for a given component. (BL- 4)
4. Describe the materials used and Post-processing techniques in Rapid Manufacturing. (BL-2)
5. Illustrate the significance of Rapid Product development. (BL-3)

UNIT- I

Introduction to Rapid Manufacturing (RM), Product Design Process

UNIT- II

Design for Modularity, Reverse Engineering, 3D measurement: laboratory demonstration

UNIT- III

Polymerization and Powder based RM processes, Liquid based, and Sheet stacking RM processes, 3D printing RM processes and laboratory demonstration

UNIT - IV

Beam Deposition RM processes, and materials in RM, Post-processing and costing in RM

UNIT –V

Rapid Product Development (CAD/CAE/CIM), Rapid Product Development (Software demonstration), and case studies on RM.

Text Books:

1. Kamrani, A.K. and Nasr, E.A., 2010. Engineering design and rapid prototyping. Springer Science & Business Media.Groover, M. P., Automation, Production Systems, and Computer-Integrated Manufacturing, Prentice Hall, 2001.
2. Gebhardt, A., 2011. Understanding additive manufacturing.
3. Gibson, I., Rosen, D.W. and Stucker, B., 2014. Additive manufacturing technologies (Vol. 17). New York: Springer.

Suggested Reading:

1. Hopkinson, N., Hague, R. and Dickens, P. eds., 2006. Rapid manufacturing: an industrial revolution for the digital age. John Wiley & Sons.
2. Pham, D. and Dimov, S.S., 2012. Rapid manufacturing: the technologies and applications of rapid prototyping and rapid tooling. Springer Science & Business Media.

18ME M04

MANUFACTURING SYSTEMS TECHNOLOGY

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the concepts of computer aided designing. (BL-2)
2. Apply the principles in process planning. (BL-3)
3. Gain knowledge on computer numerical control systems. (BL-1)
4. Distinguish between quality improvement methods. (BL-4)
5. Understand the dynamic changes that are taking place in business environment. (BL-2)

UNIT- I

Introduction: Manufacturing properties of materials

Integrated product designing: Manufacturing systems approach, historical perspective of design, material handling systems.

Computer aided designing: Introduction, homogeneous transformation, 3-D transformations, parametric and non-parametric equations, hermite cubic spline fit, Bezier curves, introduction to manufacturing processes.

UNIT- II

Principles and process planning of basic machining processes, machine tools design.

Computer aided process planning: Developing a process plan, determining machining conditions and machining time, machining cost evaluation, estimation of tool life, generative CAPP method and knowledge based process planning.

UNIT- III

Introduction to CNC part programming, motion control of NC machines, preparatory functions used in NC programming, G codes, M codes and canned cycles.

UNIT - IV

Quality systems engineering: Introduction to quality engineering, Just-in-time manufacturing, toyta production system, pull systems, kanban systems. quality costs, product design, design of experiments, applications of quality loss function, product selection strategies.

UNIT –V

Cost of quality and statistical quality control: Robust design approaches, taguchi’s method, failure mode and effects analysis, product quality improvement methods, quality tools, quality charts, X-bar chart, R-chart.

Robotic systems planning and designing: Six sigma, theory of probability, determining the defective products using probability, sampling based on permutations and combinations, bionomial distributions, poisson distribution, normal distribution, fundamental of robotics and its application in automated systems, joint configuration systems of robot.

Text Books:

1. R. Thomas Wright, “Manufacturing systems”, Goodheart-Willcox Company, 1990.
2. Katsundo Mitomi , “Manufacturing Systems Engineering: A Unified Approach to Manufacturing Technology, Production Management and Industrial Economics”, second edition, CRC press, 1996.
3. Yoram Koren , “Computer control of manufacturing systems”, McGraw Hill ,2017

Suggested Reading:

1. Rao, Kundra, and Tewari, “Numerical Control and computer aided manufacturing”, Mc Graw Hill ,2017.

18ME M05

INTRODUCTION TO ROBOTICS

(For those who have not taken ROBOTICS as their Open Elective)

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Course Outcomes: At the end of the course, the students will be to

1. Describe the basic components, specifications and applications of the Robots (BL-1)
2. Understand transformations, direct and inverse kinematics of robots (BL-2)
3. Calculate forces in links and joints of a robot and find the singularities, Jacobian and trajectory planning of a robot for various tasks (BL-3)
4. Classify drives, sensors and grippers for various applications (BL-4)
5. Programme a robot for a given task with machine vision and sensors (BL-5)

Unit I

Introduction to robotics- History, growth; Robot applications- Manufacturing industry, defence, rehabilitation, medical etc., Laws of Robotics.

Unit II

Robot mechanisms; Kinematics- coordinate transformations, DH parameters Forward kinematics, Inverse Kinematics

Unit III

Jacobians, Statics, Trajectory Planning, Computed torque control, Actuators (electrical)- DC motors, BLDC servo motors.

Unit IV

Control – PWM, joint motion control, feedback control, Probabilistic robotics, Path planning, BFS; DFS; Dijkstra; A-star; D-star; Voronoi; Potential Field; Hybrid approaches

Unit V

Sensors , sensor integration.Perception, Localisation and mapping, Simultaneous Localization and Mapping. Introduction to Reinforcement Learning

Text Books:

1. Robert J Schilling, Fundamentals of Robotics, Prentice Hall India, 2000
2. John J Craig, Introduction to Robotics, Prentice Hall International, 2005
3. Groover, “Industrial Robotics”, Mcgraw-Hill Publishing Company Ltd. 2003

Suggested Reading:

1. Asada and Slotine, “Robot analysis and Intelligence”, Wiley Interscience, 1986
2. K.S. Fu Gon ZalezRC., lEEc.S.G., “Robotics, Control Sensing Vision and Intelligence”, McGraw Hill, Int. Ed., 1987

18ME M06

FUNDAMENTALS OF ELECTRONIC DEVICE FABRICATION

Instruction	3	Hours per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Recall the basic understanding of semiconductor devices. (BL-1)
2. Understand the current fabrication practices used in the semiconductor industry, along with the challenges and opportunities in device fabrication. (BL- 2)
3. Describe process evaluation, productivity and process yield. (BL- 2)
4. Understand the concept of clean room design and contamination in device fabrication. (BL-2)
5. Describe the integrated circuit fabrication and packaging along with practices and challenges. (BL- 2)

UNIT- I

Introduction and overview of semiconductor device fabrication

UNIT- II

Fabrication operations: Oxidation, doping, and lithography

UNIT- III

Fabrication processes: etching and growth. Process evaluation

UNIT - IV

Process yield, clean room design

UNIT –V

IC logic and packaging.

Text Books:

1. Semiconductor Materials, Devices and Fabrication, Parasuraman Swaminathan, Wiley India, 2017
2. Microchip Fabrication: A Practical Guide to Semiconductor Processing, 6th Edition, Peter Van Zant, McGraw-Hill, 2013
3. Advances in Silicon Carbide Processing and Applications, Stephen E. Saddow, Anant Agarwal, 2004.

Suggested Reading:

1. Fundamentals of Industrial Electronics edited by Bogdan M. Wilamowski, J. David Irwin, 2016
2. Fundamentals of Electronics: Book 1: Electronic Devices and Circuit Applications, By Thomas F. Schubert, Ernest M. Kim, 2015.

18ME M07

PRINCIPLES OF METAL FORMING TECHNOLOGY

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Understand the fundamental concepts of metal forming technology. (BL-2)
2. Apply theory of plasticity to understand the effect of various parameters in metal forming. (BL-3)
3. Use various analysis methods to determine flow stresses in metal forming operations (BL-3)
4. Describe and differentiate various bulk forming processes. (BL-2)
5. Understand the basic concepts of Powder metallurgy and its applications. (BL-2)

UNIT- I

Introduction to metal forming technology: Classification of metal working processes, Behavior of materials, concept of stress and strain, Hydrostatic and deviatoric stresses

UNIT- II

Introduction to theory of plasticity: Flow curve, yield criteria for ductile materials, plastic stress strain relationships, yielding and ductility during instability, effect of strain rate and temperature on flow properties

UNIT- III

Mechanics of metalworking: Analysis methods, determination of flow stresses in metal working, hot and cold working

Forging & Rolling: Introduction, classification and analysis of forging and rolling operations, defects in rolled and forged components,

UNIT - IV

Extrusion: Introduction, classification and Analysis of extrusion processes

Wire Drawing: Analysis of wire, tube and rod drawing processes

UNIT –V

Sheet metal working: Introduction and classification of sheet metal processes

Powder metallurgy forming: Procedure of powder metallurgy and its applications, methods of powder manufacturing

Text Books:

1. Serope Kalpakjian, “Manufacturing Engineering &Technology”, Prentice Hall; 2013
2. George.E. Dieter, “Mechanical Metallurgy”, SI Metric Edition, McGraw-Hill.
3. P.N. Rao, “Manufacturing Technology”, TMH, Pub., 2013.

Suggested Reading:

1. Roy A lindberg, “Processes And Materials Of Manufacture”, PHI, 2017.
2. Avitzur, Metal Forming – Process and Analysis, Tata McGraw – Hill Co., New Delhi, 1977.

18ME M08

FUNDAMENTALS OF ARTIFICIAL INTELLIGENCE

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Differentiate between a rudimentary Problem and an AI problem, it's Characteristics and problem solving Techniques. (BL-2)
2. Compare the various knowledge representation schemes of AI. (BL 4)
3. Analyze various reasoning and planning techniques involved in solving AI problems. (BL 4)
4. Understand the different learning techniques. (BL 2)
5. Apply the AI techniques in the field of mechanical engineering. (BL 3)

UNIT- I

AI and Problem Solving by Search: Introduction to Artificial Intelligence, problem solving as state space search, uniformed search, heuristic search, informed search, constraint satisfaction problems, searching AND/OR graphs, game playing, minimax + alpha-beta.

UNIT- II

Knowledge Representation and Reasoning: Introduction to knowledge representation, propositional logic, first order logic-I, first order logic-II, inference in first order logic-I, inference in first order logic-II, answer extraction, procedural control of reasoning.

UNIT- III

Reasoning under Uncertainty: Reasoning under uncertainty, Bayesian network, decision network.

UNIT - IV

Planning and Decision Making: Introduction to planning, plan space planning, planning graph and graph plan, practical planning and acting, sequential decision problems, making complex decisions.

UNIT –V

Machine Learning: Introduction to machine learning, learning decision trees, linear regression, support vector machines, unsupervised learning, reinforcement learning, learning in neural networks, deep learning: a brief overview.

Text Books:

1. Elaine Rich, Kevin Night, Shivashankar B Nair, "Artificial Intelligence", 3/E, 2008, TMH

2. Russell Norvig, "Artificial Intelligence-Modern Approach", 3/E, 2010, Pearson.

3. Nilakshi Jain "Artificial Intelligence, As per AICTE: Making a System Intelligent", 2019, Wiley India

Suggested Reading:

1. Saroj Kaushik, "Artificial Intelligence", 2012, Cengage Learning India.

2. Deepak Khemani, "A First Course in Artificial Intelligence", 2017, TMH.

18ME M09

THEORY AND PRACTICE OF NON DESTRUCTIVE TESTING

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Understand Non Destructive Testing techniques of Dye penetrant inspection and Magnetic particle inspection (BL-2)
2. Compare eddy current testing with other NDT methods (BL-2)
3. Identify different types of defects using ultra sonic testing (BL-2)
4. Analyze the radiograph to detect the defects by using principles of radiography (BL-4)
5. Interpret latest Techniques of NDT with other methods (BL-3)

UNIT- I

Introduction to NDT, Visual Optical methods, Dye penetrant testing, Basic principle, Types of dye and methods of application, Developer application and Inspection. Magnetic particle testing, Basic theory of magnetism, Magnetization methods, Field indicators, Particle application, Inspection.

UNIT- II

Eddy current testing: Basic principle; Faraday's law, Inductance, Lenz's law, Self and Mutual Inductance, Impedance plane, Inspection system and probes, System calibration.

UNIT- III

Ultrasonic testing: Basics of ultrasonic waves, Pulse and beam shapes, Ultrasonic transducers, Test method, Distance and Area calibration, Weld inspection by UT.

UNIT - IV

Radiography: X-rays and their properties, X-ray generation, X-ray absorption and atomic scattering.

Image formation: Image quality, Digital Radiography, Image interpretation, Radiation Shielding. Comparison and selection of NDT methods, concluding remarks.

UNIT –V

Acoustic emission testing: Basic principle, Sources of acoustic emission, Source parameters, Kaiser-Felicity theory, Equipment and Data display, Source location schemes.

Text Books:

1. Barry Hull & Vernon John, "Non Destructive Testing", 1988.
2. H J Frissell, "Non-Destructive Evaluation and quality control", ASM handbook-International Publication USA, 1989.
3. Dove and Adams, "Experimental Stress analysis and Motion Measurement", Prentice Hall of India, Delhi.

Suggested Reading:

1. "Non-Destructive Examination and Quality Control", ASM International, Vol.17, 9th edition 1989.
2. J. Prasad and C. G. K. Nair, "Non-Destructive Test and Evaluation of Materials", Tata McGraw-Hill Education, 2nd edition 2011.

18ME M10

COMPUTER INTEGRATED MANUFACTURING

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the concepts of computer integrated manufacturing. (BL-2)
2. Apply various computer numerical control techniques. (BL-3)
3. Understand various CIM interface techniques. (BL-2)
4. Understand manufacturing systems in CIM. (BL-2)
5. Apply CIM concepts in additive manufacturing. (BL-3)

UNIT- I

Introduction: Computer integrated manufacturing, computer aided design and computer aided manufacturing.

UNIT- II

Computer Numerical Control: CNC machining, CNC tooling, CNC part programming.

Computer Aided Process Planning: Retrieval CAPP systems, generative CAPP systems.

UNIT- III

CIM Interfaces: Computer aided design versus computer aided manufacturing.

Data and Information in CIM: Automatic identification and data capture

UNIT - IV

Manufacturing Systems: Manufacturing systems and their design, simulation of manufacturing systems.

Computer Aided Maintenance: Computer aided quality control, coordinate measuring machine.

UNIT –V

Computer Integrated Additive Manufacturing: Components of CIM, rapid manufacturing.

Advanced CIM techniques.

Text Books:

1. Chang, T.C. and Wysk, R.A., "Computer-aided manufacturing", Prentice Hall PTR, 1997
2. Xu, X., "Integrating Advanced Computer-Aided Design, Manufacturing, and Numerical Control", Information Science Reference, 2009.
3. Groover, M.P., "Automation, production systems, and computer-integrated manufacturing", Prentice Hall Press, 2007.

Suggested Reading:

1. S.Kant Vajpayee: "Principles of Computer Integrated Manufacturing", Prentice Hall India, 1998
2. Weatherall, A., Computer integrated manufacturing: from fundamentals to implementation. Butterworth-Heinemann, 2013.

18ME M11

PRINCIPLES OF INDUSTRIAL ENGINEERING

Instruction	3 Hours per week
Course Duration	12 weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Understand the various concepts of organizational structure. (BL-2)
2. Analyze the process layout design. (BL-4)
3. Apply the network techniques in the project management. (BL-3)
4. Apply forecasting techniques for predicting demand. (BL-3)
5. Apply the quality control tools to improve performance of production system. (BL-3)

Unit -I

Introduction: Developments, objectives, functions and tools.

Organizational structure: Roles,Types, product strategies, principles, process and product organization.

Unit-II

Plant Location and Plant Layout: Selection of site, Factor Affecting Selection of Site, Purpose and Types of Layout, Process Layout Design, Product Layout Design.

Material Handling: Scope, Capacity Planning &Scheduling, Sequencing, Relative Performance of Priority Sequencing Rules.

Unit-III

Inventory: Fundamentals, Models I, Models II, Wilson Model, Gradual Replenishment Model.

Project Management & Network Modeling: Introduction, Network Modeling, Network Analysis.

Unit-IV

Forecasting: Introduction, Methods I, Methods II, Methods III, Methods IV, Methods V.

Unit -V

Quality Control: Introduction, Fundamentals, Control Charts for variables, Control Charts for Attributes, Productivity & Work Study.

Text Books:

1. Russel, R S, Taylor BW, “Operations Management”, Pearson education, 2003.
2. Jocobs C A ,”Production and operations management”, TMH, 1999.
3. Mitra, A “Fundamentals of Quality control and improvement”, John Willey & Sons, 2008.

Suggested Reading:

1. Besterfield DH, “Total Quality Management”, Pearson education, 1999.
2. S.N. Chary, “Production and Operations Management”, 3rd edition, Tata McGraw Hill, 2006.

18ME M12

ADVANCES IN WELDING AND JOINING TECHNOLOGIES

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Recall the fundamentals of welding and joining processes. (BL-1)
2. Understand the basic concept of laser and electron beam welding for micro-joining and nano-joining in the development of miniature components. (BL-2)
3. Describe the basic knowledge of computational welding mechanics. (BL-1)
4. Understand welding metallurgy and the most recent advances in welding and joining technologies. (BL-2)
5. Develop the fundamental understanding of metal transfer in welding and metal printing. (BL-2)

UNIT- I

Fundamentals of welding and joining

UNIT- II

Laser and electron beam welding, solid state welding processes

UNIT- III

Computational welding mechanics, Micro-joining and nano-joining.

UNIT - IV

Welding metallurgy, Welding and joining of non-metals

UNIT –V

Metal transfer in welding and metal printing.

Text Books:

1. M-K Besharati-Givi and P. Asadi, "Advances in Friction-Stir Welding and Processing", Woodhead Publishing Limited, 2014
2. J. Norrish, "Advanced welding Processes", Woodhead publishing, 2006.
3. L-E Lindgren," Computational welding mechanics", Woodhead Publishing Limited, 2007.

Suggested Reading:

1. J. A. Goldak, "Computational welding mechanics", Springer, 2005.
2. Gibson, David W. Rosen, Brent Stucke, "Additive Manufacturing Technologies", Springer, 2009.

18ME M13

ADVANCED MACHINING PROCESSES

Instruction	3 Hours per week
Course Duration	8 Weeks
Credits	2

Outcomes: At the end of the course, the students are able to

1. Compare the machining and advanced machining process and recognize the need for advanced machining process. (BL-2)
2. Analyze the processes and the role of each process parameter during machining of various advanced materials (BL-4)
3. Illustrate constructional features, performance parameters, process characteristics, applications, advantages and limitations of advanced Machining process. (BL-3)
4. Classify mechanisms of material removal of various advanced machining processes. (BL-4)
5. Identify requirements to achieve maximum material removal rate and best quality of machined surface while machining various industrial engineering materials (BL-2)

UNIT 1:

Introduction to advanced machining processes and their classification, Ultrasonic machining and its modeling and analysis, Abrasive jet machining (AJM) ,Water jet cutting (WJC) and Abrasive water jet machining (AWJM)

UNIT 2:

Magnetic abrasive finishing (MAF) and its modelling, Abrasive flow finishing (AFF) and its modelling, Magnetorheological finishing (MRF), Magnetorheological abrasive flow finishing (MRAFF) and its modelling and analysis

UNIT 3:

Electric discharge machining (EDM): Principle, applications, process parameters, and modelling, Electric Discharge Grinding (EDG), Electric Discharge Diamond Grinding (EDDG), and Wire Electric Discharge Machining (W-EDM)

UNIT 4:

Laser beam machining (LBM), Plasma arc machining (PAM), Electron Beam Machining, Electro chemical machining (ECM): Principle, applications, and process parameters and modelling

UNIT 5:

Electrochemical Grinding (ECG), Electrostream Drilling (ESD), Shaped Tube Electrolytic Machining (STEM), Chemical machining (ChM)

Text Books:

1. V. K. Jain, Advanced Machining Processes, Allied Publishers, 2009
2. Gary F. Benedict, Nontraditional Manufacturing Processes, Taylor & Francis, 1987
3. J. A. McGeough, Advanced Methods of Machining, Springer, 1988

Suggested Reading:

1. Hassan El-Hofy, Advanced Machining Processes: Nontraditional and Hybrid Machining Processes, McGraw-Hill Prof Med/Tech, 2005.
2. V. K. Jain, Introduction to Micromachining, Alpha Science International Limited, 2010.

