Mahatma Education Society's

Pillai College of Engineering

(Autonomous)

Affiliated to University of Mumbai

Dr. K. M. Vasudevan Pillai's Campus , Sector 16, New Panvel – 410 206.

PCE
PILLAI COLLEGE OF ENGINEERING
AUTONOMOUS

Department of Mechanical Engineering

Syllabus

of

B.Tech. in Mechanical Engineering

for

Academic Year 23-24

as per

Choice Based Credit and Grading System

Mahatma Education Society's

Pillai College of Engineering

Vision

Pillai College of Engineering (PCE) will admit, educate and train a diverse population of students who are academically prepared to benefit from the Institute's infrastructure and faculty experience, to become responsible professionals or entrepreneurs in a technical arena. It will further attract, develop and retain, dedicated, excellent teachers, scholars and professionals from diverse backgrounds whose work gives them knowledge beyond the classroom and who are committed to making a significant difference in the lives of their students and the community.

Mission

To develop professional engineers with respect for the environment and make them responsible citizens in technological development both from an Indian and global perspective. This objective is fulfilled through quality education, practical training and interaction with industries and social organizations.

Dr. K. M. Vasudevan Pillai's Campus , Sector - 16, New Panvel – 410 206

Department of Mechanical Engineering

Vision

To develop a world class programme with excellence in teaching, learning and research that would lead to growth, innovation and recognition.

Mission

The mission of the Mechanical Engineering Program is to benefit the society at large by providing technical education to interested and capable students. These technocrats should be able to apply basic and contemporary science, engineering and research skills to identify problems in the industry and academia and be able to develop practical solutions to them.

Program Educational Objectives (PEOs):

I. To prepare students for successful careers in industry to meet the needs of Indian and Global companies.
II. To provide students with a sound foundation in the mathematical, scientific and engineering fundamentals.
III. To develop the ability among students to synthesize data, interpret them appropriately and be able to apply concepts to mechanical system design or to a mechanical subsystem of an interdisciplinary system.
IV. To provide opportunity for students to work in their individual capacity as well as to function as teams on multidisciplinary projects.
V. To enable students for lifelong learning and introduce them to professional ethics and sustainable development.
VI. To develop among students an attitude towards self-employment through entrepreneurship

Program Outcomes:

Engineering Graduates will be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate

consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.T
6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

1. Students should be able to design and develop mechanical systems(design, thermal and manufacturing) using core as well as interdisciplinary skills.
2. Students should be able to generate and develop ideas that can result in self employment (eg.Start-ups) and also result in creation of more jobs for the society.
3. Students should be able to apply technical and managerial skills to work as good team leader as well as players in diverse interdisciplinary projects.
4. Students should be able to model and develop solutions for problems relevant to industry.

The Autonomous status of the institute has given an opportunity to design and frame the curriculum in such a way that it incorporates all the needs and requirements of recent developments in all fields within the scope of the Technical education. This curriculum will help graduates to attain excellence in their respective field. The curriculum has a blend of basic and advanced courses along with provision of imparting practical knowledge to students through minor and major projects. The syllabus has been approved and passed by the Board of Studies.

Outcome based education is implemented in the academics and every necessary step is undertaken to attain the requirements. Every course has its objectives and outcomes defined in the syllabus which are met through continuous assessment and end semester examinations. Evaluation is done on the basis of Choice Based Credit and Grading System (CBCGS). Optional courses are offered at department and institute level. Selection of electives from the same specialization makes the student eligible to attain a B. Tech. degree with respective specialization.

Every learner/student will be assessed for each course through (i) an Internal/Continuous assessment during the semester in the form of either Practical Performance, Presentation, Demonstration or written examination and (ii) End Semester Examination (ESE), in the form of either theory or viva voce or practical, as prescribed by the respective Board Studies and mentioned in the assessment scheme of the course content/syllabus. This system involves the Continuous Evaluation of students' progress Semester wise. The number of credits assigned with a course is based on the number of contact hours of instruction per week for the course. The credit allocation is available in the syllabus scheme of each semester.

The performance of a learner in a semester is indicated by a number called Semester Grade Performance Index (SGPI). The SGPI is the weighted average of the grade points obtained in all the courses by the learner during the semester. For example, if a learner passes five courses (Theory/labs./Projects/ Seminar etc.) in a semester with credits C1, C2, C3, C4 and C5 and learners grade points in these courses are G1, G2, G3, G4 and G5 respectively, then learners SGPI is equal to:

$$SGPI = \frac{C_1G_1 + C_2G_2 + C_3G_3 + C_4G_4 + C_5G_5}{C_1 + C_2 + C_3 + C_4 + C_5}$$

The learner's up to date assessment of the overall performance from the time s/he entered for the programme is obtained by calculating a number called the Cumulative Grade Performance Index (CGPI), in a manner similar to the calculation of SGPI. The CGPI therefore considers all the courses mentioned in the scheme of instructions and examinations, towards the minimum requirement of the degree learners have enrolled for. The CGPI at the end of this semester is calculated as,

$$CGPI = \frac{C_1G_1 + C_2G_2 + C_3G_3 + \ldots + C_i * G_i + \ldots + C_nG_n}{C_1 + C_2 + C_3 + \cdots + C_i + \ldots + C_n}$$

This document comprises Scheme and syllabus applicable for ACADEMIC YEAR 2023-24.

Program Structure for
Bachelor of Technology in Mechanical Engineering

Semester I
(Admitted to FY in 23-24)

Course Code	Course Name	Category	Teaching Scheme				
			Contact Hours		Credits Assigned		
			Theory	Pract/ Tut	Theory	Pract/ Tut	Total
FY 101	Engineering Mathematics I	BSC	3	2	3	1	4
FY 102	Engineering Physics I	BSC	2	1	2	0.5	2.5
FY 103	Engineering Chemistry I	BSC	2	1	2	0.5	2.5
FY 105	Basic Electrical Engineering*	ESC	3	-	3	-	3
FY 106	Engineering Mechanics	ESC	3	2	3	1	4
FY 109	Basic Electrical Engineering* - Lab	Skill	-	2	-	1	1
FY 112	Engineering Workshop I	Skill	-	2	-	1	1
FY 113	Indian Knowledge System (IKS)	HSSM	-	2+2#	-	2	2
FY 114	Co-curricular Courses - I	Liberal Learning	-	4	-	2	2
Total			**13**	**18**	**13**	**9**	**22**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)			
		1	2	Avg					
FY 101	Engineering Mathematics I	40	40	40	60	2	25	-	125
FY 102	Engineering Physics I	30	30	30	45	2	25	-	100
FY 103	Engineering Chemistry I	30	30	30	45	2	25	-	100
FY 105	Basic Electrical Engineering*	40	40	40	60	2	-	-	100
FY 106	Engineering Mechanics	40	40	40	60	2	25	25	150
FY 109	Basic Electrical Engineering* - Lab	-	-	-	-	-	25	25	50
FY 112	Engineering Workshop I	-	-	-	-	-	50	-	50
FY 113	Indian Knowledge System (IKS)	-	-	-	-	-	50	-	50
FY 114	Co-curricular Courses - I	-	-	-	-		50	-	50
Total		**180**			**270**	**-**	**250**	**75**	**775**

Program Structure for
Bachelor of Technology in Mechanical Engineering

Semester II
(Admitted to FY in 23-24)

Course Code	Course Name	Category	Teaching Scheme				
			Contact Hours		Credits Assigned		
			Theory	Pract/Tut	Theory	Pract/ Tut	Total
FY 115	Engineering Mathematics II	BSC	3	2	3	1	4
FY 116	Engineering Physics II	BSC	2	1	2	0.5	2.5
FY 117	Engineering Chemistry II	BSC	2	1	2	0.5	2.5
FY 119	Python Programing	ESC	3	-	3	-	3
FY 120	Engineering Drawing	ESC	2	4	2	2	4
FY 122	Python Programming – Lab	Skill	-	2	-	1	1
FY 121	Professional Communication and Ethics I	HSSM	1	2	1	1	2
FY 124	Engineering Workshop II	Skill	-	2	-	1	1
FY 125	Co-curricular Courses II	Liberal Learning	-	4	-	2	2
Total			**13**	**18**	**13**	**9**	**22**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Prac/ Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)			
		1	2	Avg					
FY 115	Engineering Mathematics II	40	40	40	60	2	25	-	125
FY 116	Engineering Physics II	30	30	30	45	2	25	-	100
FY 117	Engineering Chemistry II	30	30	30	45	2	25	-	100
FY 119	Python Programing	40	40	40	60	2	-	-	100
FY 120	Engineering Drawing	40	40	40	60	3	25	25	150
FY 122	Python Programming – Lab	-	-	-	-	-	25	25	50
FY 121	Professional Communication and Ethics I	20	20	20	30	1	25	-	75
FY 124	Engineering Workshop II	-	-	-	-	-	50	-	50
FY 125	Co-curricular Courses- II	-	-	-	-	-	50	-	50
Total				**200**	**300**	**-**	**250**	**50**	**800**

Program Structure for
Bachelor of Technology in Mechanical Engineering

Semester III
(Admitted to FY in 22-23)

Course Code	Course Name	Course Component	Teaching Scheme				
			Contact Hours		Credits Assigned		
			Theory	Pract /Tut	Theory	Pract /Tut	Total
ME 201	Manufacturing Processes	TL	3	2	3	1	4
ME 202	Engineering Mathematics III*	T	2	-	2	-	2
ME 203	Strength of Materials*	TL	3	2	3	1	4
ME 204	Thermodynamics*	T	3	-	3	-	3
ME 205	Metallurgy and Materials	TL	3	2	3	1	4
ME 206	Computer Aided Drafting	L	-	2	-	1	1
ME 291	Minor Project I	LC	-	4	-	2	2
Total			**14**	**12**	**14**	**6**	**20**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)			
		1	2	Avg					
ME 201	Manufacturing Processes	40	40	40	60	2	50	-	150
ME 202	Engineering Mathematics III*	30	30	30	45	2	-	-	75
ME 203	Strength of Materials*	40	40	40	60	2	25	25	150
ME 204	Thermodynamics*	40	40	40	60	2	-	-	100
ME 205	Metallurgy and Materials	40	40	40	60	2	25	-	125
ME 206	Computer Aided Drafting	-	-	-	-	-	25	50	75
ME 291	Minor Project I	25 (Mid Sem assessment)			-	-	25	25	75
Total				**215**	**285**	**-**	**150**	**100**	**750**

T- Theory , L- Lab , P-Programming, C- Communication
*** - Common with B.Tech in Automobile Engineering**

Program Structure for
Bachelor of Technology in Mechanical Engineering

Semester IV
(Admitted to FY in 22-23)

Course Code	Course Name	Course Component	Teaching Scheme				
			Contact Hours		Credits Assigned		
			Theory	Pract/ Tut	Theory	Pract/ Tut	Total
ME 207	Advanced Manufacturing Technology	TL	3	2	3	1	4
ME 208	Theory of Machines & Mechanisms*	TL	3	2	3	1	4
ME 209	Fluid Mechanics and Machinery*	TL	3	2	3	1	4
ME 210	Engineering Mathematics IV*	T	2	-	2	-	2
ME 211	Human Values and Social Ethics*	T	2	-	2	-	2
ME 212	Data Science	LP	-	4	-	2	2
ME 213	Internet of Things	TL	1	2	1	1	2
ME 292	Minor Project II	LC	-	4	-	2	2
Total			**14**	**16**	**14**	**8**	**22**