18ME M14

MATERIALS SCIENCE AND ENGINEERING

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes:At the End of the course, students are able to

1. Understand the Crystallography (BL2)
2. Describes the Phase Diagram and Transformation (BL1)
3. Explain the Fe-C, TTT and CCT diagrams (BL2)
4. Categorize the Mechanical Properties (BL4)
5. Illustrate the different materials and NDT Techniques (BL3)

UNIT-1

Crystallography: Lattice, Crystal structures, Miller indices for planes and directions, Microscopes, microstructures and quantitative metallography, Defects, diffusion.

UNIT-2

Phase Diagrams and Transformations: Phase diagram, equilibrium phase diagram, lever rule, phase transformation

UNIT-3

Fe-C Phase Diagrams: Iron-carbon phase diagram, TTT and CCT curves, and heat treatments.

UNIT-4

Mechanical Behaviour: Introduction to mechanical properties, cold and hot working, strengthening mechanism Fracture, Fatigue and Creep

UNIT-5

Materials: Ceramics and plastic, NDT techniques, alloy designation

Text Books:

1. W. D. Callister, Jr., John Wiley and Sons, Materials Science and Engineering an Introduction, 2006.
2. V. Raghavan, Materials Science and Engineering, Prentice Hall of India Pvt. Ltd. 2015
3. S.H. Avener, Introduction to physical Metallurgy, Tata McGraw Hill, 2009

Suggested Readings:

1. E. Dieter, Mechanical Metallurgy, New Age Publications (P) Ltd. 2008
2. S.P. Nayak, Engineering Metallurgy and Material Science, Charoter Publishing house, 2005

18ME H01

AUTOMATION IN MANUFACTURING

Instruction	3 Hours per week
Course Duration	12 Weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Explain the design and development of automated systems in the manufacturing. (BL-2)
2. Describe working of various blocks of automated system. (BL-2)
3. Illustrate the principle of operation and construction details of sensors/transducers, actuators, drives and mechanisms, hydraulic and pneumatic systems for automation. (BL-3)
4. Summarize the microprocessor technology, programming and CNC technology. (BL-2)
5. Use automation principles for manufacturing industrial applications. (BL-3)

UNIT- I

Introduction: Importance of automation in the manufacturing industry. Use of mechatronics, systems required.

Design of an automated system: Building blocks of an automated system, working principle and examples.

UNIT- II

Fabrication: Fabrication or selection of various components of an automated system, specifications of various elements, use of design data books and catalogues.

Sensors: Study of various sensors required in a typical automated system for manufacturing, construction and principle of operation of sensors.

UNIT- III

Microprocessor Technology: Signal conditioning and data acquisition, use of microprocessor or micro controllers, Configurations, Working.

Drives: Electrical drives, types, selection criteria, construction and operating principle.

UNIT - IV

Mechanisms: Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, and transfer systems.

Hydraulic systems: Hydraulic power pack, pumps, valves, designing of hydraulic circuits.

UNIT –V

Pneumatic systems: Configurations, compressors, valves, distribution and conditioning.

CNC technology: Basic elements, interpolators and programming.

Text Books:

1. Boltan, W., “Mechatronics: electronic control systems in mechanical and electrical engineering”, Longman, Singapore, 1999.
2. Groover, M.P., “Automation, Production Systems, and Computer-Integrated Manufacturing”, Prentice Hall, 2001.
3. Gaonkar, R.S., “Microprocessor architecture, programming, and applications with the 8085”, Penram International Publishing (India), Delhi, 2000.

Suggested Reading:

1. Regtien, P. P. L., Sensors for mechatronics, Elsevier, USA, 2012.
2. Parr, A. A., Hydraulics and pneumatics, Elsevier, 1999.

Handbooks:

1. Smid, P., CNC Programming Handbook, Industrial Press, New York, USA, 2008.
2. Rothbart, H. A., CAM Design Handbook, McGraw-Hill, 2004.
3. Norton, R. L., Cam Design and Manufacturing Handbook, Industrial press Inc, 2002.

18 ME H03

INDUSTRIAL SAFETY ENGINEERING

Instruction	3 Hours per week
Course Duration	12 Weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Identify the causes for industrial accidents and suggest preventive measures for safety (BL-2)
2. Use the concepts of engineering systems safety, dimensions of engineering systems safety.(BL-3)
3. Apply the principles of safety design and carry out analysis. (BL-3)
4. Design for engineering systems safety and control for safety. (BL-3)
5. Integrate safety with other operational goals such as quality and reliability. (BL-5)

UNIT - I

Introduction: key concepts, terminologies, and safety quantification, safety by design, Hazard identification techniques (e.g., HAZOP, FMEA, etc.)

UNIT - II

Fault tree and event tree analysis (qualitative & quantitative)andBow-tie and quantitative risk assessment (QRA)

UNIT - III

Safety function deployment, safety vs reliability, quantification of basic events (repair to failure, repair-failure-repair, and combined processes).

UNIT - IV

Systems safety quantification (e.g., truth tables, structure functions, minimal cut sets), human error analysis and safety.

UNIT – V

Accident investigation and analysis, application of virtual reality, OSHAS 18001 and OSHMS

Text Books:

1. Komamoto and Henley, “Probabilistic Risk Assessment for Engineering and Scientists”, IEEE Press, 1995.
2. Heinrich et al., “Industrial Accident Prevention”, McGraw Hill, 1980.
3. Petersen D, “Techniques for safety management - A systems approach”, ASSE 1998.

Suggested Reading:

1. H. P. Garg, “Maintenance Engineering”, S. Chand and Company, Year 2010.
2. Tyler G. Hicks and T. W. Edwards, Pump Application Engineering, McGraw-Hill, 1971.

18ME H05

MATHEMATICAL MODELING OF MANUFACTURING PROCESSES

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the basic mechanism such as heat and mass transport with associated fluid flow including metallurgical transformation, distortion and residual stress generation in different manufacturing processes. (BL-2)
2. Explain the analysis, numerical simulation at different scale and experimentation for different types of manufacturing processes. (BL-4)
3. Develop the computational models for a manufacturing process relies on mathematical expression of the governing mechanism. (BL-6)
4. Understand the most general to advanced manufacturing processes based on scientific principle. (BL-2)
5. Develop physics based computational model of manufacturing process using standard commercial package. (BL-6)

UNIT – I

Introduction to manufacturing processes, physics of manufacturing processes

UNIT – II

Conventional machining, Non-conventional machining

UNIT - III

Metal forming, welding.

UNIT – IV

Casting and powder metallurgy, Coating and additive manufacturing

UNIT - V

Heat treatment, micro/nano scale manufacturing, Processing of non-metallic materials

Text Books:

1. A Ghosh and A K Mallik, “Manufacturing Science”, East-West Press Pvt Ltd,2nd Ed., 2010.
2. D A Brandt, J C Warner, “Metallurgy Fundamentals”, Goodheart- Willcox, 2009.
3. C Lakshmana Rao and Abhijit P Deshpande, “Modelling of Engineering Materials”, Ane Books Pvt. Ltd., New Delhi, India, 2010.

Suggested Reading:

1. J. Chakrabarty, ‘Theory of plasticity”, 3rd Eds, Elsevier India, 2009.
2. Norman Y Zhou, “Micro joining and Nanoioining”, Woodhead publishing, 2008

18ME H12

MANUFACTURING STRATEGY

Instruction	2	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Understand the process of formulation of manufacturing strategy. (BL-2)
2. Apply various tools and techniques for making a world class organization like Toyota production System. (BL-3)
3. Analyze manufacturing functions to gain competitive advantage. (BL-4)
4. Understand the concepts of Total Quality Management and Manufacturing Excellence. (BL-2)
5. Apply Deming's approach to improve Quality in industry. (BL-3)

UNIT-I

Introduction: Manufacturing output, operations systems, operations strategy, functional strategy within context of a firm functional dominance within corporate strategy, concept of world class manufacturing organization, 6 Ps of manufacturing, skinners' view and Hayes and Wheelwright framework of manufacturing strategy, alternative paradigm of manufacturing strategy

UNIT-II

Generic manufacturing strategies: Developing a manufacturing strategy, understanding markets, the concept of order winners and qualifiers, basic characteristics and specific dimensions of order winners and qualifiers, some specific order winners and qualifiers-I,II &III, Some specific order winners and qualifiers (Non operation related criteria.

UNIT-III

Developing an Operations Strategy: Methodology, Roth and Miller classification, enlightened View of manufacturing.

Manufacturing Strategy Taxonomy: Some evidences from China, Quality Management, Manufacturing Excellence, and Total Quality Management

UNIT-IV

Deming's approach to Quality, business Excellence Awards, Process Choice and 3 Dimensional View, Product Profiling, Critical success factors for World Class Manufacturing, Value Added Engineering, Total Employee Involvement, HR theories for Operations Strategy, Flexible Manufacturing system.

UNIT-V

Concept of focus wrt manufacturing strategy, Toyota production System, World Class Manufacturing and India, Achieving World Class Status.

Text Books:

1. John Miltenburg ,"Manufacturing Strategy: How to Formulate and Implement a Winning Plan", Productivity Press, 2017.
2. Danny Samson ,"Manufacturing & Operations Strategy", Prentice Hall publication, 1993.
3. Terry Hill and Alex Hill, **"**Manufacturing Operations Strategy" Palgrave Macmillan publication, 2009

Suggested Readings:

1. Taiichi Ohno,“Evolution Of Toyota Production System”, Kindle Edition, 2017.
2. Richard J. Schonberger, “World class Manufacturing”, Free Press, 2008

18ME H33

ROBOTICS AND CONTROL: THEORY AND PRACTICE

Instruction	2 hours per week
Course Duration	8 weeks
Credits	2

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

1. Understand the spatial transformations associated with rigidbody motions. (BL-2)
2. Develop skill in performing kinematics and dynamic analysis of robot systems. (BL-3)
3. Analyze different robot manipulators (BL-4)
4. Understand the concept of robot exosleleton (BL-2)
5. Examine the Robot Assisted Percutaneous Interventions (BL-4)

UNIT-I

Introduction: Coordinate Frames and Homogeneous Transformations-I, Coordinate Frames and Homogeneous Frames-II, Differential Transformations, Transforming Differential Changes between Coordinate Frames

UNIT-II

Robot Kinematics: Manipulator model, Direct Kinematics, Inverse Kinematics, Manipulator Jacobian
Robot Dynamics: Trajectory Planning, Dynamics of Manipulator, Manipulator Dynamics Multiple Degree of Freedom ,Stability of Dynamical System

Unit-III

Manipulator Control and Neural networks: Biped Robot Basics and Flat Foot Biped Model, Biped Robot Flat Foot and Toe Foot Model, Artificial Neural Network, Neural Network based control for Robot Manipulator

UNIT-IV

Robotic Exoskeletons: Introduction, Force Control of an Index Finger Exoskeleton, Neural Control of a Hand Exoskeleton, Neural Control of a Hand Exoskeleton Based on Human Subjects Intention.
Redundancy Resolution of Human Fingers using Robotic Principles, Manipulability Analysis of Human Fingers during Coordinated Object Rotation ,Kinematics of Flexible Link Robots.

UNIT-V

Robot Assisted Percutaneous Interventions : Experiments on Robot Assisted Percutaneous Interventions Sliding Mode Control, Higher Order Sliding Mode Control, Smart Needles for Percutaneous Interventions-I Smart Needles for Percutaneous Interventions-II

Textbooks and references

1. Mittal & Nagrath Robotics and Control, ata McGraw-Hill Education, 2003
2. Schilling Robert J, Fundamentals of Robotics: Analysis and Control, Prentice-Hall, 1990. (TJ211.S334)

4 Niku Saeed B, An Introduction to Robotics Analysis, Systems, Applications, Prentice-Hall, 2001

Suggested reading:

1 Niku Saeed B, An Introduction to Robotics Analysis, Systems, Applications, Prentice-Hall, 2001
2 K S Fu,Ralph Gonzalez,C S G Lee, Robotics: Control Sensing. Vision and Intelligence, Tata McGraw-Hill Education, 1987

18ME H37 **FOUNDATION OF COGNITIVE ROBOTICS**

Instruction	1 hours per week
Course Duration	4weeks
Credits	1

Course Outcomes: At the end of the course students are able to

1. Understand importance of cognitive robot and smart materials (BL2)
2. Explain about intelligence, thinking (BL2)
3. Develop knowledge of artificial intelligence related to robots (BL3)
4. Design intelligent systems (BL6)
5. Apply AI based approach to various systems (BL3)

UNIT-I

Introduction: Introduction to Cognitive robotics and Human Robot Interaction, Smart materials I, II, III

UNIT-II

Intelligence Thinking: Thinking, Cognition, and Intelligence, Defining Intelligence - Embodiment and Its Implications.

UNIT-III

Artificial Intelligence and Theory of Intelligence: Role of Neuroscience and Bio robotics, Synthetic Methodology for Intelligence

UNIT-IV

Intelligent System Design and Cognition Development: Properties of Complete Agents, Agent Design Principle, Developmental Robot Design, Matching brain and Body Dynamics

UNIT -V

Control of Intelligent Systems- AI based Approach, Artificial Neural Networks (ANN), Fuzzy Logic, Genetic Algorithms and Other Nature Inspired Methods, Optimal Control using ANN

Textbooks and references

1. Neuroscience, edited by Dale Purves, et al., published by Sinauer Associates.

2. How the body shapes the way we think-A New View of Intelligence, by Rolf Pfeifer and Josh Bongard, MIT Press.

3. Control Systems: Classical, Modern, and AI-Based Approaches, by Jitendra R. Raol, Ramakalyan Ayyagari, CRC Press.

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CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

AICTE MODEL CURRICULUM

MECHANICAL ENGINEERING

B.E: MINOR ENGINEERING (Mechatronics and Nanotechnology)

Sl. No.	Course Code	Title of the Course	Credits
1	18ME M03	Rapid Manufacturing	3
2	18ME M05	Introduction to Robotics	3
3	18ME M06	Fundamentals of electronic device fabrication	1
4	18ME M10	Computer Integrated Manufacturing	3
5	18ME M11	Principles of Industrial Engineering	3
6	18ME M14	Material Science and Engineering	2
7	18ME M24	Selection of Nano materials for Energy Harvesting and Storage Application	1
8	18ME M25	Engineering Metrology	3
9	18ME M26	Structural Analysis of Nano materials	1
10	18ME M27	Nano Technology, Science and Applications	2
11	18ME M28	Soft Nano Technology	2
12	18ME M29	Surface Engineering of Nano Materials	2
13	18ME M30	Automatic Control	2
14	18ME M31	Biomedical Nanotechnology	1
15	18ME M32	Nanotechnology in Agriculture	2
16	18ME H01	Automation in Manufacturing	3
17	18ME H02	Advanced Materials and Processes	3
18	18ME H03	Industrial Safety Engineering	3
19	18ME H18	Mechanical Measurement Systems	2
20	18ME H33	Robotics and Control: Theory and Practice	2
21	18ME H37	Foundations of Cognitive Robotics	1

18ME M03

RAPID MANUFACTURING

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Define Rapid Manufacturing. (BL-1)
2. Understand Design for Modularity and the Reverse Engineering (BL-2)
3. Analyze and select a Rapid manufacturing technology for a given component. (BL- 4)
4. Describe the materials used and Post-processing techniques in Rapid Manufacturing. (BL-2)
5. Illustrate the significance of Rapid Product development. (BL-3)

UNIT- I

Introduction to Rapid Manufacturing (RM), Product Design Process.

UNIT- II

Design for Modularity, Reverse Engineering, 3D measurement: laboratory demonstration.

UNIT- III

Polymerization and Powder based RM processes, Liquid based, and Sheet stacking RM processes, 3D printing RM processes and laboratory demonstration.

UNIT - IV

Beam Deposition RM processes, and materials in RM, Post-processing and costing in RM.

UNIT –V

Rapid Product Development (CAD/CAE/CIM), Rapid Product Development (Software demonstration), and case studies on RM.

Text Books:

1. Kamrani, A.K. and Nasr, E.A., 2010. Engineering design and rapid prototyping. Springer Science & Business Media. Groover, M. P., Automation, Production Systems, and Computer-Integrated Manufacturing, Prentice Hall, 2001.
2. Gebhardt, A., 2011. Understanding additive manufacturing.
3. Gibson, I., Rosen, D.W. and Stucker, B., 2014. Additive manufacturing technologies (Vol. 17). New York: Springer.

Suggested Reading:

1. Hopkinson, N., Hague, R. and Dickens, P. eds., 2006. Rapid manufacturing: an industrial revolution for the digital age. John Wiley & Sons.
2. Pham, D. and Dimov, S.S., 2012. Rapid manufacturing: the technologies and applications of rapid prototyping and rapid tooling. Springer Science & Business Media.

18ME M05

INTRODUCTION TO ROBOTICS

Instruction	Hours per week
Course Duration	12Weeks
Credits	3

Outcomes: At the end of the course, the students will be to

1. Describe the basic components, specifications and applications of the Robots (BL-1)
2. Understand transformations, direct and inverse kinematics of robots (BL-2)
3. Calculate forces in links and joints of a robot and find the singularities, Jacobian and trajectory planning of a robot for various tasks (BL-3)
4. Classify drives, sensors and grippers for various applications (BL-4)
5. Programme a robot for a given task with machine vision and sensors (BL-5)

UNIT-I

Introduction to robotics- History, growth; Robot applications- Manufacturing industry, defence, rehabilitation, medical etc., Laws of Robotics.

UNIT-II

Robot mechanisms; Kinematics- coordinate transformations, DH parameters Forward kinematics, Inverse Kinematics

UNIT-III

Jacobians, Statics, Trajectory Planning, Computed torque control, Actuators (electrical)- DC motors, BLDC servo motors

UNIT-IV

Control – PWM, joint motion control, feedback control, Probabilistic robotics, Path planning, BFS; DFS; Dijkstra; A-star; D-star; Voronoi; Potential Field; Hybrid approaches

UNIT-V

Sensors , sensor integration.Perception, Localisation and mapping, Simultaneous Localization and Mapping. Introduction to Reinforcement Learning

Text Books:

1. Robert J Schilling, Fundamentals of Robotics, Prentice Hall India, 2000
2. John J Craig, Introduction to Robotics, Prentice Hall International, 2005
3. Groover, “Industrial Robotics”, Mcgraw-Hill Publishing Company Ltd. 2003

Suggested Reading:

1. Asada and Slotine, “Robot analysis and Intelligence”, Wiley Interscience, 1986
2. K.S. Fu Gon ZalezRC., lEEc.S.G., “Robotics, Control Sensing Vision and Intelligence”, McGraw Hill, Int. Ed., 1987

18ME M06

FUNDAMENTALS OF ELECTRONIC DEVICE FABRICATION

Instruction	1Hours per week
Course Duration	4Weeks
Credits	1

Outcomes: At the end of the course, the students are able to

1. Recall the basic understanding of semiconductor devices. (BL-1)
2. Understand the current fabrication practices used in the semiconductor industry, along with the challenges and opportunities in device fabrication. (BL- 2)
3. Describe process evaluation, productivity and process yield. (BL- 2)
4. Understand the concept of clean room design and contamination in device fabrication. (BL-2)
5. Describe the integrated circuit fabrication and packaging along with practices and challenges. (BL- 2)

UNIT- I
Introduction and overview of semiconductor device fabrication

UNIT- II
Fabrication operations: Oxidation, doping, and lithography

UNIT- III
Fabrication processes: etching and growth. Process evaluation

UNIT - IV
Process yield, clean room design

UNIT –V
IC logic and packaging.

Text Books:

1. Parasuraman Swaminathan “Semiconductor Materials, Devices and Fabrication”, Wiley India, 2017
2. Peter Van Zant “Microchip Fabrication: A Practical Guide to Semiconductor Processing”, 6th Edition, McGraw-Hill, 2013
3. Stephen E. Saddow “Advances in Silicon Carbide Processing and Applications”, Anant Agarwal, 2004.

Suggested Reading:

1. “Fundamentals of Industrial Electronics” edited by Bogdan M. Wilamowski, J. David Irwin, 2016
2. “Fundamentals of Electronics: Electronic Devices and Circuit Applications”, By Thomas F. Schubert, Ernest M. Kim, 2015

18ME M10

COMPUTER INTEGRATED MANUFACTURING

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the concepts of computer integrated manufacturing. (BL-2)
2. Apply various computer numerical control techniques. (BL-3)
3. Understand various CIM interface techniques. (BL-2)
4. Understand manufacturing systems in CIM. (BL-2)
5. Apply CIM concepts in additive manufacturing. (BL-3)

UNIT- I

Introduction: Computer integrated manufacturing, computer aided design and computer aided manufacturing.

UNIT- II

Computer Numerical Control: CNC machining, CNC tooling, CNC part programming.

Computer Aided Process Planning: Retrieval CAPP systems, generative CAPP systems.

UNIT- III

CIM Interfaces: Computer aided design versus computer aided manufacturing.

Data and Information in CIM: Automatic identification and data capture.

UNIT - IV

Manufacturing Systems: Manufacturing systems and their design, simulation of manufacturing systems.

Computer Aided Maintenance: Computer aided quality control, coordinate measuring machine.

UNIT –V

Computer Integrated Additive Manufacturing: Components of CIM, rapid manufacturing.

Advanced CIM techniques.

Text Books:

1. Chang, T.C. and Wysk, R.A., “Computer-aided manufacturing”, Prentice Hall PTR, 1997
2. Xu, X., “Integrating Advanced Computer-Aided Design, Manufacturing, and Numerical Control”, Information Science Reference, 2009.
3. Groover, M.P., “Automation, production systems, and computer-integrated manufacturing”, Prentice Hall Press, 2007

Suggested Reading:

1. S.Kant Vajpayee: “Principles of Computer Integrated Manufacturing”, Prentice Hall India, 1998
2. Weatherall, A., Computer integrated manufacturing: from fundamentals to implementation. Butterworth-Heinemann, 2013.

18ME M11

PRINCIPLES OF INDUSTRIAL ENGINEERING

Instruction	3 Hours per week
Course Duration	12 weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Understand the various concepts of organizational structure. (BL-2)
2. Analyze the process layout design. (BL-4)
3. Apply the network techniques in the project management. (BL-3)
4. Apply forecasting techniques for predicting demand. (BL-3)
5. Apply the quality control tools to improve performance of production system. (BL-3)

Unit -I

Introduction: Developments, objectives, functions and tools.

Organizational structure: Roles,Types, product strategies, principles, process and product organization.

Unit-II

Plant Location and Plant Layout: Selection of site, Factor Affecting Selection of Site, Purpose and Types of Layout, Process Layout Design, Product Layout Design.

Material Handling: Scope, Capacity Planning &Scheduling, Sequencing, Relative Performance of Priority Sequencing Rules.

Unit-III

Inventory: Fundamentals, Models I, Models II, Wilson Model, Gradual Replenishment Model.

Project Management & Network Modeling: Introduction, Network Modeling, Network Analysis.

Unit-IV

Forecasting: Introduction, Methods I, Methods II, Methods III, Methods IV, Methods V.

Unit -V

Quality Control: Introduction, Fundamentals, Control Charts for variables, Control Charts for Attributes, Productivity & Work Study.

Text Books:

1. Russel, R S, Taylor BW, “Operations Management”, Pearson education, 2003.
2. Jocobs C A ,”Production and operations management”, TMH, 1999.
3. Mitra, A “Fundamentals of Quality control and improvement”, John Willey & Sons, 2008.

Suggested Reading:

1. Besterfield DH, “Total Quality Management”, Pearson education, 1999.
2. S.N. Chary, “Production and Operations Management”, 3rd edition, Tata McGraw Hill, 2006.

18ME M14

MATERIALS SCIENCE AND ENGINEERING

Instruction	2	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes:At the End of the course, students are able to

1. Understand the Crystallography (BL2)
2. Describes the Phase Diagram and Transformation (BL1)
3. Explain the Fe-C, TTT and CCT diagrams (BL2)
4. Categorize the Mechanical Properties (BL4)
5. Illustrate the different materials and NDT Techniques (BL3)

UNIT-1

Crystallography: Lattice, Crystal structures, Miller indices for planes and directions, Microscopes, microstructures and quantitative metallography, Defects, diffusion.

UNIT-2

Phase Diagrams and Transformations: Phase diagram, equilibrium phase diagram, lever rule, phase transformation

UNIT-3

Fe-C Phase Diagrams: Iron-carbon phase diagram, TTT and CCT curves, and heat treatments.

UNIT-4

Mechanical Behaviour: Introduction to mechanical properties, cold and hot working, strengthening mechanism Fracture, Fatigue and Creep

UNIT-5

Materials: Ceramics and plastic, NDT techniques, alloy designation

Text books and references

1. W. D. Callister, Jr., John Wiley and Sons, Materials Science and Engineering an Introduction, 2006.
2. V. Raghavan, Materials Science and Engineering, Prentice Hall of India Pvt. Ltd. 2015
3. S.H. Avener, Introduction to physical Metallurgy, Tata McGraw Hill, 2009

Suggested Readings:

1. E. Dieter, Mechanical Metallurgy, New Age Publications (P) Ltd. 2008
2. S.P. Nayak, Engineering Metallurgy and Material Science, Charoter Publishing house, 2005

18ME M24

SELECTION OF NANO MATERIALS FOR ENERGY HARVESTING AND STORAGE APPLICATION

Instruction	1	Hours per week
Course Duration	4	Weeks
Credits	1	

Course Objectives:

1. To select Nanomaterials for Energy Harvesting and Storage Applications.
2. To understand working of Perovskite Solar Cells
3. To know the importance and need of hydrogen energy
4. To familiarize with concept of nanogenerators
5. To provide the knowlge of energy storage in present scenario

Course Outcomes: After completing this course, the students will be able to

1. Understand the importance of nanomaterials. (BL-2)
2. Apply Perovskite solar cell technology and its synthesis procedures. (BL-3)
3. Compare different methods to produce hydrogen energy. (BL-3)
4. Distinguish conventional energy generation techniques. (BL-4)
5. Solve key challenges for energy storage. (BL-3)

UNIT-I

Introduction, Criteria for choosing the nanomaterials for energy harvesting and storage applications, Brief discussion about all types of energy harvesting and storage systems, Solar energy, Nanomaterials used for solar energy, Types of solar energy, Solar thermal and heat transfer fluids with example.

UNIT-II

Perovskite Solar Cells: introduction, history, properties of perovskite materials, classification of perovskite structure, perovskite solar cell device structure, electron transport layer, hole transport layer, classification of synthesis procedures of the perovskite solar cells:solution process, one step spin coating,two step spin coating, vapor deposition process, advantages and applications.

UNIT-III

Hydrogen energy: Introduction, Nanomaterials used for hydrogen energy generation, Methods to produce hydrogen energy,Hydrogen production from fossil fuels and biomass, thermo-chemical process, electrolysis, solar and biological, Key Challenges for hydrogen energy generation.

UNIT-IV

Nanogenerators: Introduction, Types of Nanogenerators: Piezoelectric, Thermoelectric, Pyro-electric, Electromagnetic, and Triboelectric, Key challenges for choosing nanomaterials for nanogenerators, Other conventional energy generation techniques: Wind energy, Tidal, Thermal, hydro power generation, Nuclear and geothermal energy production.

UNIT-V

Energy storage, Nanomaterials used for energy storage, key challenges for energy storage, Solution of key challenges, Type of energy storages: Electrochemical (Batteries), Supercapacitor, Hydrogen storage, Thermal energy storage.

Text Books:

1. Quan Li, Nanomaterials for sustainable energy, Springer, 2016.
2. Kathy Lu, Materials in energy conversion, harvesting and storage, John Wiley & Sons, Inc., 2014.
3. Alfred Rufer, Energy storage systems and components, CRC Press, 2017.

Suggested Reading:

1. S.A. Sherif, Handbook of Hydrogen energy, CRC Press, 2014.
2. SivaramArepalli, Nanomaterials for energy applications:Generation, Harvesting, Transmission and Storage, William Andrew Publishing, 2014.

18ME M25

ENGINEERING METROLOGY

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the need, accuracy and associated concepts of measurements. (BL-2)
2. Demonstrate the knowledge of linear and angular measurements as per requirements. (BL-2)
3. Calculate surface roughness by using appropriate instruments. (BL-3)
4. Analyze and interpret the types of errors, strain measurement and instrument characteristics. (BL-4)
5. Identify measuring methods and devices for displacement, pressure & temperature. (BL-3)

UNIT- I

Introduction to Engineering Metrology: Instruments in measurement systems, general concepts in metrology, standards of measurements, Limits, fits and tolerances.

UNIT- II

Linear and Angular Measurements: Dial gauge, micrometer, vernier height gauge, surface plate, spirit level, combination set, slip gauges, sine bar. Comparators: Dial indicator, sigma mechanical comparator, pneumatic comparator, mechanical-optical comparator, Optical projector, Toolmaker's microscope. Optical flats, interferometer.

UNIT- III

Surface roughness measurement: Roughness and waviness, specification, Nano-metrology, importance of Nano dimension, atomic force microscopy, quality control, statistics in metrology, coordinate measuring machine.

UNIT - IV

Screw threads and gear tooth metrology: screw thread nomenclature, measurement of effective diameter, two wire method, best wire size, gear terminology, gear tooth thickness, errors in instrumentation,characteristics,strain measurements, gauge factor, strain gauge rosette, piezo elective transducer, load cells.

UNIT –V

Transducers; classification, Linear variable differential transformer, measurement,manometers,measurement of vacuum, pirani gauge, ionization gauge Pressure, thermocouples, resistance temperature detectors, thermistors.

Text Books:

1. Bewoor, A.K. and Kulkarni, V.A., 2009. Metrology and measurement. McGraw-Hill Education.
2. Venkateshan, S.P., 2015. Mechanical measurements. John Wiley & Sons.
3. Fridman, A.E., 2011. The quality of measurements: a metrological reference. Springer Science & Business Media.

Suggested Reading:

1. Doeblin, "Measurement Systems Application and Design", TMH, 5/e., 2004.
2. B.C. Nakra & K.K. Chaudhary , "Instrumentation Measurement and Analysis", 3/e., Mc Grawhill, 2014

18ME M26

STRUCTURAL ANALYSIS OF NANO MATERIALS

Instruction	1	Hours per week
Course Duration	04	Weeks
Credits	1	

OUTCOMES: By the end of the course, students should able to

1. Recall the concepts of atomic structure and structure of materials. (BL 1)
2. Describe the phase diagrams (BL 1)
3. Understand the basic properties of metals, ceramics and polymers needed for nanomaterials (BL 2)
4. Analyze the characterization techniques by X-Ray based procedures (BL 4)
5. Apply the characterization procedures to nanomaterials (BL 3)

UNIT-I

Introduction: Fundamental concepts of atomic structure and interatomic bonding, Structure of materials, Defects in structure of materials

UNIT-II

Phase diagram: Determination of phases, Transformation of phases.

UNIT-III

Basic properties: Metals, Ceramics

Basic properties: Polymers, Selection of nanomaterials, Structure property relationship of advanced nanomaterials.

UNIT-IV

Characterization by X-Ray based procedures: Introduction to X-Ray Spectroscopy, Diffraction direction and methods of XRD, Determination of crystal structures by XRD Pattern, Precise parameter measurements, Orientation of single crystals.

UNIT V

Characterization by microscopy based techniques: Qualitative analysis by diffraction, Quantitative analysis by diffraction, Microscopic structural analysis of nanomaterials-I, Microscopic structural analysis of nanomaterials-II, Other characterization used.

Text Books:

1. Cullity, B.D., Stock, S.R. and Stock, S, “Elements of X-Ray diffraction”, Prentice Hall, 2001
2. Phillips, R., “Crystal defects and microstructures” ,Cambridge university press, 2001
3. Wang, Z.L., “Characterization of nanophase materials”, Wiley-VCH, 2001

Suggested Reading:

1. Allen, S.M., Thomas, E.L., “The structure of materials”, John Wiley & Sons, 1999
2. Guozhong Cao, “Nanostructures and Nano Materials, Synthesis properties and applications”, Imperial College Press, 2004

18ME M27

NANOTECHNOLOGY, SCIENCE AND APPLICATIONS

Instruction	2	Hours per week
Course Duration	08	Weeks
Credits	2	

OUTCOME: At the end of the course, students are able to

1. Understand the synthesis procedure of nanomaterials. (BL 2)
2. Remember the experimental investigation of inverse Hall Petch relationship and optical effects (BL 1)
3. Understand nanoscale for superplasticity (BL 2)
4. Describe magnetic effects and ferroelectrics (BL 2)
5. Analyze the material behavior and synthesis of nanomaterials (BL 4)

UNIT-I

Introduction: History of nanomaterials Top down approach, bottom up approach to synthesize nanomaterials

Thermodynamic considerations: Impact of the nanoscale on the thermodynamic considerations, phase diagrams and stable phases, calorimetry

UNIT-II

Inverse Hall Petch relationship: Zirconia ZrO_2, Experimentally investigating the Hall-Petch relationship, Impact of the nanoscale on the Hall-Petch relationship

Optical effects: Impact of the nanoscale on optical properties and its measurements, Experimental approach to study impact of the nanoscale on optical properties

UNIT-III

Introduction to nanoscale: Impact of the nanoscale on mechanical properties,

Superplasticity and the nanoscale: Background, Experimental aspects

UNIT-IV

Magnetic effects: Nanocomposites, Effect of nanoscale on magnetic properties, Potential use of bio-materials, Effect of nanostructure on damping properties.

Ferroelectrics: Ferroelectric effects at nanoscale

UNIT V

Severe Plastic Deformation: Severe Plastic Deformation and the nanoscale, Experimental utility

Synthesis: An approach to prepare bulk nanostructures, Nanosized ferroelectrics

Special materials: Carbon, Carbon Nanotubes, Graphene, a 2D nanomaterial

Text Books:

1. Semiconductor Materials, Devices and Fabrication, Parasuraman Swaminathan, Wiley India, 2017.
2. Microchip Fabrication: A Practical Guide to Semiconductor Processing, 6th Edition, Peter Van Zant, McGraw-Hill, 2013
3. Dieter Vollath, “Nanomaterials: An introduction to Synthesis, properties and applications”, Wiley, 2013

Suggested Reading:

1. Guozhong Cao, “Nanostructures and Nano Materials, Synthesis properties and applications”, Imperial College Press, 2004
2. Carl C Koch, “Nano materials Synthesis , Properties and applications”, Jaico Publishing House, 2008

18ME M28

SOFT NANOTECHNOLOGY

Instruction	2	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Explain scientific and technical developments in nanotechnology (BL-2)
2. Understand methods of nanomaterial synthesis and nanofabrication as well as advanced characterization techniques (BL-2)
3. Differentiate nanomaterials based on their thermal, mechanical, optical and magnetic properties (BL-2)
4. Apply tool of nanotechnology (BL-3)
5. Categorize nanomaterials using atomic force microscopy. (BL-4)

UNIT- I

Introduction to patterning of thin films, application of nano patterned films and surfaces, basic concepts of wetting: cassie and wenzel regimes, basic concepts of surface tension.

UNIT- II

Different nano fabrication regimes including self assembly micelle formation.

UNIT- III

Introduction to photo lithography, discussion on photo lithography: photo resists, spin coating, exposuredevelopment.

UNIT - IV

Nano imprint lithography, soft lithography: introduction, soft lithography techniques.

UNIT –V

Basic concepts of atomic force microscopy, different imaging modes of atomic force microscopy.

Text Books:

1. B. S. Murty, Textbook of Nanoscience and Nanotechnology, Springer-Verlag Berlin Heidelberg, 2013.
2. K.T. Ramesh, Nanomaterials: Mechanics and Mechanisms, Springer US, 2009.
3. Xiaodong Chen, Soft Matter Nanotechnology, Wiley- VCH Verlag GmbH & Co, 2015.

Suggested Reading:

1. Ye Zhang, Soft Nanomaterials, World scientific series in nanoscience and nanotechnology Vol 19, 2019.
2. Sulabha K. Kulkarni, Nanotechnology : Principles and Practices, Cham : Springer, 2014.

18ME M29

SURFACE ENGINEERING OF NANOMATERIALS

Instruction	2	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Understand the effect of tribology on surface of nanomaterials. (BL- 2)
2. Apply surface engineering principles and methods to modify and improve the properties of surfaces for structural and functional applications. (BL- 3)
3. Identify suitable processing methods to create surface engineering solutions. (BL- 1)
4. Apply various thin film techniques for surface modification. (BL- 3)
5. Understand the concept of microencapsulation. (BL- 2)

UNIT- I

Tribology: Tribology and its classification, friction tribology, wear and corrosion, lubrication, effect of tribology on surface of nanomaterials.

Surface Engineering: Conventional surface engineering, Types of surface modifications, physical modifications, Chemical modifications, Applications of surface engineering towards nanomaterials.

UNIT- II

Deposition and Surface Modification Methods: Physical vapor deposition, chemical vapor deposition, advanced surface modification practices, advantages of deposition for surface modification.

UNIT- III

Coatings: Synthesis, processing and characterization of nano-structured coatings, functional coatings, advanced coating practices, characterization of nano-coatings, applications of nano-coatings, need of advanced methods for surface and coating testings, size dependency in nanostructures of nano coatings, size effect in electrochemical properties of nanostructured coatings, size effect in mechanical properties of nanostructured coatings, size effect in physical and other properties of nanostructured coatings.

UNIT - IV

Thin films: Thin films for surface engineering of nanomaterials, sputtering techniques, evaporation processes, thin film deposition through gas phase techniques, liquid phase techniques.

Microencapsulation: Processes, kinetics of release, plating of nanocomposite coatings, advantages of microencapsulation over other conventional methods.

UNIT –V

Modified Nanomaterials: Current trends in surface modification of nanomaterials, modified Nanomaterials: In-use for consumer products, main problems in synthesis of modified nanomaterials.

Text Books:

1. Krishna Seshan, “Handbook of thin film deposition processes and techniques” William Andrew Publishing Norwich, New York, U.S.A, 2002.
2. Jamal Takadoum, John Wiley & Sons, “Nanomaterials and Surface Engineering”, Inc., USA, 2013
3. Mahmood Aliofkhazrae “Nanocoatings: Size Effect in Nanostructured Films”, Springer-Verlag, USA, 2011.

Suggested Reading:

1. Bharat Bhusan, “Introduction to Tribology” by John Wiley & Sons, USA, 2013.
2. S.K.Basu, S.N.Sengupta&B.B.Ahuja ,”Fundamentals of Tribology”, Prentice –Hall of India Pvt Ltd , New Delhi, 2005.