Course Code	Course Name	Examination Scheme							
		Theory							
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)	Term Work	Pract /Oral	Total
		1	2	Avg					
ME 207	Advanced Manufacturing Technology	40	40	40	60	2	50	-	150
ME 208	Theory of Machines & Mechanisms*	40	40	40	60	2	25	25	150
ME 209	Fluid Mechanics and Machinery*	40	40	40	60	2	25	25	150
ME 210	Engineering Mathematics IV*	30	30	30	45	2	-	-	75
ME 211	Human Values and Social Ethics*	-	-	-	-	-	50	-	50
ME 212	Data Science	-	-	-	-	-	25	50	75
ME 213	Internet of Things	-	-	-	-	-	50	25	75
ME 292	Minor Project II	25 (Mid Sem assessment)			-	-	25	25	75
Total				**175**	**225**	**-**	**250**	**150**	**800**

 # - Theory class to be conducted for full class

*** - Common with B.Tech in Automobile Engineering**

T- Theory , L- Lab , P-Programming, C- Communication

Program Structure for
Bachelor of Technology in Mechanical Engineering

Semester V
(Admitted to FY in 21-22)

Course Code	Course Name	Course Component	Teaching Scheme				
			Contact Hours		Credits Assigned		
			Theory	Pract / Tut	Theory	Pract / Tut	Total
ME 301	Finite Element Analysis*	TL	3	2	3	1	4
ME 302	Heat Transfer*	TL	3	2	3	1	4
ME 303	Measurements and Instrumentation	TL	3	2	3	1	4
ME 304	Machine Design I	TL	3	2	3	1	4
ME 305	Professional Communication and Ethics II	TLC	1	2	1	1	2
ME 30x	DLOC I	T/TL	3	-	3	-	3
ME 391	Minor Project III	LC	-	4	-	2	2
Total			**16**	**14**	**16**	**7**	**23**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)			
		1	2	Avg					
ME 301	Finite Element Analysis*	40	40	40	60	2	25	25	150
ME 302	Heat Transfer*	40	40	40	60	2	25	25	150
ME 303	Measurements and Instrumentation	40	40	40	60	2	25	25	150
ME 304	Machine Design I	40	40	40	60	2	25	-	125
ME 305	Professional Communication and Ethics II	-	-	-	-	-	50	-	50
ME 30x	DLOC I	40	40	40	60	2	-	-	100
ME 391	Minor Project III	25 (Mid Sem assessment)			-	-	25	25	75
Total				**225**	**300**	**-**	**175**	**100**	**800**

T- Theory , L- Lab , P-Programming, C- Communication
*** - Common with B.Tech in Automobile Engineering**

Group	Department Specialization	Course Code	DLOC I
1	Thermal Engineering and Fluid Science	ME 306	Advanced Fluid Mechanics (T)
2	Design Engineering	ME 307	Design for Excellence (T)
3	Mechatronics & Robotics	ME 308	Control Systems (T)

Program Structure for
Bachelor of Technology in Mechanical Engineering

Semester VI
(Admitted to FY in 21-22)

Course Code	Course Name	Course Component	Teaching Scheme				
			Contact Hours		Credits Assigned		
			Theory	Pract/ Tut	Theory	Pract/ Tut	Total
ME 309	Mechatronics	TL	3	2	3	1	4
ME 310	Machine Design II	T	3	2	3	1	4
ME 311	Power Engineering	T	3	2	3	1	4
ME 3xx	DLOC II	T/TL	3	-	3	-	3
ME 3xx	DLOC III	T/TL	3	-	3	-	3
IL 36x	ILOC I	T	3	-	3	-	3
ME 392	Major Project I	LC	-	6	-	3	3
Total			**18**	**12**	**18**	**6**	**24**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract /Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)			
		1	2	Avg					
ME 309	Mechatronics	40	40	40	60	2	25	25	150
ME 310	Machine Design II	40	40	40	60	2	25	25	150
ME 311	Power Engineering	40	40	40	60	2	25	25	150
ME 3xx	DLOC II	40	40	40	60	2	-	-	100
ME 3xx	DLOC III	40	40	40	60	2	-	-	100
IL 36x	ILOC I	40	40	40	60	2	-	-	100
ME 392	Major Project I	-			-	-	25	50	75
Total				**240**	**360**	**-**	**100**	**125**	**825**

T- Theory , L- Lab , P-Programming, C- Communication

Group	Department Specialization	Course Code	DLOC II
1	Thermal Engineering and Fluid Science	ME 312	Advanced Heat Transfer (T)
		ME 313	Experimental Methods for Thermal and Fluid Systems (T)
2	Design Engineering	ME 314	Reliability Engineering (T)
		ME 315	Failure Analysis (T)
3	Mechatronics & Robotics	ME 316	Micro Electro Mechanical Systems (T)
		ME 317	Signal Processing (T)

Group	Department Specialization	Course Code	DLOC III
4	Materials Science and Nanotechnology	ME 318	Advanced Composites and Polymeric Materials (T)
		ME 319	Biomaterials & Tissue Engineering (T)
5	Manufacturing Engineering	ME 320	Manufacturing Analytics (T)
		ME 321	Optimization Techniques (T)
6	Energy Science and Engineering	ME 322	Wind Energy & Conversion Systems (T)
		ME 323	Thermal Energy Storage Systems and Applications (T)
7	Automotive System	ME 324	Vehicle Systems (T&L)
		ME 325	Automotive Chassis and Body Systems (T)

Group	Institute Specialization	Course Code	ILOC I
1	Business and Entrepreneurship	IL 360	Entrepreneurship (T)
		IL 361	IPR and Patenting (T)
2	Bio Engineering	IL 362	Introduction to Bioengineering (T)
3	Engineering Design	IL 363	Product Design (T)
4	Art and Humanities	IL 364	Visual Art (T)
		IL 365	Journalism, Media and Communication studies (T)
5	Applied Science	IL 366	Computational Physics (T)
		IL 367	Polymers and Polymeric Materials (T)
6	Life Skills, Repair, Maintenance and Safety	IL 368	Vehicle Safety (T)
		IL 369	Maintenance of Electronics Equipment (T)

Program Structure for
Bachelor of Technology in Mechanical Engineering

Semester VII
(Admitted to FY in 20-21)

Course Code	Course Name	Course Component	Teaching Scheme				
			Contact Hours		Credits Assigned		
			Theory	Pract/ Tut	Theory	Pract/ Tut	Total
ME 401	Production Planning and Systems	T	3	-	3	-	3
ME 402	Refrigeration and Air Conditioning	TL	3	2	3	1	4
ME 4xx	DLOC IV	T/TL	3	-	3	-	3
ME 4xx	DLOC V	T/TL	3	-	3	-	3
IL 4xx	ILOC II	T	3	-	3	-	3
ME 491	Major Project II	LC	-	8	-	4	4
Total			**15**	**10**	**15**	**5**	**20**

Course Code	Course Name	Examination Scheme							
		Theory							
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)	Term Work	Pract /Oral	Total
		1	2	Avg					
ME 401	Production Planning and Systems	40	40	40	60	2	-	-	100
ME 402	Refrigeration and Air Conditioning	40	40	40	60	2	25	25	150
ME 4xx	DLOC IV	40	40	40	60	2	-	-	100
ME 4xx	DLOC V	40	40	40	60	2	-	-	100
IL 4xx	ILOC II	40	40	40	60	2	-	-	100
ME 491	Major Project II	-	-	-	-	-	50	50	100
Total				**200**	**300**	**-**	**75**	**75**	**650**

T- Theory , L- Lab , P-Programming, C- Communication

Group	Department Specialization	Course Code	DLOC IV
1	Thermal Engineering and Fluid Science	ME 403	Thermal Design of Electronic Equipment (T)
		ME 404	Computational Methods in Thermal Engineering (T)
2	Design Engineering	ME 405	Design of Mechanical Systems (T)
		ME 406	Engineering Vibrations (T&L)
3	Mechatronics & Robotics	ME 407	Robotics (T)
		ME 408	Modelling and Simulation (T&L)

Group	Department Specialization	Course Code	DLOC V
4	Materials Science and Nanotechnology	ME 409	Nanotechnology, Nanostructures and Nanomaterials (T)
		ME 410	Electrical, Magnetic and Optoelectronic Materials (T)
5	Manufacturing Engineering	ME 411	Logistics and Supply Chain Management (T)
		ME 412	Quality Engineering (T)
6	Energy Science and Engineering	ME 413	Sustainable/Zero Energy Buildings (T)
		ME 414	Energy Systems Modelling & Analysis (T&L)
7	Automotive System	ME 415	Alternate Fuels and Emissions (T&L)
		ME 416	Automotive Electronics (T&L)

Group	Institute Specialization	Course Code	ILOC II
1	Business and Entrepreneurship	IL 470	E commerce and E business (T)
		IL 471	Business Analytics (T)
2	Bio Engineering	IL 472	Biomedical Instrumentation (T)
3	Engineering Design	IL 473	Design for sustainability (T)
4	Art and Humanities	IL 474	Political Science (T)
5	Applied Science	IL 475	Research Methodology (T)
6	Life Skills, Repair, Maintenance and Safety	IL 476	Maintenance of Mechanical Equipment (T)
		IL 477	Cooking and Nutrition (T)

Program Structure for
Bachelor of Technology in Mechanical Engineering

Semester VIII
(Admitted to FY in 20-21)

Course Code	Course Name	Course Component	Teaching Scheme				
			Contact Hours		Credits Assigned		
			Theory	Pract /Tut	Theory	Pract /Tut	Total
ME 417	Personal Financial Management	T	2	-	2	-	2
ME 4xx	DLOC VI	T/TL	3	-	3	-	3
IL 4xx	ILOC III	T	3		3		3
ME 492	Major Project III	LC	-	4	-	2	2
ME 493	Internship*	LC	-	-	-	8	8
Total			**8**	**4**	**8**	**10**	**18**

Course Code	Course Name	Examination Scheme							
		Theory							
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)	Term Work	Pract /Oral	Total
		1	2	Avg					
ME 417	Personal Financial Management	20	20	20	40	2	-	-	60
ME 4xx	DLOC VI	40	40	40	60	2	-	-	100
IL 4xx	ILOC III	40	40	40	60	2	-	-	100
ME 492	Major Project III	-	-	-	-	-	25	-	25
ME 493	Internship	-	-	-	-	-	200	-	200
Total				**100**	**160**	**-**	**225**	**-**	**485**

T- Theory , L- Lab , P-Programming, C- Communication

*** - Six months internship to be undertaken by the student during the semester**

Group	Department Specialization	Course Code	DLOC VI
1	Thermal Engineering and Fluid Science	ME 418	Instrumentation in Thermal Systems (T&L)
2	Design Engineering	ME 419	Synthesis of Mechanisms (T&L)
3	Mechatronics & Robotics	ME 420	Microprocessor and Controllers (T&L)
4	Materials Science and Nanotechnology	ME 421	Characterization Techniques (T&L)
		ME 422	Processing and Testing of Materials (T&L)
5	Manufacturing Engineering	ME 423	Tool Engineering (T)
		ME 424	Additive Manufacturing (T)
6	Energy Science and Engineering	ME 425	Energy Audit and Management (T)
		ME 426	Solar Energy Engineering (T&L)
7	Automotive System	ME 427	Hybrid & Electric Vehicles (T&L)
		ME 428	Vehicle Dynamics and Control (T&L)

Group	Institute Specialization	Course Code	ILOC III
1	Business and Entrepreneurship	IL 480	Digital Business Management and Digital Marketing (T)
2	Bio Engineering	IL 481	Medical Image Processing (T)
3	Engineering Design	IL 482	Technologies for Rural Development (T)
4	Art and Humanities	IL 483	Economics (T)
5	Applied Science	IL 484	GIS and Remote Sensing (T)
6	Life Skills, Repair, Maintenance and Safety	IL 485	Physical Education (T)
		IL 486	Environmental Management (T)

Department Specialization:
Minimum **Two Specialization** to be completed (Minimum **Three** subjects from each.)