18ME M30

AUTOMATIC CONTROL

Instruction	2	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Understand control system, modeling and transfer functions of different systems. (BL-2)
2Apply the concept of block diagram and signal flow graphs to different systems. (BL-3)
3. Differentiate between time domain and frequency domain techniques. (BL-2)
4. Examine the stability of a system using different approaches. (BL-3)
5. Analyze the system in state space and to find out the controllability and observability. (BL-4)

UNIT- I

Definition and Types, Performance Specifications, Design Process, Laplace Transform and Transfer Function, Translational Mechanical System, Rotational Mechanical System, Electrical System, Linearization of Nonlinear Systems, Numerical Problems.

UNIT-II

Poles and Zeros, First Order System, Second Order System, Underdamped Second Order System-I, Underdamped Second Order System-II, Definition of Stability, Routh-Hurwitz Criterion, Routh-Hurwitz Criterion- Special Cases, Steady State Errors, Static Error Constants.

UNIT-III

Define Root Locus, Sketching of Root Locus-I, Sketching of Root Locus-II, Sketching of Root Locus -III, Numerical Examples and Second Order Approximation, PI Controller Design, PD Controller Design, PID Controller Design, Lag Compensation, Lead and Lag-Lead Compensation.

UNIT-IV

State Space Representation, Converting a Transfer Function to State Space, Converting From State Space to Transfer Function, Controller Design, Controller Design and Controllability, Transfer Function, Poles, Zeros, Response.

UNIT-V

Steady State Error, Root Locus, Design via Root Locus, Compensation - I, Design via Root Locus, Compensation - II, State Space Method. Application of Matlab in automatic control systems.

Text Books:

1. Nise, N.S., Control Systems Engineering, 5th Ed., Willey, 2008.
2. Ogata, K., “Modern Control Engineering”, 5th Ed., Prentice Hall of India, 2013.
3. Kuo, B.C., “Automatic Control System”, 5th Ed., Prentice Hall of India, 1995.

Suggested Reading:

1. R.C. Dorf, “Modern Control systems”, 12th edition Addison Wesley, 2011.
2. Raven, F.H., “Automatic Control Theory”, 5th Ed., McGraw Hill, 1995.

18ME M31

BIOMEDICAL NANOTECHNOLOGY

Instruction	1	Hours per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Describe about variousSynthesis and characterization techniques of Nanomaterials. (BL- 1)
2. Explain the importance of Cell Behavior toward Nanostructured Surfaces and Bio – Applications. (BL- 2)
3. Understand the Nanomaterials and Nanotechnology for Cancer Diagnostics, Tissue Engineering and organ printing. (BL-2)
4. Diagnose the role of Nano structured materials and study various Nano pharmacology & Drug Targeting. (BL-3)
5. Understand the biomedical applications of nanomaterials. (BL-2)

UNIT- I

Introduction to nano, Nano-biomimicry, Synthesis of nanomaterials by physical and chemical methods, Synthesis of nanomaterials by biological methods, Characterisation of nanomaterials.

UNIT- II

DNA nanotechnology, Protein &glyco nanotechnology, Lipid nanotechnology, Bio-nanomachines, Carbon nanotube and its bio-applications.

UNIT- III

Nanomaterials for cancer diagnosis, Nanomaterials for cancer therapy, Nanotechnology in tissue engineering, Nano artificial cells, Nanotechnology in organ printing.

UNIT - IV

Nanotechnology in point-of-care diagnostics, Nano pharmacology & drug targeting, Cellular uptake mechanisms of Nanomaterials.

UNIT –V

In vitro methods to study antibacterial and anticancer properties of nanomaterials, Nanotoxicology.

Text Books:

1. Malsch, N.H., “Biomedical Nanotechnology”, CRC Press. (2005).
2. Mirkin, C.A. and Niemeyer, C.M., “Nanobiotechnology II: More Concepts and Applications”, Wiley-VCH. (2007).
3. Kumar, C. S. S. R., Hormes, J. and Leuschner C., “Nanofabrication Towards Biomedical Applications: Techniques, Tools, Applications, and Impact”, WILEY -VCH Verlag GmbH & Co. (2005).

Suggested Reading:

1. Lamprecht, A., “Nanotherapeutics: Drug Delivery Concepts in Nanoscience”, Pan Stanford Publishing Pte. Ltd. (2009).
2. Jain, K.K., “The Handbook of Nanomedicine”, Humana press. (2008).

18ME M32

NANOTECHNOLOGY IN AGRICULTURE

Instruction	2	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Identify role of chemicals in modern agriculture (BL- 1)
2. Explain about nanotechnology (BL- 2)
3. Illustrate the application of nanotechnology in modern day agriculture (BL- 3)
4. Discuss various Nanotechnologies for water quality and availability (BL- 2)
5. Describe Green nanotechnology, the role of good governance and policies (BL-2)

UNIT- I

History of agriculture and the role of chemicals in modern agriculture

UNIT- II

Overview of nanotechnology

UNIT- III

Application of nanotechnology in modern day agriculture practices I. Application of nanotechnology in modern day agriculture practices II. Application of nanotechnologies in animal production

UNIT - IV

Nanotechnology and shelf life of agricultural and food products. Nanotechnologies for water quality and availability

UNIT –V

Green nanotechnology and the role of good governance and policies for effective nanotechnology development

Text Books:

1. Introduction to Nano Technology by Charles. P. Poole Jr& Frank J. Owens.Wiley India Pvt.Ltd.
2. Jennifer Kuzma and Peter Ver Hage, “Nanotechnology in agriculture and food production”, Woodrow Wilson International Center, 2006.
3. Lynn. J, Frewer, WillehmNorde. R. H, Fischer and Kampers. W. H “Nanotechnology in the Agri- food sector”, Wiley-VCH Verlag, 2011.

Suggested Reading:

1. Nanotechnology in Agriculture and Food Science (Applications of Nanotechnology) by Monique A. V. Axelos, Marcel Van de Voorde, 2017.
2. Applied Nanotechnology in Agriculture. S.Choudary, 2011.

18ME H01

AUTOMATION IN MANUFACTURING

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Explain the design and development of automated systems in the manufacturing. (BL-2)
2. Describe working of various blocks of automated system. (BL-2)
3. Illustrate the principle of operation and construction details of sensors/transducers, actuators, drives and mechanisms, hydraulic and pneumatic systems for automation. (BL-3)
4. Summarize the microprocessor technology, programming and CNC technology. (BL-2)
5. Use automation principles for manufacturing industrial applications. (BL-3)

UNIT- I

Introduction: Importance of automation in the manufacturing industry. Use of mechatronics, systems required.

Design of an automated system: Building blocks of an automated system, working principle and examples.

UNIT- II

Fabrication: Fabrication or selection of various components of an automated system, specifications of various elements, use of design data books and catalogues.

Sensors: Study of various sensors required in a typical automated system for manufacturing, construction and principle of operation of sensors.

UNIT- III

Microprocessor Technology: Signal conditioning and data acquisition, use of microprocessor or micro controllers, Configurations, Working.

Drives: Electrical drives, types, selection criteria, construction and operating principle.

UNIT - IV

Mechanisms: Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, and transfer systems.

Hydraulic systems: Hydraulic power pack, pumps, valves, designing of hydraulic circuits.

UNIT –V

Pneumatic systems: Configurations, compressors, valves, distribution and conditioning.

CNC technology: Basic elements, interpolators and programming.

Text Books:

1. Boltan, W., “Mechatronics: electronic control systems in mechanical and electrical engineering”, Longman, Singapore, 1999.
2. Groover, M.P., “Automation, Production Systems, and Computer-Integrated Manufacturing”, Prentice Hall, 2001.
3. Gaonkar, R.S., “Microprocessor architecture, programming, and applications with the 8085”, Penram International Publishing (India), Delhi, 2000.

Suggested Reading:

1. Regtien, P. P. L., Sensors for mechatronics, Elsevier, USA, 2012.
2. Parr, A. A., Hydraulics and pneumatics, Elsevier, 1999.

Handbooks:

1. Smid, P., CNC Programming Handbook, Industrial Press, New York, USA, 2008.
2. Rothbart, H. A., CAM Design Handbook, McGraw-Hill, 2004.
3. Norton, R. L., Cam Design and Manufacturing Handbook, Industrial press Inc, 2002.

18ME H02

ADVANCED MATERIALS AND PROCESSES

Instruction	3 Hours per week
Course Duration	12 Weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Understand the classification of structural and functional materials. (BL-2)
2. Learn the processing and applications of bulk metallic glasses. (BL-1)
3. Identify the use of various materials. (BL-2)
4. Design materials based on applications. (BL-3)
5. Understand the importance of Shape memory alloys and Super alloys. (BL-2)

UNIT – I

Introduction: Metastable and functional alloys

Bulk Metallic glasses: Fundamental concepts, mechanical and functional properties

UNIT - II

Shape memory alloys, Pseduelasticity, shape memory alloys applications and case studies.

UNIT - III

Introduction to high temperature materials

Super alloys: Alloy design, Microstructure and Properties

UNIT - IV

Nano-materials

UNIT - V

Soft and hard magnetic materials, Non-equilibrium Processes, Single Crystal Growth, Rapid Solidification, Inert Gas Condensation and Advanced Functional Alloys

Text Books:

1. Leonardo Lecce and Antonio Concilio, “Shape Memory Alloy Engineering: For Aerospace, Structural and Biomedical Applications”, Butterworth-Heinemann, 2014.
2. Helmi A. Youssef, “Machining of Stainless Steels and Super Alloys: Traditional and Nontraditional Techniques”, Wiley, 2016.
3. Guozhong Cao and Ying , “Nanostructures and Nanomaterials: Synthesis, Properties, and Applications”, World Scientific Publishing Company, 2010.

Suggested Reading:

1. Mark J. Mezger, Kay J. Tindle, "Energetic Materials: Advanced Processing Technologies for Next Generation Materials", CRC Press, 2017.
2. C. Suryanarayana and A. Inoue, "Bulk Metallic Glasses", CRC Press; 2 edition, 2017.

18 ME H03

INDUSTRIAL SAFETY ENGINEERING

Instruction	3 Hours per week
Course Duration	12 Weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Identify the causes for industrial accidents and suggest preventive measures for safety (BL-2)
2. Use the concepts of engineering systems safety, dimensions of engineering systems safety.(BL-3)
3. Apply the principles of safety design and carry out analysis. (BL-3)
4. Design for engineering systems safety and control for safety. (BL-3)
5. Integrate safety with other operational goals such as quality and reliability. (BL-5)

UNIT - I

Introduction: key concepts, terminologies, and safety quantification, safety by design, Hazard identification techniques (e.g., HAZOP, FMEA, etc.)

UNIT - II

Fault tree and event tree analysis (qualitative & quantitative)andBow-tie and quantitative risk assessment (QRA)

UNIT - III

Safety function deployment, safety vs reliability, quantification of basic events (repair to failure, repair-failure-repair, and combined processes).

UNIT - IV

Systems safety quantification (e.g., truth tables, structure functions, minimal cut sets), human error analysis and safety.

UNIT – V

Accident investigation and analysis, application of virtual reality, OSHAS 18001 and OSHMS

Text Books:

1. Komamoto and Henley, “Probabilistic Risk Assessment for Engineering and Scientists”, IEEE Press, 1995.
2. Heinrich et al., “Industrial Accident Prevention”, McGraw Hill, 1980.
3. Petersen D, “Techniques for safety management - A systems approach”, ASSE 1998.

Suggested Reading:

1. H. P. Garg, “Maintenance Engineering”, S. Chand and Company, Year 2010.
2. Tyler G. Hicks and T. W. Edwards, Pump Application Engineering, McGraw-Hill, 1971.

18ME H18

MECHANICAL MEASUREMENT SYSTEMS

Instruction	2	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Understand the various characteristics of instrument. (BL-2)
2. Analyze the generalized model of a measuring system. (BL-4)
3. Understand the frequency response of a measuring system. (BL-2)
4. Evaluate measuring methods and devices for displacement, pressure and temperature measurement. (BL-5)
5. Understand the various thermophysical properties of measurement. (BL-2)

UNIT-I

Basic concepts of measurement, functional elements of instruments, classification of measuring instruments, methods of correction for interfering and modifying inputs.

UNIT-II

Static characteristics of measuring instruments, loading effect and impedance matching, statistical analysis, Chi-square test, least square method, uncertainty analysis, problem solving, generalized model of a measuring system, zero and first order system.

UNIT-III

First order system- ramp response, impulse response, frequency response. Second order system- step response,ramp response, impulse and frequency response. Higher order systems, compensation, transducers, flow measurement, temperature measurement.

UNIT-IV

Strain gauges, piezoelectric transducers pressure measurement, force and torque measurement, displacement and acceleration measurement.

UNIT-V

Sound measurement, thermophysical properties measurement, flow visualization, air pollution sampling and measurement, problem solving.

Text Books:

1. Venkateshan, S.P., “Mechanical measurements”, John Wiley & Sons, 2015.
2. Fridman, A.E., “The quality of measurements: a metrological reference”, Springer Science & Business Media, 2011.
3. Bewoor, A.K. and Kulkarni, V.A., “Metrology and measurement”, McGraw-Hill Education, 2009.

Suggested Reading:

1. R.K. Rajput, “Mechanical Measurements and Instrumentation”, S.K. Kataria & Sons, 2013.
2. Dr. D.S. Kumar, “Mechanical Measurements & Control”, Metropolitan Book Co. (P) Ltd, 2015.

18ME H33 ROBOTICS AND CONTROL: THEORY AND PRACTICE

Instruction	2 hours per week
Course Duration	8 weeks
Credits	2

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

1. Understand the spatial transformations associated with rigid body motions. (BL2)
2. Develop skill in performing kinematics and dynamic analysis of robot systems. (BL3)
3. Analyze different robot manipulators (BL4)
4. Understand the concept of robot exosleleton (BL2)
5. Examine the Robot Assisted Percutaneous Interventions (BL4)

Unit 1
Introduction: Coordinate Frames and Homogeneous Transformations-I, Coordinate Frames and Homogeneous Frames-II, Differential Transformations, Transforming Differential Changes between Coordinate Frames

Unit 2
Robot Kinematics: Manipulator model, Direct Kinematics, Inverse Kinematics, Manipulator Jacobian
Robot Dynamics: Trajectory Planning, Dynamics of Manipulator, Manipulator Dynamics Multiple Degree of Freedom ,Stability of Dynamical System

Unit 3
Manipulator Control and Neural networks: Biped Robot Basics and Flat Foot Biped Model, Biped Robot Flat Foot and Toe Foot Model, Artificial Neural Network, Neural Network based control for Robot Manipulator

Unit 4
Robotic Exoskeletons: Introduction, Force Control of an Index Finger Exoskeleton, Neural Control of a Hand Exoskeleton, Neural Control of a Hand Exoskeleton Based on Human Subjects Intention. Redundancy Resolution of Human Fingers using Robotic Principles, Manipulability Analysis of Human Fingers during Coordinated Object Rotation ,Kinematics of Flexible Link Robots

Unit 5
Robot Assisted Percutaneous Interventions : Experiments on Robot Assisted Percutaneous Interventions Sliding Mode Control, Higher Order Sliding Mode Control, Smart Needles for Percutaneous Interventions-I Smart Needles for Percutaneous Interventions-II

Textbooks and references

1. Mittal & Nagrath Robotics and Control, ata McGraw-Hill Education, 2003
2. Schilling Robert J, Fundamentals of Robotics: Analysis and Control, Prentice-Hall, 1990. (TJ211.S334)
3. Niku Saeed B, An Introduction to Robotics Analysis, Systems, Applications, Prentice-Hall, 2001

Suggested reading:

1. Niku Saeed B, An Introduction to Robotics Analysis, Systems, Applications, Prentice-Hall, 2001
2. K S Fu,Ralph Gonzalez,C S G Lee, Robotics: Control Sensing. Vision and Intelligence, Tata McGraw-Hill Education, 1987

18ME H37 **FOUNDATION OF COGNITIVE ROBOTICS**

Instruction	1 hours per week
Course Duration	4weeks
Credits	1

Course Outcomes: At the end of the course students are able to

1. Understand importance of cognitive robot and smart materials (BL2)
2. Explain about intelligence, thinking (BL2)
3. Develop knowledge of artificial intelligence related to robots (BL3)
4. Design intelligent systems (BL6)
5. Apply AI based approach to various systems (BL3)

UNIT-I

Introduction: Introduction to Cognitive robotics and Human Robot Interaction, Smart materials I, II, III

UNIT-II

Intelligence Thinking: Thinking, Cognition, and Intelligence, Defining Intelligence - Embodiment and Its Implications.

UNIT-III

Artificial Intelligence and Theory of Intelligence: Role of Neuroscience and Bio robotics, Synthetic Methodology for Intelligence

UNIT-IV

Intelligent System Design and Cognition Development: Properties of Complete Agents, Agent Design Principle, Developmental Robot Design, Matching brain and Body Dynamics

UNIT-V

Control of Intelligent Systems- AI based Approach, Artificial Neural Networks (ANN), Fuzzy Logic, Genetic Algorithms and Other Nature Inspired Methods, Optimal Control using ANN

Textbooks:

1. Neuroscience, edited by Dale Purves, et al., published by Sinauer Associates.

2. How the body shapes the way we think-A New View of Intelligence, by Rolf Pfeifer and Josh Bongard, MIT Press.

3. Control Systems: Classical, Modern, and AI-Based Approaches, by Jitendra R. Raol, Ramakalyan Ayyagari, CRC Press.

Revision of Vision, Mission, PEOs and PSOs

Vision of the institute

To be a Centre of Excellence in Technical Education and Research

Mission of the institute

To Address the Emerging Needs through Quality Technical Education and Advanced Research

Vision of the Department

Existing

To be a Pace Setterin the field of Mechanical Engineering by providingconducive environment for understanding and applying its principles to cater the needs of Society.

Proposed

To be the destination for aspiring young minds to become globally competitive,enlightened, innovative, immediate contributors to the industry and successful in higher studies in the field of mechanical engineering.

Mission of the Department

Existing

To impart quality & innovative technical education to the students of MechanicalEngineering for their professional achievements in Consultancy, R&D and tobecome successful Entrepreneur enabling them to serve the society in generaland the industry in particular.

Proposed

1.To impart quality and innovative education in mechanical engineering withbasic and specialised training, internships to meet the current and emerging needs of the industry.

2.To prepare the students for successful professional career by inculcating ethical, entrepreneurial and leadership qualities.

3. To foster Researchand Development environment by disseminating knowledge and technology by involving the students in publications, sponsored projects and consultancy.

PEOS B.E. (Mechanical Engineering)

Existing

1. The graduating students from mechanical engineering will have a widespread knowledge in basic sciences and fundamentals of mechanical engineering to be able to solve application level problems pertaining to society.
2. The graduating students from mechanical engineering will have knowledge in core areas in mechanical engineering like Design Engineering, Industrial Engineering, Manufacturing Engineering, and Thermal Engineering.
3. The programme prepares the graduates to acquire competency for research in core areas and also in interdisciplinary research activities like environment & sustainability.
4. The graduating students from Mechanical Engineering will inculcate professional & ethical values, team work, leadership skills, moral responsibility, industrial relations and communication skills.
5. The graduating students from mechanical engineering will be enriched in project, finance management and technical knowhow skills.

Proposed

After Four years of graduation graduates will have

1. Ample technical knowledge and skills for a successful career in Mechanical Engineering and product development, design, development and implementation of engineering systems, services and processes
2. Capability to develop competitive technologies and find solutions to industry, societal challengesand engineering problems with ethical and professional standards
3. Ability to be entrepreneurial, innovative in the context of global scenarios of technological challenges and environmental issues.