Department Specializations						
1	**2**	**3**	**4**	**5**	**6**	**7**
Thermal and Fluids Science	***Design Engineering***	***Mechatronics & Robotics***	***Materials Science & Nanotechnology***	**Manufacturing Engineering**	***Energy Science and Engineering***	***Automotive System***
Advanced Fluid Mechanics (T)	Design for Excellence (T)	Signal Processing (T)	Advanced Composites and Polymeric Materials (T)	Manufacturing Analytics (T)	Wind Energy & Conversion Systems (T)	Vehicle Systems (T&L)
Advanced Heat Transfer (T)	Reliability Engineering (T)	Micro Electro Mechanical Systems (T)	Biomaterials & Tissue Engg (T)	Optimization Techniques (T)	Thermal Energy Storage Systems and Applications (T)	Automotive Chassis and Body Systems (T)
Experimental Methods for Thermal/Fluid Systems (T)	Failure Analysis (T)	Control Systems (T)	Nanotechnology, Nanostructures and Nanomaterials (T)	Logistics & Supply Chain Management (T)	Sustainable/Zero Energy Buildings (T)	Alternate Fuels and Emissions (T&L)
Thermal Design of Electronic Equipment (T)	Design of Mechanical Systems (T)	Robotics (T)	Electrical, Magnetic and Optoelectronic Materials (T)	Quality Engineering (T)	Energy Systems Modelling & Analysis (T&L)	Automotive Electronics (T&L)
Computational methods in Thermal Engg (T)	Engineering Vibrations (T&L)	Modelling and Simulation (T&L)	Characterization Techniques (T&L)	Tool Engg (T)	Energy Audit and Management (T)	Hybrid & Electric Vehicles (T & L)
Instrumentation in Thermal Systems (T&L)	Synthesis of Mechanisms (T&L)		Processing and Testing of Materials (T&L)	Additive Manufacturing (T)	Solar Energy Engineering (T&L)	Vehicle Dynamics and Control (T&L)

Institute Specialization:

Minimum **One Specialization** to be completed (Minimum **Three** subjects from each.)

Institute Specializations					
1	**2**	**3**	**4**	**5**	**6**
Business and Entrepreneurship	***Bio Engineering***	***Engineering Design***	***Art and Humanities***	***Applied Science***	***Life Skills, Repair, Maintenance and Safety***
Entrepreneurship	Introduction to Bioengineering	Product Design	Visual Art	Computational Physics	Vehicle Safety
IPR and Patenting	Biomedical Instrumentation	Design for Sustainability	Journalism, Media and Communication studies	Polymers and Polymeric Materials	Maintenance of Electronics Equipment
E- Commerce and E-Business	Medical Image Processing	Technologies for Rural Development	Political Science	Research Methodology	Maintenance of Mechanical Equipment
Business Analytics			Economics	GIS and Remote Sensing	Cooking and Nutrition
Digital Business Management and Digital Marketing					Physical Education
					Environmental Management

SEMESTER I

SEMESTER II

SEMESTER III

Course Code	Course Name	Credits
ME 201	**Manufacturing Processes**	**3+1**

Course Objectives:

1. To familiarize with the various production processes used on shop floors
2. To study appropriate production processes for a specific application.
3. To introduce to the learner various machine tools used for manufacturing
4. To introduce to the learner various production toolings used for manufacturing

Course Outcomes:

Learner will be able to

1. Demonstrate an understanding of casting and forming process
2. Demonstrate applications of various types of welding processes.
3. Operate machine tools for various machining processes and Select proper machine tools and cutting tools for economic production.
4. Develop competency for selecting appropriate machining parameters to optimize output characteristics such as MRR, surface finish.
5. Design jigs and fixtures for simple jobs and Select dies for sheet metal processing
6. Illustrate the concept of producing polymer components and ceramic components.

Theory Syllabus:

Module	Detail Content	Hrs.
1	**Introduction to Production Processes and Metal Casting** 1.1. Classification of Production Processes and applications areas 1.2. Pattern making materials, Types of pattern and allowances. 1.3. Sand moulding and Machine moulding 1.4. Gating system :Types of riser, types of gates, solidification 1.5. Special casting processes : CO2 and shell moulding, Investment casting, Die casting, Vacuum casting, Inspection & casting defects and remedies	06
2	**Joining Processes** 2.1. Classification of various joining processes; Applicability, advantages and limitations of Adhesive bonding, Mechanical Fastening; Welding and allied processes, Hybrid joining processes. 2.2. Classification and Working of various welding methods: Gas, Arc, Chemical, Radiant, Solid State etc. 2.3. Welding Joints, Welding Positions, Welding defects and their remedies.	08
3	**Forming processes** 3.1 Introduction and classification of metalworking processes, hot and cold working processes 3.2 Introduction, classification and analysis of forging and rolling operations, Defects in rolled and forged components, 3.3 Extrusion process, Classification and analysis of wire and tube drawing processes.	06
4	**Machine Tools and Machining Processes** Lathe Machines, Milling Machines, Drilling Machines, and Grinding Machines and selection of grinding wheel (Dressing and Truing), Broaching	08

	machines, Lapping/Honing machines (Super Finishing Operations) and shaping/slotting/planning Machines. **Gear Manufacturing** Gear milling, standard cutters and limitations, Gear Hobbing, Gear Shaping, Gear Shaving and Gear Grinding processes	
5	**Machining science** Theory of metal cutting Mechanics of chip formation, Concept of chip formation and types of chips, Geometry and nomenclature of single point cutting tool, Speed, feed, depth of cut, Taylor's tool life equation, factors affecting tool life, MRR, Computation of tool life. **Sheet metal working processes** Classification of Sheet metal operations, types of Presses used in sheet metal operations, types of dies, metal cutting in a punch and die set up, die details and accessories, clearance, angular clearance, economic strip layout, centre of pressure, cutting forces, methods of reducing cutting forces. Force calculations. **Work holding devices** Introduction to Jigs and Fixtures and types, P3-2-1 principle of location and principles of clamping and guiding. Design of jig for simple component, design of milling fixture for simple component.	08
6	**Polymer Processing:** Polymer Molding Techniques for thermoplastic and thermosetting plastics. Applications of Plastics in engineering field, compression moulding, transfer moulding, injection moulding, film and sheet forming, thermoforming and their applications. **Powder Metallurgy** Introduction to PM, Powder making processes, Steps in PM. Compaction and Sintering processes. Secondary and finishing operations in PM.	04

Laboratory Syllabus:

S. No.	Details	Hrs.
1	Introduction to Lathe Machine, demonstration of various machining processes performed on lathe machine. One Job on Plain and Precision Turning, Taper Turning and; Screw Cutting by setting gear train; for desired thread cutting on lathe as per chart	10
2	Introduction to Shaping Machine and various machining processes performed on Shaping Machine One job on shaping machine to make horizontal and inclined surface	04
3	One composite job including welding, grinding, milling,	10
4	Lathe Machine maintenance activity, like apron overhauling, tailstock overhaul etc.	02

Theory Assessment:
Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests - 40 Marks
2. Continuous evaluation- Test/Assignments /Quiz/Case studies/Seminar presentation - 40 Marks

End Semester Examination: 60 Marks
Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Laboratory Assessment:
Internal Assessment for 50 marks.
Term Work:

1. All the jobs mentioned above
2. Complete Work-Shop Book giving details of drawing of the job and time sheet

The distribution of marks for Term work shall be as follows:

Job Work with complete workshop book : 40 marks
Attendance : 10 marks

Books/References:

1. Welding technology by O P Khanna
2. Foundry technology by O P Khanna
3. Elements of workshop technology. Vol. 1 & II by S K Hajra Choudhury
4. Tool Design by Cyril Donaldson, George H. LeCain, and V. C. Goold
5. Jigs and Fixtures by P H Joshi, Tata McGraw Hill
6. Manufacturing Science by Ghosh and Malik
7. Rapid Manufacturing –An Industrial revolution for the digital age by N.Hopkinson, R.J.M.Hauge, P M, Dickens, Wiley
8. Rapid Manufacturing by Pham D T and Dimov, Springer Verlag
9. Production Technology by WAJ Chapman Vol I, II, III
10. Production Technology by P C Sharma.
11. Production Technology by Raghuvanshi.
12. Industry 4.0: The Industrial Internet of Things by Alasdair Gilchrist, 2016, Apress.
13. Cyber-Physical Systems: From Theory to Practice by Danda B. Rawat, Joel Rodrigues, Ivan Stojmenovic, 2015, C.R.C. Press.
14. Optimization of Manufacturing Systems using Internet of Things by Yingfeng Zhang, Fei Tao, 2017, Academic Press (AP), Elsevier.

Course Code	Course Name	Credits
ME 202	**Engineering Mathematics III**	**2**

Course Objectives:

1. To learn the Laplace Transform, Inverse Laplace Transform of various functions, and its applications.
2. To understand the concept of Fourier Series and enhance the problem-solving skills, To learn complex form of Fourier series and Fourier Transform
3. To understand the concept of Fourier Series and enhance the problem-solving skills,
4. To learn complex form of Fourier series and Fourier Transform.
5. To understand the regression analysis and interpolation methods.
6. To learn matrices eigen values and eigen vectors useful in engineering.

Course Outcomes:

On successful completion of course learner/student will be able to:

1. Understand the concept of Laplace transform and its application to solve the real integrals.
2. Understand the concept of inverse Laplace transform of various functions and its applications in engineering problems.
3. Apply the knowledge of Fourier series in engineering problems.
4. Apply the knowledge of complex form of Fourier series and Fourier Transform in problem solving.
5. Apply the concept of regression and interpolation in engineering problems.
6. Use the concept of matrices eigen values in many areas of research.

Theory Syllabus:

Module	Detailed	Hrs.
1	**Laplace Transform** 1.1 Definition, Laplace Transforms of Standard Functions. 1.2 Linearity properties of Laplace Transform, First Shifting theorem, 1.3 Change of scale Property, Effect of multiplication by t, 1.4 Effect of Division by t.	4
2	**Inverse Laplace Transform** 2.1 use of standard formulae of Inverse Laplace Transform , 2.2 Partial fractions method, 2.3 First shift property, 2.4 Convolution theorem (without proof) .	4
3	**Fourier Series** 3.1 Orthogonal and orthonormal set of functions, 3.2 Fourier series of periodic function with period 2π , 3.3 Fourier series of even and odd functions with period 2π, 3.4 Half range Sine and Cosine Series with period π.	4

4	**Fourier Integral and Fourier Transform** 4.1 Complex form of Fourier Series with period 2π , 4.2 Fourier Integrals , 4.3 Fourier transform (Definition only), 4.4 Fourier cosine and sine transform of constant and exponential function.	4
5	**Interpolation, Regression , Correlation & Fitting of Curves** 5.1 Interpolation: - Lagrange's Linear and Quadratic 5.2 Linear Regression, Lines of regression 5.3 Karl Pearson's Coefficient of correlation (r) , Spearman's Rank correlation coefficient (R) (Repeated & non repeated ranks problems). 5.4 Fitting of Curves : Fitting of straight line and Second degree curve by Method of least squares.	4
6	**Matrices** **Prerequisite:** Inverse of a matrix, addition, multiplication and transpose of a matrix ,Elementary row and column transformation, System of homogeneous and non –homogeneous equations, their consistency and solutions 6.1 Eigen values and Eigen vectors of Matrices. 6.2 Properties of Eigen values without proof. 6.3 Cayley Hamilton theorem(Without Proof): Verification of Cayley Hamilton theorem (CHT) , 6.4 Application of CHT to find inverse of a matrix .	4

Theory Assessment:
Internal Assessment Test:
Assessment consists of two class tests of 30 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and IA2 is in the form of Term Work for 30 marks . Duration of the test shall be 75 minutes.

End Semester Theory Examination:

1. Question paper will comprise of total 4 questions, each carrying 15 marks.
2. Total 03 questions need to be solved.
3. Question No: 01 will be compulsory and based on the entire syllabus wherein 5 sub-questions of 3 marks each will be asked.
4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to number of respective lectures mentioned in the syllabus.

Books/References:

1. Higher Engineering Mathematics, Dr.B.S.Grewal, Khanna Publication
2. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley EasternLimited, 9thEd.
3. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa publication,
4. Probability, Statistics and Random Processes, T. Veerarajan, McGraw-Hill education
5. Advanced Engineering Mathematics H.K. Das, S. Chand, Publications
6. Matrices, Shanti Narayan, S. Chand publication.
7. Introductory Methods of Numerical Analysis, S. S. Sastry, Prentice-Hall of India Private Limited.

Course Code	Course Name	Credits
ME 203	**Strength of Materials**	**3+1**

Prerequisites:

1. Fundamentals of engineering mechanics
2. Concept of centroid, Analysis of forces and moments
3. Algebra and trigonometry, Elementary Calculus

Course Objectives:

1. To understand mechanical behavior of the body by determining the stresses, strains and deflections produced by the loads up to the elastic limit.
2. To understand the fundamental concepts related to shear force and bending moments, torsional moments, strain energy.
3. To understand the fundamental concepts related to deflection of beams, columns and struts, thin cylindrical and spherical shells

Course Outcomes: Upon successful completion of this course, learner will be able to:

1. Apply principles of statics to determine reactions & internal forces in statically determinate beams
2. Understand the different types of stresses and strains developed in the member subjected to axial, bending, shear & torsional loads.
3. Compute slope and deflection at various points of a beam.
4. Identify, formulate, and solve static engineering problems.
5. Comprehend the behaviour & properties of engineering materials.

Theory Syllabus:

Module	Detail Content	Hrs.
1	**Simple stresses and strains:** Stress, strain, Stress-strain diagram for ductile and brittle materials, factor of safety. Hooke's law, Poisson's ratio, Modulus of Elasticity, Modulus of Rigidity, Bulk Modulus. Interrelation between elastic constants. Thermal stresses and strains. Principal stresses and Principal planes, Mohr's circle. Moment of Inertia and Polar moment of Inertia.	06
2	**Shear Force and Bending Moment in Beams:** Definition of bending moment and shear force, Sign conventions, Relationship between load intensity, bending moment and shear force. Shear force and bending moment diagrams for statically determinate beam due to concentrated load, uniformly distributed load, uniformly varying load and couple, Point of Contraflexure. Beams with Internal Hinges/Moment Release (limited to two per beam).	07
3	**Stresses in Beams:** **Flexural stresses –** Theory of simple bending, Assumptions, derivation of equation of bending, neutral axis, determination of bending stresses, section modulus. **Shear stresses –** Derivation of formula, shear stress distribution across various beam sections like rectangular, circular, I, T sections **Direct and Bending stresses-** Introduction, eccentric loading, columns with eccentric loading, Limit of eccentricity,	07

4	**Torsion of Shafts:** Introduction to Torsion, Torsion formula – stresses and deformations in circular and hollow shafts, Stepped shafts, Design of shafts according to theories of failure. **Strain Energy:** Strain energy due to axial load (gradual, sudden and impact), Strain energy due to bending and torsion.	06
5	**Deflection of Beams:** Double integration method, Maxwell's reciprocal theorems for computation of slopes and deflection in beams for point and distributed loads, derivation of formula for slope and deflection for standard cases, Area moment theorems for computation of slopes and deflections in beams – Conjugate beam method	07
6	**Columns and Struts:** Concept of buckling of columns, derivation of Euler's formula for buckling load for columns with various end conditions, concept of equivalent length, limitations of Euler's formula, Rankine's formula, safe load on columns. **Thin Cylinders and Spheres:** Cylinders and Spheres due to internal pressure, Cylindrical shell with hemispherical ends.	07

Laboratory Syllabus:

Module	Details	Hrs.
1	Tension Test on Mild Steel Bar and other ductile materials using UTM (Universal Testing Machine), for specimens having diameter between 6 - 12 mm.	2
2	Compression Test on Concrete or Wooden Block using UTM.	2
3	Flexure (Bending) Test on Simply Supported Beam (3 Point Bending) using UTM.	2
4	Shear Test on rods of various materials using Shear Attachment on UTM.	2
5	Hardness Tests using Hardness Testing Machine: (a). Rockwell Hardness Test (b). Brinell Hardness Test	2
6	Impact Tests on Impact Testing Machine: (a). Izod Impact Test (b). Charpy Impact Test	2
7	Torsion Test on Tor-steel rod using Torsion Testing Machine.	2
8	Tensile Test on thin cross-section (rectangular/circular) specimens using Tensile Testing Machine.	2

Theory Assessment:
Internal Assessment: 40 marks.

1. Consisting of One Compulsory Class Tests - 40 Marks
2. Continuous evaluation- Test/Assignments /Quiz/Case studies/Seminar presentation - 40 Marks

End-Semester (Theory) Examination: 60 marks.
Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Laboratory Assessment:

Term Work: 25 marks.

Term Work consists of an ample number of assignments and experiments as decided by the Instructor. Mini-project based on this subject may be undertaken for which the number of assignments may be suitably reduced. Students can also avail NPTEL Certification for this course, which shall be considered in place of the assignment work.

Viva-você / Practical: 25 marks.

Viva-você (on the entire syllabus) or Practical exam (on at least one experiment) shall be conducted at the end of the course. In case both viva-voce and practical exams are conducted, 15 marks shall be allotted to viva-voce and 10 marks to the practical exam.

Books/References:

1. S. S. Rattan, Strength of Materials, TMH Publications
2. R.K. Bansal, Strength of Materials, Laxmi Publications, India
3. Beer and Johnston - Strength of materials - CBS Publication
4. Ramamrutham - Strength of material - Dhanpat Rai Publication
5. W. A. Nash and M. C. Potter, Strength of Materials, Schaum's Outline Series, McGraw-Hill
6. Singer and Pytel - Strength of materials - Harper and Row Publication
7. Strength of Materials - Lab Manual, by Anand Jayakumar Arumugham, Notion Press.
8. Experiments in Strength of Materials and Cement Laboratory, by Earl B. Smith, Leopold Classic Library.
9. Laboratory Strength of Materials, by Murad, Hassan, Abdulrahman

Course Code	Course Name	Credits
ME 204	**Thermodynamics**	**3**

Course Objectives:

1. To explore ideas about energy into forms suitable for engineering analysis.
2. To introduce entropy and show its use for thermodynamic analysis.
3. To study power systems utilizing working fluids like vapour and gas.
4. To study the overview of fuels & combustion.
5. To demonstrate the procedures for determining thermodynamic properties of pure substances from tables of property data.
6. To introduce the first law of thermodynamics, energy balances, and mechanisms of energy transfer to or from a system.

Course Outcomes:

Upon successful completion of this course, the learner will be able to

1. Able to solve energy balance problems for closed (fixed mass) systems that involve heat and work interactions
2. Able to apply the second law of thermodynamics to cycles and cyclic devices.
3. Able to evaluate internal energy, enthalpy, entropy of simple compressible systems from properties that are more readily measured.
4. Able to calculate the enthalpy of reaction, enthalpy of combustion, and the heating values of fuels.
5. Able to investigate the performance of vapour & gas power cycles.
6. Able to do the availability analysis for the design and analysis of thermal systems.

Module	Detail Content	Hrs.
1	**1.1 Introduction** Importance of Thermodynamics, concept of equation of state, energy, internal energy, specific properties, heat & work transfer, pdV work or displacement work. **1.2 First Law of thermodynamics** First law applied to the closed system undergoing a cycle and change of state, ideal gas processes, PMM1. Flow process and flow energy, First law applied to steady flow processes, − vdp work, relation between non flow work and flow work, Limitations of the 1st law.	6
2	**2.1 Second Law of Thermodynamics:** Thermal reservoir, Concept of heat engine, Heat pump and Refrigerator, Statement of the second law of thermodynamics, equivalence between Kelvin-Planck and Clausius statement, Reversible and irreversible Process, Causes of irreversibility, PMM2, Carnot cycle, Carnot theorem, Corollary of Carnot theorem, Thermodynamic temperature scale. **2.2 Entropy:** Clausius Inequality theorem, Entropy - a property of the system, Temperature-Entropy diagram, increase of entropy principle, entropy transfer and entropy generation, Entropy balance, Entropy change during a process.	7
3	**3.1 Availability:** Quality energy, available and unavailable energy, useful work and dead state, availability of closed systems and steady flow process. **3.2 Thermodynamic Relations**	6

	Helmholtz and Gibbs functions, Maxwell equation (without derivation), TdS relations, Volumetric expansivity, Isothermal & isentropic compressibility, Clausius-Clapeyron equation, Joule Thomson coefficient – porous plug experiment, definition of third law of thermodynamics.	
4	**4.1 Properties of Pure Substance:** Pure substance, phase change phenomenon of pure substance, saturation pressure and saturation temperature, terminology of pure substance, P-V-T surfaces, p-v, p-T, T-s & h-s (Mollier diagram) diagrams, Steam diagram, critical point and triple point, Quality of steam, Calculation of various properties of steam, advantages & applications of use of steam, **4.2 Vapour Power Cycle:** Carnot cycle, Limitations of Carnot vapour cycle, Rankine cycle, mean temperature of heat addition, Rankine cycle with superheat, reheat.	7
5	**5.1 Gas Power Cycle:** Nomenclature of a reciprocating engine, Mean effective pressure, Assumptions of air Standard Cycle, Otto cycle, Diesel Cycle and Dual cycle, Comparison of Otto and Diesel cycle for same compression ratio. Working principle of Brayton Cycle, Stirling Cycle, Ericsson Cycle, Lenoir cycle and Atkinson cycle. (No Numerical for Brayton, Stirling, Ericsson, Lenoir & Atkinson Cycle).	6
6	**6.1 Combustion Thermodynamics:** Complete and incomplete combustion, air fuel ratio, theoretical and excess air for combustion, enthalpy of formation, analysis for a non flow process involving combustion at constant volume, analysis of steady flow or constant pressure combustion, heating values, adiabatic flame temperature, combustion efficiency enthalpy and internal energy of combustion.	6