4. To pursue life-long learning and to adapt to the changing industry requirements.

5. To be a team player, lead and engage diverse teams through effective communication, inter-personal and project management skills.

PSOs of B.E. (Mechanical Engineering)

Existing

1. The graduates will be able to apply specific program principles to the specification, fabrication, test, operation, or documentation of basic mechanical systems or processes
2. The student will be able to apply his knowledge in Analysis, design, development, implementation, or oversight of more advanced mechanical systems or processes and able to do research with this basic knowledge in engineering.
3. The student will be able to inculcate leadership qualities and grow as a successful entrepreneur and gain understanding of global and contemporary issues related to engineering

Proposed

The graduates will be able to

1. Apply their learning to design and develop basic mechanical systems and processes.
2. Select manufacturing processes and their appropriate parameters for the production of typical engineering components.
3. Apply the concepts of mechanical engineering in power generation, aerospace, environmental, bio-medical, automotive,sustainable energy systems and with suitable safety precautions.

PEOs of M.E. (CAD/CAM)

Existing

1. Graduates will become professional contributors in the industry related to the area of CAD/CAM.
2. Graduates will excel in Research, Development and Consultancy
3. Graduates will become Entrepreneurs in CAD/CAM industry.

No Change is Proposed in PEOs

PSOs of M.E. (CAD/CAM)

Existing

1. The student will have thorough knowledge in core and non-core subjects
2. The student will acquire knowledge for competency in research skills
3. The student will inculcate leadership qualities and team work

Proposed

1. Apply and analyze the concepts of design engineering to provide solution for emerging needs in Mechanical Engineering.
2. Demonstrate use of design and analysis software tools to solve real world problems.
3. Develop and implement new ideas on product design with modern CAD/CAM tools, while ensuring global trends and best manufacturing practices.

PEOs of ME (Thermal Engineering)

Existing

After completion of thermal engineering PG program the graduates will

1. have solid understanding of thermal engineering fundamentals and applications required to solve real life problems.
2. excel in research and to practice the technologies in field of thermal engineering in a broad way.
3. have scientific and engineering knowledge so as to comprehend, analyze the design products and systems pertaining to thermal engineering.
4. face typical thermal engineering problems with confidence through multi-disciplinary team approach.
5. aware of the professional excellence and leadership through interaction with practicing engineering and professional bodies.

Proposed

1. Prepare Graduates with Good Analytical, Computational and Experimental Skills to Design and Develop Energy Efficient Systems for Sustainable Development.
2. Prepare Graduates with High Level of Technical Competency combined with Research and Complex Problem Solving Ability to Generate Innovative Solutions in Thermal Engineering and allied areas.
3. Pursue Lifelong Learning for Career and Professional Growth with a Concern for Society and Environment.
4. Inculcate Teamwork, Communication and Interpersonal Skills adapting to Changing needs of society.

PSOs of ME (Thermal Engineering)

Existing

1. The student will have thorough knowledge in core and non-core subjects
2. The student will acquire knowledge for competency in research skills
3. The student will inculcate leadership qualities and team work

Proposed

1. Apply domain knowledge of thermal and fluid sciences to solve engineering problems with the help of advanced technology.
2. Develop alternative energy sources for sustainable growth.
3. Demonstrate knowledge and skill in the use of CFD software tools.

AICTE MODEL CURRICULUM
M.E. (CAD/CAM)

SEMESTER – I

S. No.	Course Code	Title of the Course	Scheme of Instruction			Scheme of examination			Credits
			Hours per week			Duration in Hours	Maximum Marks		
			L	T	P		CIE	SEE	
THEORY									
1	19MEC 101	Computer Aided Modeling and Design	3	--	--	3	30	70	3
2	19MEC 102	Computer Integrated Manufacturing	3	--	--	3	30	70	3
3		Programme Elective – I	3	--	--	3	30	70	3
4		Programme Elective – II	3	--	--	3	30	70	3
5	19MEC 103	Research Methodology and IPR	2	--	--	2	25	50	2
6		Audit Course – 1	2	--	--	2	--	50*	Non-Credit
PRACTICALS									
7	19MEC 104	Integrated Design and Manufacturing Lab	--	--	4	--	50	--	2
8	19MEC 105	Vibrations and Acoustics Lab	--	--	4	--	50	--	2
		TOTAL	**16**	--	**8**	--	**245**	**380**	**18**

L:TheoryLecture P: LabWork
CIE-ContinuousInternalEvaluation SEE–SemesterEndExamination * Pass / Fail

Programme Elective – I (3/3)			**Programme Elective – II (3/3)**		
S. No	**Subj. Code**	**Name of the Subject**	**S. No**	**Subj. Code**	**Name of the Subject**
1	19MEE 101	Advanced Machine Design	1	19MEE 104	Automation
2	19MEE 102	Advanced Vibrations and Acoustics	2	19MEE 105	Design for Manufacturing and Assembly
3	19MEE 103	Optimization Techniques	3	19MEE 106	Industrial Robotics

Audit Course – 1					
S No	**Subj. Code**	**Name of the Subject**	**S No**	**Subj. Code**	**Name of the Subject**
1	19CEA 101	Disaster Mitigation and Management	5	19EGA 101	English for Research Paper Writing
2	19EEA 101	Sanskrit for Technical Knowledge	6	19EGA 102	Indian Constitution and Fundamental Rights
3	19ECA 101	Value Education	7	19EGA 103	Stress Management by Yoga
4	19ITA 101	Pedagogy Studies	8	19EGA 104	Personality Development through Life's Enlightenment Skills

AICTE MODEL CURRICULUM
M.E. (CAD/CAM)

SEMESTER – II

S. No.	Course Code	Title of the Course	Scheme of instruction			Scheme of examination			Credits
			Hours per week			Duration inHours	Maximum Marks		
			L	T	P		CIE	SEE	
THEORY									
1	19MEC 106	Finite Element Techniques	3	--	--	3	30	70	3
2	19MEC 107	Mechanical Design and Analysis	3	--	--	3	30	70	3
3		Programme Elective – III	3	--	--	3	30	70	3
4		Programme Elective – IV	3	--	--	3	30	70	3
5		Audit Course – 2	2	--	--	2	--	50*	Non-Credit
PRACTICALS									
6	19MEC 108	Computer Aided Engineering Lab	--	--	4	--	50	--	2
7	19MEC 206	Computational Fluid Dynamics Lab	--	--	4	--	50	--	2
8	19MEC 109	Mini Project with Seminar	--	--	4	--	50	--	2
		TOTAL	**14**	--	**12**		**270**	**330**	**18**

L:TheoryLecture P: LabWork
CIE-ContinuousInternalEvaluation SEE–SemesterEndExamination
* Pass / Fail

Programme Elective – III (3/3)			**Programme Elective – IV (3/3)**		
SNO	**Subj. Code**	**Name of the Subject**	**SNO**	**Subj. Code**	**Name of the Subject**
1	19MEE 206	Computational Fluid Dynamics	1	19MEE 109	Multibody Dynamics
2	19MEE 107	Mechanics of Composite Materials	2	19MEE 110	Tribology in Design
3	19MEE 108	Fracture Mechanics	3	19MEE 111	Failure Analysis and Design

Audit Course-2					
SNO	**Subj. Code**	**Name of the Subject**	**SNO**	**Subj. Code**	**Name of the Subject**
1	19CEA 101	Disaster Mitigation and Management	5	19EGA 101	English for Research Paper Writing
2	19EEA 101	Sanskrit for Technical Knowledge	6	19EGA 102	Indian Constitution and Fundamental Rights
3	19ECA 101	Value Education	7	19EGA 103	Stress Management by Yoga
4	19ITA 101	Pedagogy Studies	8	19EGA 104	Personality Development through Life's Enlightenment Skills

AICTE MODEL CURRICULUM
M.E. (CAD/CAM)

SEMESTER – III

S. No.	Course Code	Title of the Course	Scheme of instruction			Scheme of examination			Credits
			Hours per week			Duration inHours	Maximum Marks		
			L	T	P		CIE	SEE	
THEORY									
1		Programme Elective - V	3	--	--	3	30	70	3
2		Open Elective	3	--	--	3	30	70	3
3	19MEC 110	Dissertation Phase - I	--	--	20	--	100	--	10
TOTAL			**6**	--	**20**		**160**	**140**	**16**

L:TheoryLecture P: LabWork

CIE-ContinuousInternalEvaluation SEE–SemesterEndExamination

ELECTIVES

Programme Elective – V (3/3)

SNO	Subj. Code	Name of the Subject
1	19MEE 112	Advanced Finite Element Method
2	19MEE 113	Product Design and Process Planning
3	19MEE 114	Theory of Elasticity and Plasticity

Open Elective (3/3)

SNO	Subj. Code	Name of the Subject
1	19MEO 101	Industrial Safety
2	19MEO 102	Introduction to Optimization Techniques
3	19MEO 103	Composite Materials
4	19CEO 101	Cost Management of Engineering Projects
5	19EEO 101	Waste to Energy

AICTE MODEL CURRICULUM
M.E. (CAD/CAM)

SEMESTER – IV

S. No.	Course Code	Title of the Course	Scheme of instruction			Scheme of examination			Credits
			Hours per week			Duration inHours	Maximum Marks		
			L	T	P		CIE	SEE	
THEORY									
1	19MEC 111	Dissertation Phase - II	--	--	32	Viva	100	100	16
TOTAL			**--**	--	32	Viva	**100**	**100**	**16**

L:TheoryLecture P: LabWork

CIE-ContinuousInternalEvaluation SEE–SemesterEndExamination

19MEE 112

ADVANCED FINITE ELEMENT METHOD
(Programme Elective – V)

Instruction	3 Hours perweek
DurationofSEE	3Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. Nonlinear FE formulation by 1D element.
2. Formulation of elasto-plastic Timoshenko beam element.
3. Elasto-plastic formulation in 2D problems.
4. Plate bending phenomenon by Mindlin theory.
5. Convergence requirements

Outcomes: At the end of the course, the students are able to

1. Understand FE formulation for nonlinear elastic and elasto-plastic problems in one dimension. (BL-2)
2. Explain the solution behavior of elasto-plastic Timoshenko beam element. (BL-2)
3. Outline program structure for 2D elasto-plastic problems. (BL-4)
4. Solve nonlinear problems based on Mindlin plate theory. (BL-3)
5. Describe convergence in linear and nonlinear problems. (BL-1)

UNIT - I

One-dimensional nonlinear problems: Introduction, basic numerical solution processes for nonlinear problems, systems governed by a quasi-harmonic equation, nonlinear elastic problems, elasto-plastic problems in one dimension.

UNIT - II

Elasto-plastic Timoshenko beam analysis: Basic assumptions of Timoshenko beam theory, finite element idealization for linear elastic Timoshenko beams, elasto-plastic nonlayered Timoshenko beam.

UNIT- III

Elasto-plastic problems in two dimensions: Mathematical theory of plasticity matrix formulation, alternative form of the yield criteria for numerical computation, basic expressions for two-dimensional problems, singular points on the yield surface, finite element expressions and program structure.

UNIT - IV

Elasto-plastic Mindlin plate bending analysis: Introduction, equilibrium equations, discretization, solution of nonlinear equations, software for the nonlayered approach.

UNIT - V

Element Performance: Completeness, consistency and reproducing conditions, convergence results for linear problems, convergence in nonlinear problems.
Element properties and patch tests: Patch test, standard patch test, patch test in nonlinear programs.

Text Books:

1. T.BelytschkoandW.K.LiuandB.Moran,"Nonlinearfiniteelements forcontinuaandstructures",JohnWiley&Sonsltd.,England, 2000.
2. D.R.J.OwenandE.Hinton,"Finiteelementsinplasticity:Theory and practice", Pineridge pressltd, 1980.
3. O.C.ZienkiewiczandR.L.Taylor,"Finiteelementmethod:Volume2 solidmechanics",5/e,Butterworth-Heinemann,Oxford, 2000.

Suggested Reading:

1. K.J.Bathe,"Finiteelementprocedures",Prentice-HallofIndiaprivate limited, NewDelhi,1996.
2. J.C.SimoandT.J.R.Hughes,"Computationalinelasticity",Springer- Verlag,NewYork,1998.

19MEE 113

PRODUCT DESIGN ANDPROCESS PLANNING

(Programme Elective – V)

Instruction	3 Hours perweek
DurationofSEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. Basic concepts of product design and processplanning.
2. Reliability,IPRandvalueanalysis.
3. Conceptual design rules for few manufacturingtechniques.
4. Principles of ergonomics and advanced productivitytechniques.
5. Role of computers in design andmanufacturing.

Outcomes: At the end of the course, the students are able to

1. Define the needs of the customer while designing a new product or modifying an existing product. (BL-1)
2. Understand reliability techniques, intellectual property rights and value engineering. (BL-2)
3. Identify appropriate manufacturing process. (BL-3)
4. Implement ergonomic concepts and productivity techniques. (BL-3)
5. Influence the effectiveness of product design and process planning by using computers. (BL-5)

UNIT - I

Productdesignandprocessdesignfunctions: Selectionofarightproduct, essential factors of product design, morphology of design, sources of new ideas for products, evaluation of new product ideas, product innovation procedure- flow chart, qualifications of product design engineer, criteria for success/failure of a product, value of appearance, colours and laws of appearance.

UNIT - II

New product development: Product reliability, mortality curve, reliability systems, manufacturing reliability and quality control, patents – definitions, classes of patents, applying for patents, trademarks and copyrights, elements of cost, costing methods, cost reduction and cost control activities, economic analysis, break even analysis charts, value engineering in product design, creativity aspects and techniques, procedures of value analysis – cost reduction, material and process selection.

UNIT- III

Variousmanufacturingprocesses: Degreeofaccuracyandfinishobtainable, process capability studies, basic product designrulesforcasting,forging,machining,sheetmetalandwelding, physical propertiesofengineeringmaterialsandtheirimportanceonproducts, selection of plastics, rubber and ceramics for productdesign.

UNIT - IV

Industrial ergonomics: Man-machine considerations, ease of maintenance, ergonomicconsiderationsinproductdesign – anthropometry,designofcontrols, man – machineinformationexchange, processsheetdetailandtheirimportance, advancedtechniquesforhigherproductivity, just-in-timeandKanban system, modern approaches to product design, quality function development, rapid prototyping.

UNIT - V

Roleofcomputerinproductdesign: Managementofmanufacturing,creation ofmanufacturingdatabase,computerintegratedmanufacturing,communication network,productionflowanalysis,grouptechnology,computeraidedproduct design and process planning, integrating product design, manufacture and productioncontrol.

Text books:

1. B.W. Niebel and A.B. Draper, "Product design and process engineering",McGrawHill , Tokyo,1974.
2. A.K.Chitale and R.C. Gupta, "Product design and manufacturing", PHI., New Delhi, 2004.
3. Karl T. Ulrich, Stephen Eppinger, "Product design and development", Mc Graw Hill publication, 2012.

Suggested reading:

1. M. Mahajan, "Industrial engineering and production management", Dhanpath Rai & co., 2000.
2. Bhaskaran Gopalakrishnan, "Product design and process planning", Chapman and Hall, New York, 1994.

19MEE 114

THEORY OF ELASTICITY AND PLASTICITY
(Programme Elective – V)

Instruction	3 Hours perweek
DurationofSEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. Concepts of stress &strain.
2. Problems related to stress and straintensor.
3. Stresstensorforagivenstraintensorandviceversaforanisotropic and orthotropicmaterial.
4. Derivations of the constitutive equations inplasticity.
5. Evaluation of the load required in deformation process such as forging, rolling, extrusion and wire drawing processes by various methods and comparethem.

Outcomes: At the end of the course, the students are able to

1. Describe concepts of stress andstrain. (BL-2)
2. Estimate principle components, normal &stress components, deviatoric and hydrostatic components of a given stress or strain tensor. BL-3)
3. Computethestresstensorforagivenstresstensorandviceversafor isotropic and orthotropic materials under various conditions. (BL-3)
4. Express the stress strain relations of plasticdeformation. (BL-2)
5. Analyze the loadrequirementinvariousbulkdeterministicprocessessuch asforging,rolling,extrusion,wiredrawingwithvariousmethods.(BL-4)

UNIT - I

Basic concepts of stress: Definition, state of stress at a point, stress tensor, invariants of stress tensor, principle stresses, stress ellipsoid, derivation for maximum shear stress and planes of maximum shear stress, octahedral shear stress,deviatoricandhydrostaticcomponentsofstress,invarianceofdeviatoric stress tensor, planestress.

UNIT - II

Basicconceptsofstrain: Deformationtensor,straintensorandrotationtensor, invariantsofstraintensor,principlestrains,derivationformaximumshearstrain and planes of maximum shear strain, octahedral shear strain, deviatoric and hydrostaticcomponentsofstraintensor,invarianceofdeviatoricstraintensor, planestrain.

UNIT- III

GeneralizedHooke'slaw: Stress-strainrelationshipsforanisotropicbodyfor three-dimensional stress space, for plane stress and plane strain conditions, differentialequationsofequilibrium,compatibilityequations,material(d)matrix for orthotropicmaterials.

UNIT - IV

True stress and true strain: von-Mise's and Tresca yield criteria, Haigh–Westergardstressspacerepresentationofvon-Mise'sandTrescayieldcriteria, effectivestressandeffectivestrain,St.Venantstheoryofplasticflow,Prandtle– ReussandLevy–Mise'sconstitutiveequationsofplasticflow,strainhardening and work hardening theories, work of plasticdeformation.

UNIT - V

Analysis methods: Slab method, slip line field method, uniformdeformation energy method, upper and lower bound solutions, application of slab method toforging,wiredrawing,extrusionandrollingprocesses.

Text books:

1. TimoshenkoandGoodier,“Theoryofelasticity”,3/e,McGrawHill publications,2004
2. J.Chakrabarty,“Theoryofplasticity”,2/e,Butterworth- Heimann,2006.
3. D.W.A. Rees, “Basic engineering plasticity”, Butterworth- Heimann, 2006.

Suggested reading:

1. GeorgeEDieter,“Mechanicalmetallurgy”,McGrawHillpublications 2017.
2. L.M. Kachanov, “Fundamentals of theory of plasticity”, Dover publications,2004.

19MEO 101

INDUSTRIAL SAFETY
(Open Elective)

Instruction		3 Hours perweek
DurationofSEE		3 Hours
SEE		70Marks
CIE		30Marks
Credits	3	

Objectives:

1. Causes for industrial accidents and preventive steps to betaken.
2. Fundamental concepts of maintenanceengineering.
3. About wear and corrosion along with preventive steps to betaken.
4. The basic concepts and importance of faulttracing.
5. The steps involved in carrying out periodic and preventive maintenance of various equipments used inindustry.

Outcomes: At the end of the course, the students are able to

1. Identify the causes for industrial accidents and suggest preventive measures for safety. (BL-2)
2. Understand the basic need and requirements of different maintenance procedures. (BL-2)
3. Apply different techniques to reduce and prevent wear and corrosion in industry. (BL-3)
4. Analyze different types of faults present in various equipments like machine tools, IC engines, boilers etc.(BL-4)
5. Formulate a plan for periodic and preventive maintenance techniques as required for industrial equipments like motors, pumps and air compressors.(BL-6)

UNIT - I

Industrialsafety:Accident,causes,types,resultsandcontrol,mechanicaland electricalhazards,types,causesandpreventivesteps/procedure,describesalient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, safety color codes, fire prevention and firefighting, equipment andmethods.

Workplace safety standards during pandemic: workplace safety requirements mandating appropriate personal protective equipment, sanitation, social distancing, infectious disease preparedness and response plans, record keeping, training, and hazard communications in workplaces safety.