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/ Assignments / Quiz/ Case studies/ Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Fundamentals of engineering thermodynamics by Michael J. Moran &Howard N. Shapiro, John wiley and Sons, Fifth edition,
2. Applied thermodynamics by B K Ventanna, PHI publications.
3. Thermodynamics: An Engineering Approach by Yunus A. Cengel and Michael A. Boles, 9th edition, TMH
4. Basic Engineering Thermodynamics by Rayner Joel, 5thedition, Longman Publishers
5. Engineering Thermodynamics by P Chattopadhyay, 2ndedition, Oxford University Press India
6. Thermodynamics by P K Nag, 6thEdition,TMH
7. Thermodynamics by Onkar Singh, 4th Edition New AgeInternational
8. Thermodynamics by C P Arora,1st EditionTMH
9. Thermal Engineering By Ajoy Kumar, G. N. Sah, 2nd Edition, Narosa Publishing house

10. Engineering Thermodynamics Through Examples by Y V C Rao, Universities Press (India) PvtLtd
11. Fundamentals of Thermodynamics by Moran &Shapiro, Eighth Edition, Wiley
12. Fundamentals of Classical Thermodynamics by Van Wylen G.H. & Sonntag R.E., 9th Edition John Wiley & Sons
13. Thermodynamics by W.C. Reynolds, McGraw-Hill &Co
14. Thermodynamics by J P Holman, 4th Edition McGraw-Hill & Co.

Course Code	Course Name	Credits
ME 205	**Metallurgy and Materials**	**3+1**

Prerequisites:

1. 12th std Chemistry
2. 12th std Physics

Course Objectives:

1. To help students know about the different types of materials
2. To enable students to make a good selection of materials
3. To be able to understand the significance of structure property relationship

Course Outcomes:

Upon successful completion of this course, learner will be able to:

1. Identify the different classes of materials
2. Suggest ways to improve the strength of materials
3. Differentiate between steels and cast irons wrt composition and property development
4. Analyse the phase transformations in steels
5. Apply heat treatment to different components based on the property requirement
6. Evaluate the reasons of failure in components and take corrective actions

Theory Syllabus:

Module	Detail Content	Hrs.
1.	Classification of Materials, Crystal Structures,Miller's indices for planes and directions. Crystal Defects,	6
2.	Deformability and Strengthening mechanisms-Hot and Cold working, Recrystallisation-its effects and factors affecting it	6
3.	Concepts of solidification, Phases,Phase diagrams, Alloying - Fe-Fe3C diagram and cooling of steels and cast irons,	10
4.	Austenite transformation-equilibrium and non equilibrium, Hardenability and its importance, Alloy Steels-stainless steels, tool steels,	6
5.	Heat treatments-Thorough and Surface. Isothermal treatments - Patenting, Austempering and martempering, Ausforming and Maraging	5
6.	Failure by fracture-micromechanisms-fatigue and creep. Non destructive evaluation to prevent failures	6

Laboratory Syllabus:

Module	Details	Hrs.
1	Study of Characterization techniques and Metallographic sample preparation and etching	2
2	Comparison of Microstructures and hardness before and after Annealing, Normalizing and Hardening in medium carbon steel	2
3	Study of tempering characteristics of hardened steel	2
4	Determination of hardenability of steel using Jominy end Quench Test (Using different hardness testers to measure the Hardness)	2
5	Fatigue test – to determine number of cycles to failure of a given material at a given stress	2

6	Tension test on mild steel bar (stress-strain behaviour, determination of yield strength and modulus of elasticity)	2
7	Torsion test on mild steel bar / cast iron bar	2
8	Impact test on metal specimen (Izod/Charpy Impact test)	2
9	Hardness test on metals – (Brinell/ Rockwell Hardness Number	2

Theory Assessment:
Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/ Assignments / Quiz/ Case studies/ Seminar presentation of 40 Marks

End Semester Examination: 60 Marks
Weightage of each module in end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Laboratory Assessment:
Term Work Marks: 25 Marks

1) Laboratory Work (Journal Completion): 20 Marks
2) Attendance: 5 Marks

Books/References:

1. Materials Science and Engineering: An Introduction: Willaim Callister Jr. and David G. Rethwisch, Wiley Publication
2. Introduction to Physical Metallurgy, Sidney H. Avner, Tata Mcgraw Hill
3. Introduction to Engineering Materials,BK Agrawal, TataMcgraw Hill
4. Materials Science and Engineering: A First Course,Raghavan V, Prentice Hall India
5. Materials Science and Engineering: An Introduction: Willaim Callister Jr. and David G. Rethwisch, Wiley Publication
6. Introduction to Physical Metallurgy, Sidney H. Avner, Tata Mcgraw Hill
7. Introduction to Engineering Materials,BK Agrawal, TataMcgraw Hill
8. Materials Science and Engineering: A First Course,Raghavan V, Prentice Hall India
9. Automotive Materials, Brian Cantor

Course Code	Course Name	Credits
ME 206	**Computer Aided Drafting**	**1**

Prerequisites:

1. Engineering Drawing

Course Objectives:

1. To impart the 3D modeling skills for development of 3D models of basic engineering components.
2. To introduce Product data exchange among CAD systems.
3. To familiarize with production drawings with important features like GD&T, surface finish.

Course Outcomes: Upon successful completion of this course, learner will be able to

1. Visualize and prepare 2D modeling of a given object using modelling software.
2. Build a solid model of a given object using 3D modeling software.
3. Visualize and develop the surface model of a given object using modelling software.
4. Generate assembly models of given objects using assembly tools of a modelling software

Module	Detail Content	Hrs.
1	**CAD Introduction** CAD models Creation, Types and uses of models from different perspectives. Parametric modelling and Non - Parametric Modelling. **GD & T** Limits, Fits and Tolerance	4
2	**2D Sketching** Geometric modeling of an Engineering component, sketching commands of creation, modification commands and viewing the sketch.	4
3	**Solid Modeling** 3D Geometric modeling of an Engineering component, modeling features. Using 3D components from software library (Eg. Nut, Bolt, Screw etc.)	6
4	**Surface Modeling** Extrude, Sweep, Trim etc and Mesh of curves, free form surfaces etc. Feature manipulation using Copy, Edit, Pattern, Suppress, History operations etc.	6
5	**Assembly** Constraints, Exploded views, interference check. Drafting (Layouts, Standard & Sectional Views, Detailing & Plotting), Bill of materials, Giving machining symbols using software in drafting.	4
6	**Data Exchange** CAD data exchange formats Like IGES, PDES, PARASOLID, DXF and STL along with their comparison and applicability. **Case Study**	2

Assessment:

Term work:

1. Printouts/Plots: 20 marks
2. Attendance : 05 marks

Using the above knowledge and skills acquired through six modules students should complete minimum six assignments/experiments from the given sets of assignments **(two from each set)** using standard CAD modeler like PTC Creo/CATIA/ Solid work/UG /any other suitable software.

Set 1: Beginner Level:

3D modeling of basic Engineering components likes Nuts, Bolts, Keys, cotter, Screws, Springs etc.

Set 2: Intermediate Level:

3D modeling of basic Machine components like Clapper block, Single tool post, Lathe and Milling tail stock, Shaper tool head slide, jigs and fixtures Cotter, Knuckle joint, Couplings: simple, muff, flanged Protected flange coupling, Oldham's coupling, Universal coupling, element of engine system and Miscellaneous parts.

Set 3: Advance Level:

1. Generation of any Assembly model (minimum five child parts) along with Production drawing for any of the system by creating 3D modeling with assembly constraints, Interference check, Exploded view, GD&T, Bill of material.
2. Reverse Engineering of a physical model: disassembling of any physical model having not less than five parts, measure the required dimensions of each component, sketch the minimum views required for each component, convert these sketches into 3-D model and create an assembly drawing with actual dimensions.

End Semester Practical/Oral examination:

To be conducted by pair of Internal and External Examiners

1. Practical examination duration is two hours, based on Advance level of the Term work. Oral examination should also be conducted to check the knowledge of CAD Modelling Tools.
2. The distribution of marks shall be as follows:
   Practical Exam : 30 marks
   Oral Exam : 20 marks
3. Evaluation of practical examinations to be done based on the printout of students' work.
4. Students work along with evaluation reports to be preserved till the next examination.

Books/References:

1. Machine Drawing by N.D. Bhatt.
2. A textbook of Machine Drawing by Laxminarayan and M.L.Mathur, Jain brothers Delhi
3. Machine Drawing by Kamat and Rao
4. Machine Drawing by M.B.Shah
5. A text book of Machine Drawing by R.B.Gupta, Satyaprakashan, Tech. Publication
6. Machine Drawing by K.I. Narayana, P. Kannaiah, K.Venkata Reddy
7. Machine Drawing by Sidheshwar and Kannaiah

Course Code	Course Name	Credits
ME 291	**Minor Project I**	**2**

Course Objectives:

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4. To inculcate the process of self-learning and research.

Course Outcome: Learner will be able to

1. Identify problems based on societal /research needs.
2. Apply Knowledge and skill to solve societal problems in a group.
3. Develop interpersonal skills to work as member of a group or leader.
4. Draw the proper inferences from available results through theoretical/ experimental/simulations.
5. Analyse the impact of solutions in societal and environmental context for sustainable development.
6. Use standard norms of engineering practices
7. Excel in written and oral communication.
8. Demonstrate capabilities of self-learning in a group, which leads to life long learning.
9. Demonstrate project management principles during project work.

Guidelines for Minor Project:

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do surveys and identify needs, which shall be converted into a problem statement for minor-project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Student groups shall submit an implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of the minor project.
- A log book has to be prepared by each group, wherein the group can record weekly work progress, and the guide/supervisor can verify and record notes/comments.
- Faculty supervisors may give inputs to students during minor project activity; however, focus shall be on self-learning.
- Students in a group shall understand the problem effectively, propose multiple solutions and select the best possible solution in consultation with the guide/supervisor.
- Students shall convert the best solution into a working model using various components of their domain areas and demonstrate.
- The solution has to be validated with proper justification and the report has to be compiled in the standard format.
- With the focus on self-learning and innovation, addressing societal problems and entrepreneurship quality development within the students through the Minor Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students. i.e. Minor Project 1 in semester III and IV. Similarly, Minor Project 2 in semesters V and VI may be considered. In other words, based on the individual students' or group's capability, with the mentor's recommendations, if the proposed Minor Project adhering to the

qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Minor Project, in even semester with suitable improvements/modifications.