UNIT – II

Fundamentalsofmaintenanceengineering:Definitionandaimofmaintenance engineering,primaryandsecondaryfunctionsandresponsibilityofmaintenance department, types of maintenance, types and applications of tools used for maintenance,maintenancecost&itsrelationwithreplacementeconomy,service life ofequipment.

UNIT – III

Wear: Types, causes, effects, wear reduction methods.

Lubrication:Types and applications, lubrication methods, general sketch, working and applications of screw down grease cup, pressure grease gun, splash lubrication, gravity lubrication, wick feed lubrication, side feed lubrication, ring lubrication.

Corrosion and prevention: Definition of corrosion, principle and factors affecting the corrosion, types of corrosion, corrosion prevention methods.

UNIT–IV

Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive,thermalandelectricalequipment'slike,anyonemachinetool,pump, aircompressor,internalcombustionengine,boiler,electricalmotors,typesof faults in machine tools and their generalcauses.

UNIT – V

PeriodicandPreventiveMaintenance:Periodicinspection-concept andneed, degreasing, cleaning and repairing schemes, overhauling of mechanical components and electricmotors.Periodic and preventive maintenance of machine tools, pumps, air compressors, diesel generator sets.

Text Books:

1. H. P. Garg, "Maintenance engineering", S. Chand & co, 2010.
2. Tyler G. Hicks and T. W. Edwards, "Pump application engineering", Mc Graw Hill, 1971.
3. Roger L Brauer, "Safety and health for engineers', Wiley-Interscience & Sons, 2016.

SuggestedReadings:

1. Higgins & Morrow, "Maintenance engineering handbook", 3rd edition, Mc Graw Hill, 1977.
2. Winterkorn, Hans, "Foundation engineering handbook", Chapman & Hall, London, 1975.

19MEO 102

INTRODUCTION TO OPTIMIZATION TECHNIQUES

(Open Elective)

Instruction	3 Hours perweek
DurationofSEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. CometoknowtheformulationofLPPmodels.
2. Understand the transportation and assignmenttechniques.
3. CometoknowtheprocedureofprojectmanagementalongwithCPM and PERTtechniques.
4. Understand the concepts of queuing theory and inventorymodels.
5. Understand sequencingtechniques.

Outcomes: At the end of the course, the students are able to

1. Build and Solve the linear programming problems. (BL-3)
2. Solve the given transportation problem. (BL-3)
3. Analyze project management techniques like CPM and PERT to plan and execute projects successfully. (BL-4)
4. Compare various inventory control techniques. (BL-4)
5. Apply sequencing and queuing theory concepts for industry applications.(BL-3)

UNIT - I

Operationsresearch:Definition,scope,models,linearprogrammingproblems (LPP),Formulation,graphicalmethod,andSimplexmethod.

UNIT - II

Transportationmodels:Findinganinitialfeasiblesolution-northwestcorner method,leastcostmethod,Vogel'sapproximationmethod,findingtheoptimal solution,specialcasesintransportationproblems-unbalancedtransportation problem,degeneracyintransportation,profitmaximizationintransportation.

UNIT- III

Project management: Definition, procedure and objectives of project management,differencesbetweenPERTandCPM,rulesfordrawingnetwork diagram, scheduling the activities, Fulkerson's rule, earliest and latest times, determinationofESandEFtimesinforwardpath,LS&LFtimesinbackward path,determinationofcriticalpath,durationoftheproject,freefloat, independent float and totalfloat.

UNIT - IV

Queuing theory and inventory: Kendall's notation, single server models, inventory control - deterministic inventory models - probabilistic inventory control models.

UNIT - V

Sequencingmodels:Introduction,objectives,generalassumptions,processing 'n' jobs through two machines, processing 'n' jobs through three machines.

Text Books:

1. H.A. Taha, "Operations research", 10th edition, Prentice Hall of India, New Delhi, 2017.
2. S. D. Sharma, Himanshu Sharma, "Operations research: Theory, methods and applications", 15th edition, Kedar Nath Ram Nath, 2010
3. Dr. D. S. Hira, Er. Prem Kumar Gupta, "Operations research", S. Chand & company ltd,2014.

Suggested Reading:

1. Hillier F.S. and Lieberman G.J., "Introduction to operations research", 7th Edition, TMH, 2009
2. Rao. S. S., "Optimization theory and applications", 2nd edition, Wiley Eastern ltd., 2004.

19MEO 103

COMPOSITE MATERIALS

(Open Elective)

Instruction	3 Hours perweek
DurationofSEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. Composite materials and theirconstituents.
2. Classification of the reinforcements and evaluate the behaviour of composites.
3. Fabricationmethodsofmetalmatrixcomposites.
4. Manufacturingofpolymermatrixcomposites.
5. Failuremechanismsincompositematerials.

Outcomes: At the end of the course, the students are able to

1. Classify and characterize the composite materials. (BL-4)
2. Describe types of reinforcements and their properties. (BL-2)
3. Understand different fabrication methods of metal matrix composites. (BL-2)
4. Understand different fabrication methods of polymer matrix composites. (BL-2)
5. Decide the failure of composite materials. (BL-5)

UNIT - I

Introduction: Definition, classification and characteristics of composite materials, advantagesandapplicationofcomposites, functionalrequirements ofreinforcementandmatrix, effectofreinforcement(size,shape,distribution, volumefraction)onoverallcompositeperformance.

UNIT – II

Reinforcements: Preparation-layup,curing,propertiesandapplicationsofglass fibers,carbonfibers,kevlarfibersandboronfibers, propertiesandapplications ofwhiskers,particlereinforcements, mechanicalbehaviorofcomposites, rule ofmixtures,inverseruleofmixtures, isostrainandisostressconditions.

UNIT – III

Manufacturing of metal matrix composites: Casting, solid state diffusion technique, cladding, hot isostatic pressing, properties and applications.

Manufacturing of ceramic matrix composites: liquid metal infiltration, liquid phase sintering.

Manufacturing of carbon–carbon composites: knitting, braiding, weaving, properties and applications.

UNIT–IV

Manufacturing of polymer matrix composites: Preparation of moulding compounds and prepregs, hand layup method, autoclave method, filament winding method, compression moulding, reaction injection moulding, properties and applications.

UNIT – V

Strength:Laminafailurecriteria-strengthratio,maximumstresscriteria,maximum straincriteria,interactingfailurecriteria,hygrothermalfailure, laminatefirstplay failure, insightstrength.

Text Books:

1. Deborah D.L. Chung “Composite materials: Science and applications”, Springer 2/e, 2010.
2. WD Callister, Jr., adapted by R. Balasubramaniam, “Materials science and engineering, an introduction”., John Wiley & sons, NY, Indian edition, 2/e, 2007.
3. R.M. Jones, “Mechanics of composite materials”, 2/e, Mc Graw Hill co., 1998.

Suggested Readings:

1. K.K.Chawla, 4/e “Composite materials”, Springer Book Archives, 2019.
2. Daniel Gay, Suong V. Hoa, and Stephen W. Tsai, “Composite materials design and applications”, CRC press, 2015.

19CEO 101

COST MANAGEMENT OF ENGINEERING PROJECTS

(Open Elective)

Instruction	3 Hours perweek
DurationofSEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

1. To enable the students to understand the concepts of projectmanagement.
2. To provide knowledge on concepts of project planning and scheduling.
3. To create an awareness on project monitoring and costanalysis.
4. To provide adequate knowledge to the students on recoursemanagement costing-varianceanalysis.
5. Totrainthestudentswiththeconceptsofbudgetarycontrolforcost managementandtoprovidebasicplatformonquantitativetechniques for costmanagement.

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

1. Acquire in-depth knowledge about the concepts of project management and understand the principles of projectmanagement.
2. DeterminethecriticalpathofatypicalprojectusingCPMandPERT techniques.
3. Prepareaworkbreakdownplanandperformlinearschedulingusing variousmethods.
4. Solve problems of resource scheduling and leveling using network diagrams.
5. Learn the concepts of budgetary control and apply quantitative techniques for optimizing projectcost.

UNIT- I

ProjectManagement: Introductiontoprojectmanagements,stakeholders,roles, responsibilitiesandfunctionalrelationships,Principlesofprojectmanagement, objectives and project management system, Project team, organization, roles, and responsibilities, Concepts of project planning, monitoring, staffing, scheduling andcontrolling.

UNIT-II

ProjectPlanningandScheduling: Introductionforprojectplanning,defining activitiesandtheirinterdependency,timeandresourceestimation.Workbreakdownstructure.Linearscheduling methods-barcharts,LineofBalance(LOB), theirlimitations.Principles,definitionsofnetwork-basedschedulingmethods: CPM,PERT.Networkrepresentation,networkanalysis-forwardandbackward passes.

UNIT-III

ProjectMonitoringandCostAnalysis:introduction-Costconceptsindecision-making;Relevantcost,Differentialcost,IncrementalcostandOpportunitycost. ObjectivesofaCostingSystem;Inventoryvaluation;CreationofaDatabasefor operationalcontrol;ProvisionofdataforDecision-Making,Timecosttradeoff-Crashingprojectschedules,itsimpactontimeontime,cost,Projectdirectand indirectcosts.

UNIT- IV

ResourcesManagementandCosting-VarianceAnalysis: Planning,Enterprise ResourcePlanning,Resourceschedulingandleveling,TotalQualityManagement andTheoryofconstraints.Activity-BasedCostManagement,BenchMarking; BalancedScoreCardandValue-ChainAnalysis

StandardCostingandVarianceAnalysis: Pricingstrategies:ParetoAnalysis, Target costing, Life Cycle Costing, Costing of service sector. Just-in-time approach, MaterialRequirement

UNIT- V

Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets, Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitativetechniquesforcostmanagement:LinearProgramming,PERT/CPM, TransportationAssignmentproblems,Simulation,LearningCurveTheory.

Text Books:

1. Charles T Horngren "Cost Accounting A Managerial Emphasis", PearsonEducation, 14/e, 2012.
2. Charles T. Horngren and George Foster, "Advanced Management Accounting"Prentice-Hall, 6/e,1987.
3. Robert S Kaplan Anthony A. Atkinson, "Management &Cost Accounting",Pearson, 2/e,1996.

Suggested Reading:

1. K. K Chitkara, "Construction Project Management: Planning, schedulingandcontrolling",TataMcGraw-HillEducation, 2004.
2. Kumar Neeraj Jha "Construction Project Management Theory and Practice",PearsonEducationIndia;2/e, 2015.

19EEO 101

WASTE TO ENERGY

(Open Elective)

Instruction	3 Theory Hours perweek
DurationofSEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Objectives:

4. To know the various forms ofwaste
5. To understand the processes of biomasspyrolysis.
6. To learn the technique of biomasscombustion.

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

1. Understand the concept of conservation ofwaste.
2. Identify the different forms ofwastage.
3. Chose the best way for conservation to produce energy fromwaste.
4. Explorethewaysandmeansofcombustionofbiomass.
5. Developahealthyenvironmentforthemankind.

UNIT - I

IntroductiontoEnergyfromWaste:Classificationofwasteasfuel–Agrobased, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers,digestors.

UNIT – II

Biomass Pyrolysis: Pyrolysis – Types, slow, fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT – III

BiomassGasification:Gasifiers–Fixedbedsystem–Downdraftandupdraft gasifiers–Fluidizedbedgasifiers–Design,constructionandoperation–Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electricalpower–Equilibriumandkineticconsiderationingasifieroperation.

UNIT–IV

BiomassCombustion:Biomassstoves–Improvedchullahs,types,someexotic designs,Fixedbedcombustors,Types,inclinedgratecombustors,Fluidizedbedcombustors,Design,constructionan doperation-Operationofalltheabove biomasscombustors.

UNIT – V

Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technologyandstatus-Bioenergysystem-Designandconstructionalfeatures

- Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysisandliquefaction-biochemicalconversion-anaerobicdigestion-Types ofbiogasPlants–Applications-Alcoholproductionfrombiomass-Biodiesel production-Urbanwastetoenergyconversion-Biomassenergyprogrammein India.

Text Books:

3. V.AshokV.,“NonConventionalEnergy”,Desai,WileyEasternLtd., 1990.
4. K.C.KhandelwalandMahdi,S.S.,“BiogasTechnology-APractical HandBook”-Vol.I&II,TataMcGrawHillPublishingCo.Ltd.,1983.

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Suggested Readings:

3. D.S.Challal,"Food,FeedandFuelfromBiomass",IBHPublishingCo. Pvt. Ltd.,1991.
4. C. Y. WereKo-Brobby and E. B. Hagan, "Biomass Conversion and Technology",JohnWiley&Sons,1996.

19MEC 110

DISSERTATION PHASE - I

Instruction	20 Hours perweek
CIE	100Marks
Credits	10

Outcomes: At the end of the course, the students are able to

1. Identify a topic in advanced areas of mechanical / allied fields of engineering. (BL-1)
2. Review literature to identify the gaps, define the objectives and scope of the work. (BL-2)
3. Generate innovative ideas for societal benefit and Nation building. (BL-6)
4. Develop prototypes/models, experimental setup and software systems necessary to meet the objectives (BL-6)
5. Prepare a technical report and present before the departmental committee (BL-5)

Guidelines:

1. Theproject work will preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individualcontribution.
2. Seminars hould be based on the area in which the candidate has undertaken the dissertation work.
3. TheCIEshallincludereviewsandthepreparationofreportconsisting ofadetailedproblemstatementandaliteraturereview.
4. The preliminary results (if available)oftheproblemmay also be discussed in thereport.
5. Theworkhastobepresentedinfrontofthecommitteeconsistsof Head,Chairperson-BoS,supervisorandprojectcoordinator.
6. Thecandidatehastobeinregularcontactwithhissupervisorand thetopicofdissertationmustbemutuallydecidedbytheguideand student.

GuidelinesforawardingCIE marks

Evaluation by	Max. Marks	Evaluation Criteria / Parameter
Supervisor	30	Project status / Review(s)
	20	Report
Department Committee	10	Relevance of the topic
	10	PPT preparation(s)
	10	Presentation(s)
	10	Question and answers
	10	Report preparation
Total	**100**	

Note:Department committee has to assess the progress of the student for every two weeks.

19MEC 111

DISSERTATION PHASE - II

Instruction	32 Hours perweek
DurationofSEE	Viva
SEE	100Marks
CIE	100Marks
Credits	16

Outcomes: At the end of the course, the students are able to

1. Summarize the literature review for the identified problem. (BL-2)
2. Identify methods and materials to carry out experiments/develop code/simulation. (BL-4)
3. Integrate the methodology and engineering tools adopted for solving the problem. (BL-6)
4. Analyze the results to draw valid conclusions, prepare a report as per recommended format and defend the work. (BL-4)
5. Explore the possibility of publishing papers in peer reviewed journals/conference proceedings. (BL-3)

Guidelines:

1. Itisacontinuationofprojectworkstartedinsemester III.
2. Thestudenthastosubmitthereportinprescribedformatandalso present aseminar.
3. Thedissertationshouldbepresentedinstandardformatasprovided by thedepartment.
4. Thecandidatehastoprepareadetailedprojectreportconsistingof introductionoftheproblem,problemstatement,literaturereview, objectivesofthework,methodology(experimentalsetupornumerical detailsasthecasemaybe)ofsolutionandresultsanddiscussion.
5. Thereportmustbringouttheconclusionsoftheworkandfuture scope for the study. The work has to be presented in front of the examinerspanelconsistingofanapprovedexternalexaminer,an internalexaminer(HoDandChairperson- BoS)guide/co-guide.
6. Thecandidatehastobeinregularcontactwithhis/herguide/co- guide.

GuidelinesforawardingCIE marks		
Evaluation by	**Max. Marks**	**Evaluation Criteria / Parameter**
Department Review Committee	05	Review 1
	10	Review 2
	10	Review 3
	15	Final presentation with the draft copy of the report standard format
	10	Submission of the report in a standard format
Supervisor	10	Regularity and punctuality
	10	Work progress
	10	Quality of the work which may lead to publications
	10	Analytical / Programming / Experimental skills preparation
	10	Report preparation in a standard format
Total	**100**	

GuidelinesforawardingSEE marks		
Evaluation by	**Max. Marks**	**Evaluation Criteria / Parameter**
External and Internal Examiner(s) Together	20	Powerpoint presentation
	40	Quality of thesis and evaluation
	20	Quality of the project 1. Innovations 2. Applications 3. Live research projects 4. Scopeforfuturestudy 5. Applicationtosociety
	20	Viva-Voce
Total	**100**	

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

AICTE MODEL CURRICULUM

M.E. (THERMAL ENGINEERING)

SEMESTER – I

S. No.	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per week			Duration in Hours	Maximum Marks		
			L	T	P		CIE	SEE	
THEORY									
1	19MEC 201	Thermodynamics and Combustion	3	--	--	3	30	70	3
2	19MEC 202	Advanced Fluid Dynamics	3	--	--	3	30	70	3
3		Programme Elective - I	3	--	--	3	30	70	3
4		Programme Elective - II	3	--	--	3	30	70	3
5	19MEC 103	Research Methodology and IPR	2	--	--	2	25	50	2
6		Audit course – 1	2	--	--	2	--	50*	Non-Credit
PRACTICALS									
5	19MEC 203	Thermal Systems Lab	--	--	4	--	50	--	2
6	19MEC 204	Design of Solar and Wind Systems Lab	--	--	4	--	50	--	2
TOTAL			**16**	--	**8**	--	**245**	**380**	**18**

L:TheoryLecture P: LabWork
CIE-ContinuousInternalEvaluation SEE–SemesterEndExamination
*Pass / Fail

Programme Elective – I (3/3)			Programme Elective – II (3/3)		
S No	**Subj. Code**	**Name of the Subject**	**S No**	**Subj. Code**	**Name of the Subject**
1	19MEE201	Thermal and Nuclear Power Plants	1	19MEE203	Air Conditioning System Design
2	19MEE202	Environmental Engineering and Pollution Control	2	19MEE204	Energy Conservation and Management
3	19MEE103	Optimization Techniques	3	19MEE205	Design of Solar and Wind Systems

Audit Course – 1					
S NO	**Subj. Code**	**Name of the Subject**	**S NO**	**Subj. Code**	**Name of the Subject**
1	19CEA101	Disaster Mitigation and Management	5	19EGA101	English for Research Paper Writing
2	19EEA101	Sanskrit for Technical Knowledge	6	19EGA102	Indian Constitution and Fundamental Rights

3	19ECA101	Value Education	7	19EGA103	Stress Management by Yoga
4	19ITA 101	Pedagogy Studies	8	19EGA104	Personality Development through Life's Enlightenment Skills

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

AICTE MODEL CURRICULUM

M.E. (THERMAL ENGINEERING)

SEMESTER – II

S. No.	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per week			Duration in Hours	Maximum Marks		
			L	T	P		CIE	SEE	
THEORY									
1	19MEC 106	Finite Element Techniques	3	--	--	3	30	70	3
2	19MEC 205	Advanced Heat and Mass Transfer	3	--	--	3	30	70	3
3		Programme Elective - III	3	--	--	3	30	70	3
4		Programme Elective - IV	3	--	--	3	30	70	3
5		Audit Course – 2	2	--	--	2	--	50*	Non-Credit
PRACTICALS									
6	19MEC 108	Computer Aided Engineering Lab	--	--	4	--	50	--	2
7	19MEC 206	Computational Fluid Dynamics Lab	--	--	4	--	50	--	2
8	19MEC 207	Mini Project with Seminar	--	--	4	--	50	--	2
TOTAL			**14**	--	**12**		**270**	**330**	**18**

L:TheoryLecture P: LabWork
CIE-ContinuousInternalEvaluation SEE–SemesterEndExamination
*Pass / Fail