- Alternatively, student groups can work completely on a new project idea in the even semester, bearing no resemblance with the topic of odd semester. This policy can be adopted on a case to case basis.

Assessment:
Term Work - 25 marks
Mid Semester Evaluation - 25 marks
Practical/Oral Examination - 25 marks

Guidelines for Assessment of Minor Project - Term Work:

- The review/ progress monitoring committee shall be constituted by heads of department. The progress of the minor project to be evaluated on a continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In the first semester the entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on the presentation given by the student group.
  - If the problem is based on development of a mechanism or a simple device for attaining a desired objective, the first presentation shall be reviewed based on generation of multiple feasible solutions to the given problem and identification of the best possible solution based on various parameters which may include one of more of the following viz., the total weight, volume, power consumption, mechanical advantage, efficiency, cost (including labour) per piece once manufactured, and so on. This may include creation of unique free-hand sketches by each and every member of the group to contribute to the solution of the given problem. The best possible solution has to be finalized during one or more brainstorming sessions by the members of the student group. In case the problem is of a programming/coding type, then the first presentation may be dedicated to the understanding of the theory behind the problem related to a particular domain subject, including the drafting of an algorithm and/or flowchart, and may also include the introductory part of the programming.
  - Second review shall be based on the computerization (3D CAD model of parts and assembly), and possibly the animation, depicting the working characteristics of the proposed solution to the given problem, allocating material properties to each part, identifying mass properties of the assembled parts, and so on. Checking interference is one of the important criteria that can be used when assembling the parts. For software based projects, this may include the presentation based on the extension of the programming work so as to cover the major portion of the remaining part of the topic.

- In the second semester expected work shall be procurement of components/systems, building of working prototype, testing and validation of results based on work completed

in an earlier semester. For those selecting software based projects, this may include completing the other half of the programming related work, identifying the errors, optimizing the software code, customization, creating a graphical user interface of input and output (GUI), displaying output data in the form of graphs/tables/figures/diagrams, creation of the code in executable (.exe) format or in the form of a mobile App, etc.
    - First review shall be conducted based on the readiness of the working prototype, or programming of the remaining code for software based projects.
    - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester. This may also include the testing and validation of tests with the literature/available data/theory. For software based projects, the presentation includes the remaining work other than the programming, as described above.

- Apart from the hardware type (development of device) and software (program/coding) type of projects, the topics may also include computer based work, viz., generation of virtual laboratory (for one or more experiments) for any subject/domain of choice, or CAD modeling, analysis, optimization, and/or product design, without any relevance to developing any physical product.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including:
    - Identification of need/problem
    - Proposed final solution
    - Procurement of components/systems
    - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
    - First shall be for finalisation of problem and proposed solution
    - Second shall be for implementation and testing of solutions.

Assessment criteria of Minor Project:

1. Quality of survey/need identification
2. Clarity of problem definition based on need
3. Innovativeness/uniqueness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness/uniqueness
8. Cost effectiveness and societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual as member or leader
13. Clarity in written and oral communication

- In a **one year project**, the first semester evaluation may be based on the first six criteria as highlighted above and the remaining criteria may be used for second semester evaluation of performance of students in the minor project.
- In the case of a **half year project,** all criteria in general may be considered for evaluation of performance of students in the minor project.

Guidelines for Assessment of Minor Project - Practical/Oral Examination:

- Report should be prepared as per the guidelines issued.
- Minor project shall be assessed through a presentation and demonstration of working model or the execution of programme code by the student project group to a panel of Internal and External Examiners preferably from industry or research organisations having experience of more than five years approved by the Head of Institution.
- Students shall be motivated to publish a paper based on the work in conferences or student competitions.

Course Code	Course Name	Credits
ME 207	**Advanced Manufacturing Technology**	**3+1**

Course Objectives:

1. To familiarize with subtractive manufacturing processes in particular CNC systems.
2. To familiarize with various additive manufacturing processes
3. To familiarize with principle and working of non-traditional manufacturing
4. To introduce to them the Intelligent manufacturing in the context of Industry 4.0
5. To acquaint with basic process of developing 3D model using biomedical data.

Course Outcomes:
Learner will be able to

1. Develop and execute CNC part program for various machining operations.
2. Understand the generation of tool paths through different approaches.
3. Identify the additive manufacturing process for development of a component.
4. Illustrate principles and working of non-traditional manufacturing and select the proper process for the purpose of manufacturing.
5. Understand the manufacturing technologies enabling Industry 4.0
6. Develop a 3D model using available 2D images.

Theory Syllabus:

Module	Detail Content	Hrs.
1	**Computer aided Manufacturing:** Introduction, NC/CNC/DNC machines, Machining Centers, Coordinate system. CNC machining practices and programming: Manual part programming method, Canned Cycles for milling, turning.	08
2	**CAPP:** APT, Loops, Macros and Subroutines	06
3	**Additive Manufacturing:** Product development cycle and importance of prototyping, types of prototypes-principles and advantages, different types of generative manufacturing process viz. Vat Photopolymerisation, Material extrusion, Material Jetting, Binder Jetting, Powder bed Fusion, Direct energy deposition, Sheet Lamination.	08
4	**Nano Manufacturing techniques and micro-machining:** High speed machining and hot machining. Introduction to microfabrication for MEMS, bulk micromachining of silicon, surface micromachining of MEMS, wafer bonding for MEMS, LIGA process, micromachining of polymeric MEMS devices, 3D microfabrication	06
5	**Non-traditional Manufacturing processes** – Introduction, Construction, Working principle, Types, Process parameters, problems, merits, demerits and applications of : Chemical Machining, Ultrasonic Machining, Electro-Chemical Machining, Electric Discharge Machining, Electron Beam Machining, Plasma Arc Machining, Laser beam Machining and Ion Beam Machining.	06
6	**Intelligent manufacturing in the context of Industry 4.0:** Collaborative Manufacturing: Definition and Concept, Aims of Collaborative Manufacturing, Business Process Change Considerations for Collaborative Manufacturing, Enabling Technologies for	04

	Collaborative Manufacturing, Benefits and Limitations of Collaborative Manufacturing, Cloud Manufacturing ● Cyber-physical systems (CPS) ● Internet of Things (IoT) enabled manufacturing	

Laboratory Syllabus:

Module	Details	Hrs.
	Part A	
1.	Part programming and part fabrication on CNC Turning trainer (Involving processes like Step turning, facing, Taper turning, threading, etc.)	2
2.	Part programming and part fabrication on CNC Milling trainer (Involving processes like contouring, drilling, facing, pocketing etc.)	2
3.	Part Programming Simulation for any Unconventional Machining Process (Electric Discharge Machining, laser cutting Machining, Plasma Cutting Machining etc.)	2
4.	Tool-path generation by translation of part geometry from computer aided design (CAD) to computer aided manufacturing (CAM) systems.	4
	Part B	
5.	Development of physical 3D mechanical structure using any one of additive manufacturing processes.	4
6.	Study of the effect of variation in various parameters involved in additive manufacturing	2
7.	Creation of 3D model from 2D images using any image processing software and printing it. (3D Slicer open source) (Application: Any body organ like Heart, Gallbladder etc. as per available Dicom files)	2
8.	Manufacturing Simulation and Integration	2
	Part C	
9.	Case Study: Report on a visit conducted to any Commercial CNC Machining Centre explaining the Design features, pre processing in CAM software and its capabilities.	4

Theory Assessment:

Internal Assessment for 40 marks:

1. Consisting of One Compulsory Class Tests **-** 40 Marks
2. Continuous evaluation- Class Test/Assignments /Quiz/Case studies/Seminar presentation - 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Laboratory Assessment:
Internal Assessment: 50 marks
Term Work:

A. Minimum 3 exercises from 1-4 of the above list need to be undertaken.
B. Minimum 3 exercises from 2-8 of the above list need to be undertaken.
C. Exercise 9 is compulsory. Presentation/Seminar of the study done is required.

The distribution of marks for Term work shall be as follows:

Part A …….20 marks
Part B …….20 marks
Part C …….10 marks

Books/References:

1. CNC Programming for Machining, Kaushik Kumar, Chikesh Ranjan, J. Paulo Davim, Springer Publication.
2. Manufacturing Science by Ghosh and Malik
3. CAD/CAM Computer Aided and Manufacturing, Mikell P. Groover and Emory W. Zimmers, Jr., Eastern Economy Edition
4. CNC Technology and Programming, Krar, S., and Gill, A., McGraw Hill Publishers.
5. CAD/CAM Principles and Applications, P. N. Rao, Tata McGraw Hill Publications
6. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson l D. W. Rosen l B. Stucker, Springer Publication.
7. Rapid Manufacturing –An Industrial revolution for the digital age by N.Hopkinson, R.J.M.Hauge, P M, Dickens, Wiley.
8. Rapid Manufacturing by Pham D T and Dimov, Springer Verlag
9. Rapid Prototyping and Manufacturing, P. F. Jacobs, Society of Manufacturing Engineers
10. Production Technology by P C Sharma.
11. Industry 4.0: The Industrial Internet of Things by Alasdair Gilchrist, 2016, Apress.
12. Cyber-Physical Systems: From Theory to Practice by Danda B. Rawat, Joel Rodrigues, Ivan Stojmenovic, 2015, C.R.C. Press.
13. Optimization of Manufacturing Systems using Internet of Things by Yingfeng Zhang, Fei Tao, 2017, Academic Press (AP), Elsevier.
14. Medical Modelling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
15. Biomaterials, artificial organs and tissue engineering, Edited by Larry L. Hench and Julian R. Jones, Woodhead Publishing and Maney Publishing, CRC Press 2005

Course Code	Course Name	Credits
ME 208	**Theory of Machines & Mechanisms**	**3+1**

Prerequisites:

1. Engineering Mathematics
2. Engineering Mechanics
3. Engineering Physics

Course Objectives:

1. To provide students with the knowledge on mechanisms and inversions.
2. To impart students with knowledge about forces acting on machine parts.
3. To enable students to understand the fundamental concepts of machines.
4. To study functioning of motion and power transmission machine elements.
5. To facilitate students to understand the functions of cams, gears, belt drives, chain drives and brakes.

Course Outcomes:

Upon successful completion of this course, learner will be able to

1. Identify mechanisms and their inversions.
2. Compute velocity and acceleration of various plane mechanisms by different methods.
3. Apply the principles for analyzing cams, gears and gear trains.
4. Synthesize mechanisms for following useful paths.
5. Draw cam profile for specific follower motion.
6. Develop and design mechanisms.

Theory Syllabus:

Module	Detail Content	Hrs.
1.	**Fundamentals of Kinematics and Mechanisms** Concepts of Kinematics and Dynamics, Mechanisms and Machines, Planar and Spatial Mechanisms, Kinematic Pairs, Kinematic Chains, Kinematic Diagrams, Kinematic Inversion. Four bar chain and Slider Crank Mechanisms and their Inversions, Degrees of Freedom, Mobility and range of movement - Kutzbach and Grubler's criterion, Number Synthesis, Grashof's criterion.	06
2.	**Mechanisms with Lower Pairs:** Straight line mechanisms - Exact and Straight, Steering gear mechanisms: Condition for correct steering, Davis steering gear mechanism, Ackermann steering gear mechanism. Hooke's joint- Single and Double.	06
3.	**Velocity and Acceleration Analysis:** **Relative velocity method:** Relative velocity of a point on a link, Angular velocity of a link, Sliding velocity, Velocity polygons for simple mechanisms. **Relative acceleration method:** Relative acceleration of a point on a link, Angular acceleration of a link, Acceleration polygons for simple mechanisms. (limit to only 4 link mechanisms) **Instantaneous center of rotation (ICR) method:** Definition of ICR, Types of ICRs, Methods of locating ICRs (limit to only 6 link mechanisms), Kennedy's Theorem, Coriolis component of acceleration.	08

4.	**Flexible Power Transmission Systems:** **Belts:** Introduction, Types and all other fundamentals of belting, Dynamic analysis—belt tensions, condition of maximum power transmission. **Chains:** Types of chains, chordal action, variation in velocity ratio, length of chain. **Brakes:** Introduction, types and working principles, Introduction to braking of vehicles.	06
5.	**Kinematics of Cams:** Types of cams and followers, Cam and follower terminology, displacement, velocity and acceleration diagrams of follower motions viz Uniform velocity, Simple harmonic motion, Uniform acceleration and retardation motion and cycloidal motion.	06
6.	**Gears and Gear Trains:** **Gears:** Terminology, Law of Gearing, Characteristics of involute and cycloidal action, Interference and undercutting, centre distance variation, minimum number of teeth, contact ratio, spur, helical, spiral bevel and worm gears, problems. **Gear Trains:** Synthesis of Simple, compound & reverted gear trains, Analysis of epicyclic gear trains.	07

Laboratory Syllabus:

Module	Details	Hrs.
1.	3 to 5 problems on velocity analysis using the ICR method.	04
2.	3 to 5 problems on velocity and acceleration analysis using relative velocity and acceleration methods.	04
3.	3 to 5 problems on velocity and acceleration analysis using relative velocity and acceleration methods involving Coriolis component.	04
4.	Plotting of displacement–time, velocity-time and acceleration-time, jerk-time, and layout of cam profiles - 3 to 5 problems	06
5.	Project based learning on design and fabrication of any one mechanism for a group of maximum 4 students.	08

Theory Assessment:
Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests - 40 Marks
2. Continuous evaluation- Class Test/Assignments /Quiz/Case studies/Seminar presentation - 40 Marks

End-Semester Examination: 60 marks
Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Laboratory Assessment:
Term Work: 25 marks
Students have to submit signed and completed assignments based on the modules listed in the table, as a part of the term work. They can also avail NPTEL Certification for this course, for which the assignment work may be suitably reduced, at the discretion of the Instructor.
Viva-você: 25 marks
Viva-você exam shall be conducted at the end of the course.

Books/References:

1. S. S. Rattan, “Theory of Machines”, Tata McGraw Hill
2. R L Norton, Kinematics and Dynamics of Machinery, McGraw-Hill Education
3. Ashok G. Ambekar, “Mechanism and Machine Theory”, Prentice Hall, India
4. Theory of Machines, Singh Sadhu, Pearson Education.
5. Shigley J. E., and Uicker J.J., “Theory of Machines and Mechanism”, McGraw Hill Inc.
6. Wilson C.E., Sandler J. P. Kinematics and Dynamics of Machinery”, Pearson Education.

Course Code	Course Name	Credits
ME 209	**Fluid Mechanics and Machinery**	**3+1**

Course Objectives:

1. To study fluid statics and fluid dynamics
2. To study application of mass, momentum and energy equations in fluid flow.
3. To learn various flow measurement techniques.
4. To study utilization of hydraulic energy

Course Outcomes:

Upon successful completion of this course, the learner will be able to

1. Calculate the forces exerted by fluid at rest on plane or curved submerged surfaces.
2. Apply Bernoulli equation to solve a variety of fluid flow problems.
3. Categorize the type of flow (whether laminar or turbulent) using Reynolds equation.
4. Estimate the loss of energy of the incompressible fluid associated with pipe flow.
5. Compare the performance of the impulse and reaction Turbine and plot their characteristics.
6. Estimate performance parameters of Centrifugal and positive displacement pumps.

Theory Syllabus:

Module	Detail Content	Hrs.
1.	1.1 **Introduction:** Definition of Fluid, Properties of fluid (density, weight density, viscosity, specific gravity). No Numerical. 1.2 Newton's Law of viscosity, Classification of fluid. No Numerical on 1.2. 1.3 **Fluid Statics:** Hydrostatic pressure, Hydrostatic law, Forces on horizontal, vertical and inclined submerged plane.	6
2.	**Fluid Kinematics:** 2.1 Eulerian and Lagrangian approach, Velocity and acceleration in a Eulerian flow field. Classification of the fluid flow, streamlines, path lines and streak lines. 2.2 Definition and equations for stream function, velocity potential function, potential flow, vortex flow. No numerical on 2.2.	5
3.	**Fluid Dynamics:** 3.1 Definition of control volume and control surface, Differential equations for conservation of mass, energy and momentum, 3.2 Euler's equations in one and three dimensions. Derivation of Bernoulli's equation from principle of conservation of energy. Application of Bernoulli's equation in flow measurement device (pitot tube, venturimeter, orifice meter). Impulse momentum equation (Numerical on bent pipe only).	7
4.	**4.1 Laminar Viscous flow**: Introduction to Reynolds number, Derivation of relationship between shear stress and pressure gradient, Laminar flow between stationary parallel plates (only derivation), Laminar flow in circular pipe (Hagen-Poiseuille flow). **4.2 Flow through pipes**: Head loss in pipes due to friction (Darcy-Weisbach equation without proof), Loss of energy in pipe	7

	(major and minor losses), Hydraulic gradient and Energy gradient line, Pipes in series and parallel. **4.3 Hydrodynamic Boundary Layer Theory:** Concept of formation of boundary layer, boundary layer parameters. (No Numerical) **4.4 Flow around submerged objects:** Concept of drag and lift, Types of drag, Streamlined and bluff bodies. (No Numerical)	
5.	**Hydraulic Turbines:** General layout of hydro-electric power plant. Classification of hydraulic turbines, definition of various turbine parameters like head, Euler head, discharge, work done, input power, output power, efficiency, schematic representation of losses in turbine. 5.1 Pelton Turbine: Components, construction, working, workdone and efficiency, velocity triangle, Calculation of velocity of jet, speed ratio, jet ratio, number of jets, head, power and efficiency. 5.2 Francis Turbine: Components, construction and working, velocity diagram and numerical, Draft tube and its function.	7
6.	**Pumps** 6.1 Detailed classification of Pump, applications. 6.2 Reciprocating pumps: operating principle of reciprocating pump, Different types of head, discharge coefficient, slip. Calculation of work done and power input, concept of indicator diagram. 6.3 Centrifugal Pumps: Different types of head, Euler's equation and velocity triangles, pump losses and efficiency, Priming of pumps, Concept of NPSH (No Numerical) 6.4 Concept of multistage pump (No Numerical)	7

Laboratory Syllabus:

Sr. No.	Details	Hrs.
1	Calibration of pressure gauge	2
2	Calibration of venturimeter	2
3	Calibration of orifice meter	2
4	Determination of friction factor for pipes	2
5	Determination of minor losses in pipe fittings	2
6	Verification of Bernoulli's equation	2
7	Trial on Pelton Wheel	2
8	Trial on Francis turbine	2
9	Trial on positive displacement pump (reciprocating/Gear pump/Vane pump/screw pump) (any one)	2
10	Trial on single stage centrifugal pump	2

Theory Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Laboratory Assessment:

Internal Assessment

Term Work Marks: 25 Marks

Laboratory Work (Journal Completion) : 20 Marks
Attendance : 5 Marks

End Semester Practical/Oral Examination:

Pair of Internal and External Examiners should conduct practical/viva based on contents. Distribution of marks for practical/viva examination shall be as follows:

Practical Examination : 15 Marks
Oral Examination : 10 Marks

Books/References:

1. Fluid Mechanics by Yunus A Cengel and John M Cimbala, Tata McGraw Hill Education, 3rd Edition, 2014.
2. Fluid Mechanics and Machinery by C S P Ojha, Chandramouli and R Berndtsson, Oxford University Press, 1st Edition, 2010.
3. Fox and McDonald's Introduction to Fluid Mechanics by Philip J. Pritchard and John W. Mitchell, Wiley Publishers, 9th Edition,2016.
4. A textbook of Fluid Mechanics & Hydraulic machines by R K Bansal, Laxmi Publication, 9th Edition, 2005
5. A textbook of Fluid Mechanics & Hydraulic machines by R K Rajput, S. Chand & company ltd Laxmi Publication, 4th Edition, 2010
6. Fluid Mechanics by Frank M. White, McGraw Hill Education, 7th Edition, 2011.
7. Fluid Mechanics by Victor Streeter, Benjamin Wylie and K W Bedford, McGraw Hill Education, 9thEdition, 2010.
8. Engineering Fluid Mechanics by K. L. Kumar, Eurasia Publishing House (P) Ltd, 1 st Edition and Reprint 2016.
9. Fluid Mechanics and Hydraulic Machinery, Modi and Seth, Standard Book House
10. Introduction to Fluid Mechanics by James A. Fay, MIT Press, Campbridge, 1st Edition, 1996.
11. Fluid Mechanics and Hydraulics by Suresh Ukarande, Ane Books Pvt.Ltd, Revised & Updated 1st Edition, 2016

Course Code	Course Name	Credits
ME 210	**Engineering Mathematics IV**	**2**

Course Objectives:

1. To acquaint with the concepts of probability, random variables,
2. To acquaint with the concepts of probability distribution & expectation.
3. To acquaint with the various probability distributions.
4. To acquaint with the concepts of sampling theory.
5. To learn the partial differential equations and Analytical methods to solve it which are used in engineering problems
6. To learn numerical methods to solve the partial differential equations which are used in engineering problems

Course Outcomes:

On successful completion of course learner/student will be able to:

1. Illustrate understanding of the concepts of probability & random variables.
2. Illustrate understanding of the concepts of probability distribution and expectation for decision making.
3. Use various probability distributions in data science.
4. Use the concept of sampling theory in data science.
5. To apply the analytical methods to find the solution of Mathematical Models of real-life problems
6. To apply the numerical methods to find the solution of Mathematical Models of real-life problems.

Module	Detailed Contents	Hrs.
1	Probability Theory 1.1 Introduction to probability, 1.2 Conditional probability, 1.3 Total Probability 1.4 Baye's Theorem.	4
2	Probability Distribution - I 2.1 Discrete and Continuous random variables, 2.2 Probability mass and density function, 2.3 Probability distribution for random variables, 2.4 Expectation, Variance, Co-variance .	4
3	Probability Distribution – II 3.1 Binomial distribution, 3.2 Poisson distribution, 3.3 Normal distribution .	4
4	Sampling Theory- 4.1 Sampling distribution, Test of Hypothesis, Level of Significance, Critical region, 4.2 One-tailed, and two-tailed test, Degree of freedom. 4.3 Students' t-distribution (Small sample)- Test the significance of single sample mean	4

	4.4 Test the significance of sample means of two independent sample means (paired t-test) .	
5	Partial Differential Equations : Analytical methods 5.1 Introduction of Partial Differential equations Classification 5.2 Method of separation of variables to solve the problem of Vibrations of string, 5.3 One dimensional heat and wave equations.	4
6	Partial Differential Equations : Numerical methods : 6.1 Numerical methods to solve PDE 6.2 Bender Schmidt scheme 6.3 Simplified Crank Nicholson scheme.	4

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 30 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and IA2 is in the form of Term Work for 30 marks . Duration of the test shall be 75 minutes.