Programme Elective – III (3/3)			Programme Elective – IV (3/3)		
SNo	Subj. Code	Name of the Subject	SNo	Subj. Code	Name of the Subject
1	19MEE 206	Computational Fluid Dynamics	1	19MEE 209	Turbo Machines
2	19MEE 207	Refrigeration and Cryogenics	2	19MEE 210	Gas Turbines
3	19MEE 208	Design of Heat Exchangers	3	19MEE 211	Power Plant Control andInstrumentation

Audit Course – 2

SNO	Subj. Code	Name of the Subject	SNO	Subj. Code	Name of the Subject
1	19CEA 101	Disaster Mitigation and Management	5	19EGA 101	English for Research Paper Writing
2	19EEA 101	Sanskrit for Technical Knowledge	6	19EGA 102	IndianConstitutionandFundamentalRights
3	19ECA 101	Value Education	7	19EGA 103	Stress Management by Yoga
4	19ITA 101	Pedagogy Studies	8	19EGA 104	Personality Development through Life's Enlightenment Skills

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)
AICTE MODEL CURRICULUM
M.E. (THERMAL ENGINEERING)

SEMESTER – III

S. No.	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per week			Duration in Hours	Maximum Marks		
			L	T	P		CIE	SEE	
THEORY									
1		Programme Elective - V	3	--	--	3	30	70	3
2		Open Elective	3	--	--	3	30	70	3
3	19MEC 208	Dissertation Phase – I	--	--	20	--	100	--	10
TOTAL			**6**	--	20		**160**	**140**	**16**

L: Theory Lecture P: Lab Work

CIE- Continuous Internal Evaluation SEE– Semester End Examination

Programme Elective – V(3/3)			Open Elective (3/3)		
S.No.	**Subj. Code**	**Name of the Subject**	**SNo**	**Subj. Code**	**Name of the Subject**
1	19MEE 212	Advances in IC Engines	1	19MEO 101	Industrial Safety
2	19MEE 213	Convective Heat Transfer	2	19MEO 102	Introduction to Optimization Techniques
3	19MEE 214	Theory of Heat Pipes	3	19MEO 103	Composite Materials
			4	19CEO 101	Cost Management of Engineering Projects
			5	19EEO 101	Waste to Energy

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

AICTE MODEL CURRICULUM

M.E. (THERMAL ENGINEERING)

SEMESTER – IV

S. No.	Course Code	Title of the Course	Scheme of instruction			Scheme of examination			Credits
			Hours per week			Duration inHours	Maximum Marks		
			L	T	P		CIE	SEE	
THEORY									
1	19MEC 209	Dissertation Phase - II	--	--	32	--	100	100	16
TOTAL			**--**	--	**32**	--	**100**	**100**	**16**

L: Theory Lecture P: Lab Work

CIE-Continuous Internal Evaluation SEE–Semester End Examination

19MEE 212

ADVANCES IN IC ENGINES

(Programme Elective – V)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:

1. Importance of combustion phenomena and various injection systems in SI engines.
2. Combustion phenomena and increasing methods of power output in CI engine.
3. Concept of formation of pollutants from IC engines along with pollutant control and measurement techniques.
4. Concept of alternative fuel technologies to improve the performance of theengine.
5. Concepts of recent trends with changes in engine configuration.

Outcomes: At the end of the course, the students are able to

1. Discuss the combustion phenomena and knock controlling modern tools in SI engines, using thermodynamic principles with due concern for public health, safety and environment. (BL-2)
2. Explain fuel injection systems, combustion phenomenon and power boosting techniques in CI engines with due consideration for healthy society and clean environment. (BL-2)
3. Evaluate the pollutants from IC engines using modern tools with appropriate consideration for public health, safety and environment. (BL-5)
4. Select the alternative fuels ethically in place of conventional fossil fuels for a clean environment. (BL-5)
5. Apply various modern techniques for improvement in performance and ethical reduction of pollutants with due concern for society and environment. (BL-3)

UNIT – I

Spark ignition engines: Spark ignition engine mixture requirements, carburetion, mixture strength diagram, fuel metering (quantity governing), description of a simple carburetor, compensating devices, gasoline injection systems-direct and indirect injection systems, single point and MPFI systems, flame propagation, stages of combustion, normal and abnormal combustion, factors affecting knock, role of fuels in avoiding detonation, additives, ignition quality, octane number, performance number, highest useful compression ratio (HUCR), characteristics of a good combustion chamber (Ricardo), combustion chambers.

UNIT – II

Compression ignition engines: Importance of air motion, swirl and squish stages of combustion in CI engines, P-Ɵ diagram and Way’s heat release rate diagram, normal and abnormal combustion,knock in CI Engines, basic concepts, remedial measures to control abnormal combustion, combustion chambers, fuel metering (quality governing), fuel pump fuel injectors, spray nozzle types, and injection systems in CI engines (air Injection and solid injection), CRDI, electronic control unit (ECU), size of fuel droplet (SMD) to atomize the fuel, spray patterns (Hiroyasu), supercharging and turbocharging methods.

UNIT – III

Pollutant formation and control: Pollutants, sources, formation of carbonmonoxide, unburnt hydrocarbons, aldehydes, NOx, smoke and particulate matter,methods of controlling emissions-thermal converters, chemical methods, EGR, catalytic converters, SCR and particulate traps, methods of measurements like infrared gas analyzer, flame ionization detector, chemiluminescence analyzer, opacity meters, Euro and Bharat stage emission norms.

UNIT – IV

Alternative fuels: Need for alternative fuels, desirable characteristics of a good alternative fuel,alcohol, hydrogen, natural gas, biogas and liquefied petroleum gas, vegetable oils and biodiesel-properties, suitability, merits and demerits as fuels, engine modifications for alternative fuels.

UNIT – V

Recent trends: Limitations with gasoline and diesel engineslean burn and adiabatic concepts, rotary engines, Wankel engine, stratification methods (by carburetion and combination) stratified charge engines–homogeneous charge compression ignition (HCCI) engines and GDI concepts,Texacocombustion process (TCP).

Text Books:

1. V. Ganesan, “Internal Combustion engines”, 4/e, TMH publishers, New Delhi, 2017.
2. J.B. Heywood, “Internal Combustion engine fundamentals”, Mc-GrawHills Book Co, New York, 1988.
3. H.N.Gupta, “Fundamentals of Internal Combustion Engines” PHI learning Private Limited, New Delhi, 2012.

Suggested Reading:

1. M.L. Mathur, and R.P. Sharma, “Internal Combustion Engine”, Dhanpat Rai Publications, Delhi, 2010.
2. P.W. Gill, and J.H. Smith (Jr), “Fundamentals of Internal combustionEngines”, 4/e, Oxford & IBH publishing Co., New Delhi, 2007.

19MEE 213

CONVECTIVE HEAT TRANSFER

(Programme Elective – V)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:

1. Different types of convection heat transfer and their equations to apply for various engineering applications.
2. To familiarize the concept of forced convection and its behavior inpipes.
3. To familiarize the concept of natural convection and its behavior inpipes.
4. To familiarize the concept of combination of natural convection andforced convention in pipes.
5. To understand the principles of conjugate heat transfer and its applications in engineering heat transformation.

Outcomes: At the end of the course, the studentsare able to

1. Apply various convective heat transfer equations for different engineering problems and applications. (BL-3)
2. Evaluate the rate of heat transfer under forced convection in simple to complex engineering problems. (BL-5)
3. Estimate the rate of heat transfer under natural convection in different engineering applications. (BL-3)
4. Determine the rate of heat transfer under combined convection for engineering problems of different categories. (BL-3)
5. Evaluate the rate of convective heat transfer through the porous media for different applications. (BL-5)

UNIT – I

Introduction toconvective heat transfer: Forced, free &combined convection, convective heat transfer coefficient, application of dimensional analysis to convection, physical interpretation of dimensionless numbers, equations of convective heat transfer - continuity, Navier-Stokes equation &energy equation, steady state flows, similarity equations for turbulent convective heat transfer,boundary layer equations for laminar, turbulent flows, boundary layer integral equations.

UNIT – II

Forced convection: External laminar forced convection, similarity solution for flow over an isothermal plate, integral equation solutions, numerical solutions, viscous dissipation effects on flow over aflat plate, external turbulent flows-analogy solutions for boundary layer flows, integral equation solutions, effects of dissipation on flow over a flat plate, internal laminar flows, fully developed laminar flow in pipe, plane duct & ducts with other cross-sectional shapes, pipe flow & plane duct flow with developing temperature field, pipe flows & plane duct flow with developing velocity & temperature fields, internal turbulent flows, analogy solutions for fully developed pipe flow, thermally developing pipe & plane duct flow.

UNIT- III

Natural convection: Boussinesq approximation, governing equations, similarity, boundary layer equations for free convective laminar flows, numerical solution of boundary layer equations, free convective flows through vertical channel across a rectangular enclosure, horizontal enclosure, turbulent naturalconvection.

UNIT – IV

Combined convection: Governing parameters & equations, laminar boundary layer flow over an isothermal vertical plate, combined convection over horizontal plate, correlations for mixed convection, effect of boundary forces on turbulent flows, internal flows, internal mixed convective flows, fully developed mixed convective flow in a vertical plane channel & in a horizontal duct.

UNIT – V

Heat transfer through porous media: Area weighted velocity, Darcy flow model, energy equation, boundary layer solutions for 2-D forced convection, fully developed duct flow, natural convection in porous media, filled enclosures, stability of horizontal porous layers.

Text Books:

1. Patrick H. Oosthuigen & David Naylor, "Introduction to Convective Heat Transfer Analysis", Mc Graw Hill, New York, 1999.
2. Kays & Crawford, "Convective Heat & Mass Transfer", TMH, 2000.
3. Yunus A Cengel, Afshin J. Ghajar, "Heat and Mass Transfer: Fundamentalsand Applications", Mc Graw-Hill Education, 2015.

Suggested Reading:

1. S. Mostafa Ghiaasiaan, "Convective Heat and MassTransfer", CRC press, Taylor & Francis Group, 2018.
2. Adrian Bejan, "Convection Heat Transfer", 2/e, JohnWiley,1984.

19MEE 214

THEORY OF HEAT PIPES

(Programme Elective – V)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:

1. Importance of heat pipe and its working principle.
2. Classification of heat pipe.
3. Design concept of heat pipe.
4. Testing method of heat pipe.
5. Different types of Modeling of heat pipe.

Outcomes: At the end of the course, the studentsare able to

1. Select a suitable heat pipe for a particular heating and cooling applications with principles of engineering heat transfer. (BL-2)
2. Determine the heat capacity ranges of a particular heat pipe with the basic concepts of engineering fundamentals. BL-3)
3. Interpret the behaviour of heat pipe under start up and running conditions. BL-5)
4. Evaluate the performance behaviour of heat pipe along with the applications. BL-3)
5. Evaluate the performance of heat pipe by using theoretical, numerical and analytical models. BL-3)

UNIT – I

Background and historical development of heat pipe: Operating principle, working fluids and its temperature ranges, heat transfer limits and heat pipe characteristics, various applications interfacial heat transfer, physical surface phenomena, capillary and disjoining forces-interfacial resistance in vaporization and condensation process, interfacial mass, momentum energy, pressure balance-interfacial phenomena in grooved structures.

UNIT - II

Limiting heat loads: Capillary, viscous and boiling limits-dry out and rewetting.

Classification of heat pipes: Thermo syphon heat pipes, wick heat pipes, rotating heat pipes, micro heat pipes, cryogenic heat pipes, variable condensation heat pipes, thermal switches and diodes

Steady hydrodynamics: Thermal characteristics and heat transfer limitation, thermal fluid phenomena in capillary media, vapour flow analysis, thermal characteristics including the wall effects and effect of vapour flow, capillary boiling, sonic, entrainment, viscous, condenser, continuum and frozen start up limitations.

UNIT- III

Design and manufacturing of heat pipes: Working fluids, components, wick structures, design criteria-fabrication and fluid charging, reliability tests, area temperature relations, pipe dimensions and structural considerations, heat pipe heat exchanger, transient model calculations and procedures.

UNIT – IV

Heat pipe testing: Testing methods, start-up methods.

Heatpipe applications: Power plants, electronics and space.

Heat pipe behaviour: Transient response to sudden change in temperature heat input, frozen start up and shut down of heat pipe-numerical and analytical model for frozen start up.

UNIT - V

Modelling of heat pipes: Steady state modelling, transient modelling, start-up characteristics, two phase closed thermo syphon-reflux condensation heat transfer in analysis, evaporation heat transfer analysis, transient and oscillatory behaviour of thermo syphon, minimum liquid fill requirement, thermo syphon with capillary wicks.

Text Books:

1. S.W.Chi, "Heat pipe theory and practice", Hemisphere publishing corporation, Washington, 1976.
2. Dunn & Reay, "Heat Pipes", Pergamon Press, 1994.
3. Faghri, "Heat Pipe Science and Technology", Taylor & Francis, 1995.

Suggested Reading:

1. Bahman Zohuri, "Heat Pipe Design and Technology: A PracticalApproach", CRC Publishing Company, 2011.
2. G. P. Peterson, "Introduction to Heat Pipes: Modelling, Testing,andApplications", John Wiley & Sons, 1/e, 1994.

19MEO 101

INDUSTRIAL SAFETY
(Open Elective)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:

1. Causes for industrial accidents and preventive steps to be taken.
2. Fundamental concepts of maintenance engineering.
3. About wear and corrosion along with preventive steps to be taken.
4. The basic concepts and importance of fault tracing.
5. The steps involved in carrying out periodic and preventivemaintenance of various equipment used inindustry.

Outcomes: At the end of the course, the students are able to

1. Identify the causes for industrial accidents and suggest preventive measures for safety. (BL-2)
2. Understand the basic need and requirements of different maintenance procedures. (BL-2)
3. Apply different techniques to reduce and prevent wear and corrosion in industry. (BL-3)
4. Analyze different types of faults present in various equipment like machine tools, IC Engines, boilers etc. (BL-4)
5. Formulate a plan for periodic and preventive maintenance techniques as required for industrial equipment like motors, pumps and air compressors. (BL-6)

UNIT – I

Industrial safety: Accident, causes, types, results and control, mechanical andelectrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking waterlayouts, light, cleanliness, fire, guarding, pressure vessels, safety colorcodes, fire prevention and firefighting, equipment and methods.

Workplace safety standards during pandemic: workplace safety requirements mandating appropriate personal protective equipment, sanitation, social distancing, infectious disease preparedness and response plans, record keeping, training and hazard communications in work places safety.

UNIT – II

Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, primary and secondary functions and responsibility of maintenance department, types of maintenance, types and applications of tool used formaintenance, maintenance cost & its relation with replacement economy, service life of equipment.

UNIT – III

Wear: Types, causes, effects, wear reduction methods.

Lubrication: Types and applications, lubrication methods, general sketch, working and applications of screw down grease cup, pressure grease gun, splash lubrication, gravity lubrication, wick feed lubrication, side feed lubrication, ring lubrication.

Corrosion and prevention: Definition of corrosion, principle and factors affecting the corrosion, types of corrosion, corrosion prevention methods.

UNIT–IV

Fault Tracing: Fault tracing-concept and importance, decision tree concept,need and applications, sequence of fault-finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like any one machine tool, pump, air compressor, internal combustion engine, boiler, electrical motors, types of faults in machine tools and their general causes.

UNIT – V

Periodic and preventive maintenance: Periodic inspection- concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components and electricmotors.Periodic and preventive maintenance of machine tools, pumps, air compressors, diesel generator sets.

Text Books:

1. H. P. Garg, "Maintenance Engineering", S. Chand and co, 2010.
2. Tyler G. Hicks and T. W. Edwards, "Pump application engineering", Mc-Graw Hill, 1971.
3. Roger L Brauer, "Safety and health for engineers', Wiley-Interscience & Sons, 2016.

Suggested Reading:

1. Higgins & Morrow, "Maintenance engineering handbook", 3/e, Mc Graw Hill, 1977.
2. Winterkorn, Hans, "Foundation engineering handbook", Chapman & Hall, London, 1975.

19MEO 102

INTRODUCTION TO OPTIMIZATION TECHNIQUES

(Open Elective)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:

1. Come to know the formulation of LPP models.
2. Understand the transportation and assignment techniques.
3. Come to know the procedure of project management along with CPM and PERT techniques.
4. Understand the concepts of queuing theory and inventory models.
5. Understand sequencing technique.

Outcomes: At the end of the course, the students are able to

1. Build and solve the linear programming problems. (BL-3)
2. Solve the given transportation problem. (BL-3)
3. Analyze project management techniques like CPM and PERT toplan and execute projects successfully. (BL-4)
4. Compare various inventory control techniques. (BL-4)
5. Apply sequencing and queuing theory concepts for industry applications. (BL-3)

UNIT – I

Operations research: Definition, scope, models, linear programming problems (LPP), formulation, graphical method and simplex method.

UNIT – II

Transportation models: Finding an initial feasible solution- north-west corner method, least cost method, Vogel's approximation method, finding the optimal solution, special cases in transportation problems-unbalanced transportation problem, degeneracy in transportation, profit maximization in transportation.

UNIT- III

Project management: Definition, procedure and objectives of project management, differences between PERT and CPM, rules for drawing network diagram, scheduling the activities, Fulkerson's rule, earliest and latest times, determination of ES and EF times in forward path, LS & LF times in backward path, determination of critical path, duration of the project, free float, independent float and total float.

UNIT - IV

Queuing theory and inventory: Kendall's notation, single server models, inventory control-deterministic inventory models-probabilistic inventory control models.

UNIT - V

Sequencing models: Introduction, objectives, general assumptions, processing 'n' jobs through two machines, processing 'n' jobs through three machines.

Text Books:

1. H.A. Taha, "Operations research", 10^{th} edition, Prentice Hall of India, New Delhi, 2017.
2. S. D. Sharma, Himanshu Sharma, "Operations research: Theory, methods and applications", 15^{th} edition, Kedar Nath Ram Nath, 2010
3. Dr. D. S. Hira, Er. Prem Kumar Gupta, "Operations research", S. Chand & company ltd, 2014.

Suggested Reading:

1. Hillier F.S. and Lieberman G.J., "Introduction to operations research", 7th Edition, TMH, 2009.
2. Rao. S. S., "Optimization theory and applications", 2nd edition, Wiley Eastern ltd., 2004.

19MEO 103

COMPOSITE MATERIALS
(Open Elective)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:

1. Composite materials and theirconstituents.
2. Classification of the reinforcements and evaluate the behaviour of composites.
3. Fabricationmethodsofmetalmatrixcomposites.
4. Manufacturingof polymer matrix composites.
5. Failuremechanismsincompositematerials.

Outcomes: At the end of the course, the students are able to

1. Classify and characterize the composite materials. (BL-4)
2. Describe types of reinforcements and their properties. (BL-2)
3. Understand different fabrication methods of metal matrix composites. (BL-2)
4. Understand different fabrication methods of polymer matrix composites. (BL-2)
5. Decide the failure of composite materials. (BL-5)

UNIT - I

Introduction: Definition, classification and characteristics of composite materials, advantages and application of composites, functional requirements of reinforcement and matrix, effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT – II

Reinforcements: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and boron fibers, properties and applications of whiskers, particle reinforcements, mechanical behaviour of composites, rule of mixtures, inverse rule of mixtures, isostrain and isostress conditions.

UNIT – III

Manufacturing of metal matrix composites: Casting, solid state diffusiontechnique, cladding, hot isostatic pressing, properties and applications.
Manufacturing of ceramic matrix composites: liquid metal infiltration, liquid phase sintering.
Manufacturing of carbon–carbon composites: knitting, braiding, weaving, properties and applications.

UNIT–IV

Manufacturing of polymer matrix composites: Preparation of moulding compounds and prepregs, hand layup method, autoclave method, filament winding method, compression moulding, reaction injection moulding, properties and applications.

UNIT – V

Strength: Lamina failure criteria- strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure, laminate first play failure, insight strength.

Text Books:

1. Deborah D.L. Chung “Composite materials: Science and applications”, Springer 2/e, 2010.
2. WD Callister, Jr., adapted by R. Balasubramaniam, “Materials science and engineering, an introduction”., John Wiley &sons, NY, Indian edition, 2/e, 2007.
3. R.M. Jones, “Mechanics of composite materials”, 2/e, Mc Graw Hill co, 1998.

Suggested Readings:

1. K.K. Chawla, 4/e “Composite materials”, Springer Book Archives, 2019.
2. Daniel Gay, Soung V. Hoa, Stephen W. T Sai, Stephen W. T Sai, “Composite materials design and applications”, CRC press , 2015.

19CEO 101

COST MANAGEMENT OF ENGINEERING PROJECTS

(Open Elective)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:
1. To enable the students to understand the concepts of Projectmanagement.
2. To provide knowledge on concepts of Project Planning and scheduling.
3. To create an awareness on Project Monitoring and CostAnalysis
4. To provide adequate knowledge to the students on RecourseManagement Costing-VarianceAnalysis
5. TotrainthestudentswiththeconceptsofBudgetaryControlforcost managementandtoprovidebasicplatformonQuantitativetechniques for costmanagement.

Outcomes: At the end of the course, the students are able to

1. Acquire in-depth knowledge about the concepts of project management and understand the principles of projectmanagement.
2. DeterminethecriticalpathofatypicalprojectusingCPMandPERT techniques.
3. Prepareaworkbreakdownplanandperformlinearschedulingusing variousmethods.
4. Solve problems of resource scheduling and leveling using network diagrams.
5. Learn the concepts of budgetary control and apply quantitative techniques for optimizing projectcost.

UNIT- I

ProjectManagement: Introductiontoprojectmanagements,stakeholders,roles, responsibilitiesandfunctionalrelationships,Principlesofprojectmanagement, objectives and project management system, Project team, organization, roles, and responsibilities, Concepts of project planning, monitoring, staffing, scheduling andcontrolling.

UNIT-II

ProjectPlanningandScheduling: Introductionforprojectplanning,defining activitiesandtheirinterdependency,timeandresourceestimation.Workbreakdownstructure.Linearscheduling methods-barcharts,LineofBalance(LOB), theirlimitations.Principles,definitionsofnetwork-basedschedulingmethods: CPM,PERT.Networkrepresentation,networkanalysis-forwardandbackward passes.

UNIT-III

ProjectMonitoringandCostAnalysis:introduction-Costconceptsindecision-making;Relevantcost,Differentialcost,IncrementalcostandOpportunitycost. ObjectivesofaCostingSystem;Inventoryvaluation;CreationofaDatabasefor operationalcontrol;ProvisionofdataforDecision-Making,Timecosttradeoff-Crashingprojectschedules,itsimpactontimeontime,cost,Projectdirectand indirectcosts.

UNIT- IV

ResourcesManagementandCosting-VarianceAnalysis: Planning,Enterprise ResourcePlanning,Resourceschedulingandleveling,TotalQualityManagement andTheoryofconstraints.Activity-BasedCostManagement,BenchMarking; BalancedScoreCardandValue-ChainAnalysis

StandardCostingandVarianceAnalysis: Pricingstrategies:ParetoAnalysis, Target costing, Life Cycle Costing, Costing of service sector. Just-in-time approach, MaterialRequirement

UNIT- V

Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets, Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitativetechniquesforcostmanagement:LinearProgramming,PERT/CPM, TransportationAssignmentproblems,Simulation,LearningCurveTheory.

Text Books:

1. Charles T Horngren "Cost Accounting A Managerial Emphasis", PearsonEducation;14/e,2012.
2. Charles T. Horngren and George Foster, "Advanced Management Accounting"Prentice-Hall, 6/e, 1987.
3. Robert S Kaplan Anthony A. Atkinson, "Management &Cost Accounting",Pearson2/e, 1996.

Suggested Reading:

1. K. K Chitkara, "Construction Project Management: Planning, schedulingandcontrolling",TataMcGraw-HillEducation.,2004.
2. Kumar Neeraj Jha "Construction Project Management Theory and Practice",PearsonEducationIndia;2/e, 2015.

19EEO 101

WASTE TO ENERGY

(Open Elective)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:

1. To know the various forms ofwaste
2. To understand the processes of biomasspyrolysis.
3. To learn the technique of biomasscombustion.

Outcomes: At the end of the course, the students are able to

1. Understand the concept of conservation ofwaste.
2. Identify the different forms ofwastage.
3. Chose the best way for conservation to produce energy fromwaste.
4. Explorethewaysandmeansofcombustionofbiomass.
5. Developahealthyenvironmentforthemankind.

UNIT - I

IntroductiontoEnergyfromWaste:Classificationofwasteasfuel–Agrobased, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers,digestors

UNIT – II

Biomass Pyrolysis: Pyrolysis – Types, slow, fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT – III

BiomassGasification:Gasifiers–Fixedbedsystem–Downdraftandupdraft gasifiers–Fluidizedbedgasifiers–Design,constructionandoperation–Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electricalpower–Equilibriumandkineticconsiderationingasifieroperation.

UNIT–IV

BiomassCombustion:Biomassstoves–Improvedchullahs,types,someexotic designs,Fixedbedcombustors,Types,inclinedgratecombustors,Fluidizedbedcombustors,Design,constructio nandoperation-Operationofalltheabove biomasscombustors.

UNIT – V

Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technologyandstatus-Bioenergysystem-Designandconstructionalfeatures

Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysisandliquefaction-biochemicalconversion-anaerobicdigestion-Types ofbiogasPlants–Applications-Alcoholproductionfrombiomass-Biodiesel production-Urbanwastetoenergyconversion-Biomassenergyprogrammein India.

Text Books:

1. V.AshokV.,“NonConventionalEnergy”,Desai,WileyEasternLtd., 1990.
2. K.C.KhandelwalandMahdi,S.S.,“BiogasTechnology-APractical HandBook”-Vol.I&II,TataMcGrawHillPublishingCo.Ltd.,1983.

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Suggested Readings:

1. D.S.Challal,”Food,FeedandFuelfromBiomass”,IBHPublishingCo. Pvt. Ltd.,1991.
2. C. Y. WereKo-Brobby and E. B. Hagan, “Biomass Conversion and Technology”,JohnWiley&Sons,1996.

19MEC 208

DISSERTATION PHASE - I

Instruction	20	Hours per week
CIE	100	Marks
Credits	10	

Outcomes: At the end of the course, the students are able to

1. Identify a topic in advanced areas of mechanical / allied fields of engineering. (BL-1)
2. Review literature to identify the gaps, define the objectives and scopeof the work. (BL-2)
3. Generate innovative ideas for societal benefit and Nation building. (BL-6)
4. Develop prototypes/models, experimental setup and software systemnecessary to meet the objectives. (BL-6)
5. Prepare a technical report and present before the departmental committee. (BL-5)

Guidelines:

1. The project work will preferably be a problem with research potential and should involve scientific research, design generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution.
2. Seminar should be based on the area in which the candidate has undertaken the dissertation work.
3. The CIE shall include reviews and the preparation of report consisting of a detailed problem statement and a literature review.
4. The preliminary results (if available) of the problem may also be discussed in the report.
5. The work has to be presented in front of the committee consists of Head, Chairperson-BoS, supervisor and project coordinator.
6. The candidate has to be in regular contact with his supervisor and thetopic of dissertation must be mutually decided by the guide and student.

Guidelines for awarding CIE marks		
Evaluation by	**Max. Marks**	**Evaluation Criteria / Parameter**
Supervisor	30	Project status / Review(s)
	20	Report
Department Committee	10	Relevance of the topic
	10	PPT preparation(s)
	10	Presentation(s)
	10	Question and answers
	10	Report preparation

Total	**100**	

Note: Department committee has to assess the progress of the student for every two weeks.

19MEC 209

DISSERTATION PHASE - II

Instruction	32 Hours per week
Duration of SEE	Viva
SEE	100 Marks
CIE	100 Marks
Credits	16

Outcomes: At the end of the course, the students are able to

1. Summarize the literature review for the identified problem. (BL-2)
2. Identify methods and materials to carry out experiments/ develop code / simulation. (BL-4)
3. Integrate the methodology and engineering tools adopted for solving the problem. (BL-6)
4. Analyze the results to draw valid conclusions, prepare a report as perrecommended format and defend the work. (BL-4)
5. Explore the possibility of publishing papers in peer reviewed journals/ conference proceedings. (BL-3)

Guidelines:

1. It is a continuation of Project work started in semester III.
2. The student has to submit the report in prescribed format and also present a seminar.
3. The dissertation should be presented in standard format as providedby the department.
4. The candidate has to prepare a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion.
5. The report must bring out the conclusions of the work and future scope for the study. The work has to be presented in front of the examiners panel consisting of an approved external examiner, an internal examiner (HoD and Chairperson- BoS) guide/co-guide.
6. The candidate has to be in regular contact with his/her guide/co-guide.

Guidelines for awarding CIE marks		
Evaluation by	**Max. Marks**	**Evaluation Criteria / Parameter**
Department Review Committee	05	Review 1
	10	Review 2
	10	Review 3
	15	Final presentation with the draft copy of the report standard format
	10	Submission of the report in a standard format
	10	Regularity and punctuality
	10	Work progress

Supervisor	10	Quality of the work which may lead to publications
	10	Analytical / Programming / Experimental skills preparation
	10	Report preparation in a standard format
Total	**100**	

Guidelines for awarding SEE marks		
Evaluation by	**Max. Marks**	**Evaluation Criteria / Parameter**
External and Internal Examiner(s) together	20	PowerPoint presentation
	40	Quality of thesis and evaluation
	20	Quality of the project 1. Innovations 2. Applications 3. Live research projects 4. Scopeforfuturestudy 5. Applicationtosociety
	20	Viva-Voce
Total	**100**	

20ME C01

CAD AND DRAFTING

Instruction	1 T + 3 D Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	2.5

Course Objectives:
1. To get exposure to a cad package and its utility.
2. Understanding orthographic projections.
3. To visualize different solids and their sections in orthographic projection
4. To prepare the student to communicate effectively by using isometric projection.
5. To prepare the student to use the techniques, skills, and modern tools necessary for practice.

Outcomes: At the end of the course, the Students are able to
1. Become conversant with appropriate use of CAD software for drafting. (BL-3)
2. Recognize BIS, ISO Standards and conventions in Engineering Drafting. (BL-2)
3. Construct the projections of points, lines, planes, solids (BL-3)
4. Analyse the internal details of solids through sectional views (BL-4)
5. Create an isometric projections and views (BL-6)

List of exercises:
1. Introduction to CAD package: Settings, draw, modify tools, dimensioning and documentation
2. Construction of Conic Sections by General method
3. Orthographic projection: Principles, conventions, Projection of points
4. Projection of straight lines: Simple position, inclined to one plane
5. Projection of straight lines inclined to both the planes (without traces and mid-point)
6. Projection of planes: Perpendicular planes
7. Projection of planes: Oblique planes
8. Projection of solids: Simple position
9. Projection of solids: Inclined to one plane
10. Sections of solids: Prism, pyramid in simple position
11. Sections of solids: Cone and cylinder in simple position
12. Isometric projections and views
13. Conversion of isometric views to orthographic projections and vice versa.

Text Books:

1. N.D.Bhatt, “Elementary Engineering Drawing”, Charotar Publishers, 2012.
2. K.Venugopal, “Engineering Drawing and Graphics + AutoCAD”,New Age International Pvt.Ltd, 2011.
3. Basanth Agrawal and C M Agrawal, “Engineering Drawing”, 2/e, McGraw-Hill Education (India) Pvt. Ltd.

Suggested Reading:

1. Shaw M.B and Rana B.C., “Engineering Drawing”, 2/e, Pearson, 2009.
2. K.L.Narayana and P.K.Kannaiah, “Text Book of Engineering Drawing”, Scitech Publications, 2011.

20ME C02

WORKSHOP / MANUFACTURING PRACTICE

Instruction	5P Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	2.5

Course Objectives:

1. Give a feel of Engineering Practices & develop holistic understanding of various Engineering materials and Manufacturing processes.
2. Develop skills of manufacturing, safety, precision, quality, intelligent effort, optimization, positive & team work attitude to get things right the first time.
3. To provide basic knowledge of Steel, Plastic, Composite and other materials for suitable applications.
4. Study of Principle and hands on practice on techniques of fabrication, welding, casting, manufacturing, metrology, and allied skills.
5. To advance important hard & pertinent soft skills, productivity, create skilled manpower which is cognizant of industrial workshop components and processes and can communicate their work in a technical, clear and effective way.

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

1. Understand safety measures to be followed in workshop to avoid accidents. (BL-2)
2. Identify various tools used in fitting, carpentry, tin smithy, house wiring, welding, casting and machining processes. (BL-2)
3. Make a given model by using workshop trades including fitting, carpentry, tin smithy and House wiring. (BL-3)
4. Perform various operations in welding, machining and casting processes. (BL-3)
5. Conceptualize and produce simple device/mechanism of their choice. (BL-6)

List of Exercises

CYCLE 1

Exercises in Carpentry

1. To plane the given wooden piece to required size
2. To make a lap joint on the given wooden piece according to the given dimensions.
3. To make a dove tail-joint on the given wooden piece according to the given dimensions.

Exercises in Tin Smithy

1. To make a rectangular box from the given sheet metal with base and top open. Solder the corners.
2. To make a scoop.
3. To make a pamphlet box.

Exercises in Fitting

1. To make a perfect rectangular MS flat and to do parallel cuts using Hack saw
2. To make male and female fitting using MS flats-Assembly1
3. To make male and female fitting using MS flats-Assembly2

Exercises in House Wiring

4. Wiring of one light point controlled by one single pole switch, a three pin socket controlled by a single pole switch, and wiring of one buzzer controlled by a bell push
5. Wiring of two light points connected in series and controlled by single pole switch. Verify the above circuit with different bulbs.Wiring of two light points connected in parallel from two single pole switches and a three pin socket
6. Stair case wiring-wiring of one light point controlled from two different places independently using two 2-way switches.

CYCLE 2

Exercises in Casting

1. Study of Sand casting process and its applications**.**
2. Green sand moulding practice for a single piece pattern
3. Green sand moulding practice for a split pattern with a horizontal core

Exercises in Welding

4. Study of gas welding equipment and process. Identification of flames, making of Butt joint with gas welding.
5. Study of Arc welding process, making Butt joint with DCSP, DCRP
6. Study of Arc welding process, making Lap joint with A.C

Exercises in Machine shop

7. Study of Machine Tools like Lathe, Drilling, Milling and Shaper.
8. Facing, Plain turning and Step turning operations on Lathe machine.
9. Knurling and Taper turning on Lathe machine

Open ended Exercise:

1. Student should produce a component /mechanism by applying the knowledge of any one trade or combination of trades.

TextBooks:

1. HajraChoudhury S.K., HajraChoudhury A.K. and Nirjhar Roy S.K., “Elements of Workshop Technology”, Vol. I, 2008 and Vol. II, 2010, Media promoters and publishers private limited, Mumbai.
2. Kalpakjian S. And Steven S. Schmid, “Manufacturing Engineering and Technology”,4th edition, Pearson Education India Edition, 2002.
3. Rao P.N., “Manufacturing Technology”, Vol. I and Vol. II, Tata McGrawHill House, 2017.

Suggested Reading:

1. Gowri P. Hariharan and A. Suresh Babu, “Manufacturing Technology – I”, Pearson Education, 2008.
2. Roy A. Lindberg, “Processes and Materials of Manufacture”, 4th edition, Prentice Hall India, 1998.

20ME C03

ENGINEERING EXPLORATION
(Open Elective)

Instruction	4 Hours per week
Duration of SEE	3 Hours
SEE	25 Marks
CIE	25Marks
Credits	2

Prerequisites: Nil
Course Outcomes: At the end of the course, the students are able to

1. Understand the role of an engineer as a problem solver. (BL-2)
2. Identify multi-disciplinary approaches in solving an engineering problem. (BL-4)
3. Build simple systems using engineering design process. (BL-3)
4. Analyze engineering solutions from ethical and sustainability perspectives. (BL-4)
5. Use basics of engineering project management skills in doing projects. (BL-3)

UNIT- I
Role of Engineers: Introduction, science, engineering, technology, engineer, scientist, role of engineer, various disciplines of engineering, misconception of engineering, expectations for the 21st century engineer and NBA graduate attributes.
Engineering problems and Design: Multidisciplinary facet of design, pair wise comparison chart, introduction to econometrics system, generation of multiple solution, Pugh chart, motor and battery sizing concepts, introduction to PCB design.

UNIT- II
Mechanisms: Basic components of a mechanism, degrees of freedom or mobility of a mechanism, 4-bar chain, crank rocker mechanism, slider crank mechanism, simple robotic arm building.
Platform-based development: Introduction to programming platforms (Arduino) and its essentials, sensors, transducers and actuators and their interfacing with Arduino.

UNIT- III
Data Acquisition and Analysis: Types of data, descriptive statistics techniques as applicable to different types of data, types of graphs and their applicability, usage of tools (MS-Office /OpenOffice/ LibreOffice / Scilab) for descriptive statistics, data acquisition (temperature and humidity) using sensors interfaced with Arduino, exporting acquired data to spreadsheets, and analysis using representation.

UNIT- IV
Process Management: Introduction to Agile practice, significance of team work, importance of communication in engineering profession, project management tools, checklist, timeline, Gantt chart, significance of documentation.

UNIT -V
Engineering Ethics & Sustainability in Engineering:Identifying Engineering as a profession, significance of professional ethics, code of conduct for engineers, identifying ethical dimensions in different tasks of engineering, applying moral theories and codes of conduct for resolution of ethical dilemmas.

Sustainability in Engineering:Introduction, sustainability leadership, life cycle assessment, carbon foot print.

Text books:

1. Clive L. Dym, Patric Little, Elizabeth J Orwin, "Engineering Design: A project-based introduction", 4th edition, Willey.
2. Matthew Python, "Arduino programming for beginners", Independently published, 2020.
3. Patrick F. Dunn , "Measurement and data Analysis for engineering and science" , third edition,2014.
4. Andrew Stellman, Jennifer Greene, "Head First Agile: A brain-friendly guide to Agile principles, ideas, and real-world practices", Kindle Edition.

Suggested reading:

1. Charles B. Fleddermann, "Engineering ethics", fourth edition, Prentice Hall, 2012.
2. Rob Lawlor, "Engineering in society", second edition, Royal academy of engineering.
3. Richard Dodds, Roger Venables, "Engineering for sustainable development: Guiding principles", The Royal Academy of engineering, 2005.
4. Richard S. Paul, "Robot Manipulators: Mathematics, Programming, and Control", MIT Press.

ENGINEERING EXPLORATION ASSESSMENT SCHEME				
Sno	Name of the module	Work Hours	Marks	Evaluation
1	Role of Engineers	4	-	Evaluation - I
2	Engineering Design	16	5	
3	Mechanisms	6	3	
4	Engineering Ethics	2	2	
5	Platform-based Development	16	5	Evaluation - II
6	Data Acquisition and Analysis	6	4	Evaluation-III
7	Project Management	4	4	
8	Sustainability in Engineering	6	2	
9	Course Project Reviews	12	20	Final Evaluation
10	Code of conduct	-	5	
Total		**72**	**50**	