End Semester Theory Examination:

1. Question paper will comprise of total 4 questions, each carrying 15 marks.
2. Total 03 questions need to be solved.
3. Question No: 01 will be compulsory and based on the entire syllabus wherein 5 sub-questions of 3 marks each will be asked.
4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to the number of respective lectures mentioned in the syllabus.

References:

1. Higher Engineering Mathematics, Dr.B.S.Grewal, Khanna Publication
2. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley EasternLimited, 9th Ed.
3. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa publication,
4. Probability, Statistics and Random Processes, T. Veerarajan, McGraw-Hill education
5. Advanced Engineering Mathematics H.K. Das, S. Chand, Publications
6. Matrices, Shanti Narayan, S. Chand publication.
7. Introductory Methods of Numerical Analysis, S. S. Sastry, Prentice-Hall of India Private Limited.

Course Code	Course Name	Credits
ME 211	**Human Values and Social Ethics**	**2**

Prerequisite: Should have respect for justice and be able to reflect on one's personal beliefs and values

Course Objectives:

1. To enable learners to understand the core values that shape the ethical behaviour of a professional.
2. To develop an awareness on the different ethical dilemmas at the workplace and society.
3. To inculcate the ethical code of conduct in writing technical articles and technology development.
4. To internalize ethical principles and code of conduct of a good human being at home, society and at work place.

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

1. Learners will be able to recognize the relation between ethics and values pertinent for an engineering professional.
2. Learners will be able to exercise the responsibility for establishing fair and just processes for participation and group decision making
3. Learners will be able to demonstrate an awareness of self-held beliefs and values and how they are altered in interactions with others.
4. Learners will be able to acquire the writing skills necessary to analyse data from research and attribute the source with proper citation.
5. Learners will be competent to incorporate values and ethical principles in social and professional situations.

Module	Details	Hours
1	**Ethics and Values** : Meaning & Concept of Ethics Difference between Ethics and Values Ethical code of conduct	03
2	**Professional Ethics** : Professional Ethics vs Personal ethics Components of professional ethics Professional values and its importance	05
3	**Ethics and Society** : Relevance of values and ethics in social work Ethical dilemmas Values and ethical principles of social work · Service · Dignity and worth of a person · Importance of Human relationships · Integrity · Competence · Social Justice	04
4	**Ethics in Technical writing** : Documenting sources	07

	Presentation of Information Ethics & Plagiarism	
5	**Ethics and Technology Development** : Risk management and Individual rights Moral issues in development and application of technology Privacy/confidentiality of information Managing Technology to ensure fair practices	07

Assessment:

Termwork : 50 marks (Continuous evaluation)

Reference Books:

1. Martin Cohen, *101 Ethical Dilemmas* Routledge, 2nd edition, 2007.
2. M. Govindarajan, S. Natarajan & V.S. Senthilkumar, *Professional Ethics and Human Values,* Prentice Hall India Learning Private Limited, 2013.
3. Mike W. Martin, *Ethics in Engineering*, McGraw Hill Education; Fourth edition, 2017.

Course Code	Course Name	Credits
ME 212	**Data Science**	**2**

Course Objectives:

1. To introduce concepts of Data Science using R programming language.
2. To introduce basic concepts of R programming language as well as common packages and libraries.
3. To generate an ability to utilize Data Science concepts with R programming to solve mechanical engineering related problems.

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

1. To understand concepts of data science with R programming language.
2. To understand fundamentals of R programming and data frame.
3. To be able to visualise the data using R programming package.
4. To be able to prepare the data for analysis.
5. Understanding hypothesis testing and being able to make decisions.

Module	Detail Content	Hrs.
1.	**Introduction to Data Science** What is Data Science, Importance of Data science, Data science project roles, Understanding the stages of a data science project, Application, Various programming tools to perform data analysis.	**02**
2.	**Fundamentals of R** Installation of R & R Studio, Getting started with R Script, Basic & advanced data types in R, Variable operators in R, R functions and loops, Creating Data frames, Exploring data frames, Accessing columns in a Data frame, Reading a CSV text file, Removing rows and columns, Renaming rows and columns, sorting and merging data frames.	**08**
3.	**Data visualization** Need for data visualization, Components of data visualization, Visually checking distributions for a single variable, Visually checking relationships between two variables, Introduction to grammar of graphics, Using the ggplot2 package in R to create visualizations	**06**
4.	**Basics of Statistics & Probability** Mean, Median, Mode, Variance, Standard Deviations, Skewness, Standard probability distributions: Binomial, Normal etc., Central Limit Theorem, Hypothesis testing, Significance levels & P-Value, statistical tests : t-test, chi-square test, paired t-test, ANOVA	**08**
5.	**Data Managing** **Cleaning :** Needs & methods of data preparation, Handling missing values, Imputation Methods, Outlier treatment, Transformation, Modifying data with Base R, Data processing with dplyr package **Sampling for modeling and validation:** Test and training splits	**06**
6.	**Modelling :** Linear Regression, Logistic Regression, K-Means Clustering **Evaluating models :** Evaluating classification models, Evaluating clustering models	**08**

Lab Assessment:

Termwork : 25 marks (Continuous evaluation)
Practical/Oral : 50 marks

Books/ References:

1. R for Data Science, Hadley Wickham, Garrett Grolemund, O'Reilly Media.
2. Hands-On Programming with R, Garrett Grolemund, O'Reilly Media.
3. Any digital resources and online guides for R or its packages.

Course Code	Course Name	Credits
ME 213	**Internet of Things**	**1.5**

Course Objectives:

1. To understand the need and justification of IOT
2. To familiarize with robotic systems in automated
3. To provide a IoT system for the collection of information from the environment and its transfer to a server, as well as the skills necessary for the development of control logics, processing and display of data.
4. To create an environment for research, design, development and testing of IoT solutions, in the field of energy management, communication systems, distributed sensor devices and advanced user interfaces
5. Provide students unique interdisciplinary learning and innovation experiences with IoT technologies

Course Outcomes:

Upon successful completion of this course, the learner will be able to

1. Able to understand the application areas of IOT
2. Physical Design of IOT, Home Automation IOT, Environment, Agriculture, Industry, Health & LifeStyle.
3. Installing various necessary softwares, drivers and operating systems with knowledge of lots of hardwares like various microcontrollers and microprocessors.
4. Able to use different programming languages like C++, python, logical coding, blockly.
5. Control systems remotely over the internet.

List of Experiments

1. Familiarization with Arduino/Raspberry Pi and perform necessary software installation using C++ /python.
2. To interface LED/Bluzzer with Arduino/Raspberry Pi and write a program to turn ON LED for 1 sec after every 2 seconds.
3. To interface Push button/Digital sensor (IR/LDR) with Arduino/Raspberry Pi and write a program to turn ON LED when push button is pressed or at sensor detection.
4. To interface DHT11 sensor with Arduino/Rasberry Pi and write a program to print temperature and humidity readings.
5. To interface OLED with Arduino/Rasberry Pi and write a program to print temperature and humidity readings on it.
6. Real time interfacing of sensors (temperature and humidity) and actuators (Servo motors) using Arduino. Controlling actuators & monitoring sensors output remotely using internet and wifi module.
7. To interface motor/Led bulb using relay with arduino/Raspberrypi and write a program to turn On motor from smartphone using blynk and Bluetooth module.
8. IOT Paralysis Patient Health Care Project using accelerometer, wifi module and microcontroller based notification system over smartphone for need of help.

Laboratory Assessment:

Internal Assessment

Term Work Marks: 50 Marks

Course Project	: 30 Marks
Laboratory Work (Journal Completion)	: 15 Marks
Attendance	: 5 Marks

End Semester Practical/Oral Examination:

Pair of Internal and External Examiners should conduct practical/viva based on contents.

Distribution of marks for practical/viva examination shall be as follows:

Practical Examination	: 15 Marks
Oral Examination	: 10 Marks

Books/References:

1. Getting Started with the Internet of Things: Connecting Sensors and Microcontrollers to the Cloud by Cuno Pfister.
2. Internet of Things Programming Projects: Build Modern IoT Solutions with the Raspberry Pi 3 and Python Book by Colin Dow.
3. Beginning C for Arduino, Second Edition: Learn C Programming for the Arduino Book by Jack J Purdum.
4. Learning Python with Raspberry Pi, Book by Alex Bradbury and Ben Everard.

Course Code	Course Name	Credits
ME 292	**Minor Project II**	**2**

Course Objectives:

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4. To inculcate the process of self-learning and research.

Course Outcomes:

Learner will be able to

1. Identify problems based on societal /research needs.
2. Apply Knowledge and skill to solve societal problems in a group.
3. Develop interpersonal skills to work as a member of a group or leader.
4. Draw the proper inferences from available results through theoretical/ experimental/simulations.
5. Analyse the impact of solutions in societal and environmental context for sustainable development.
6. Use standard norms of engineering practices
7. Excel in written and oral communication.
8. Demonstrate capabilities of self-learning in a group, which leads to life-long learning.
9. Demonstrate project management principles during project work.

Guidelines for Minor Project:

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do surveys and identify needs, which shall be converted into a problem statement for minor-project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Student groups shall submit an implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of the minor project.
- A log book has to be prepared by each group, wherein the group can record weekly work progress, and the guide/supervisor can verify and record notes/comments.
- Faculty supervisors may give inputs to students during minor project activity; however, focus shall be on self-learning.
- Students in a group shall understand the problem effectively, propose multiple solutions and select the best possible solution in consultation with the guide/supervisor.
- Students shall convert the best solution into a working model using various components of their domain areas and demonstrate.
- The solution has to be validated with proper justification and the report has to be compiled in the standard format.
- With the focus on self-learning and innovation, addressing societal problems and entrepreneurship quality development within the students through the Minor Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students. i.e. Minor Project 1 in semester III and IV. Similarly, Minor Project 2 in semesters V and VI may be considered. In other words, based on the individual students' or group's capability, with the mentor's

recommendations, if the proposed Minor Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Minor Project, in even semester with suitable improvements/modifications.

- Alternatively, student groups can work completely on a new project idea in the even semester, bearing no resemblance with the topic of odd semester. This policy can be adopted on a case to case basis.

Assessment:
Term Work - 25 marks
Mid Semester Evaluation - 25 marks
Practical/Oral Examination - 25 marks

Guidelines for Assessment of Minor Project:
Term Work

- The review/ progress monitoring committee shall be constituted by heads of departments of each institute. The progress of the minor project to be evaluated on a continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In the first semester the entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on the presentation given by the student group.
    - If the problem is based on development of a mechanism or a simple device for attaining a desired objective, the first presentation shall be reviewed based on generation of multiple feasible solutions to the given problem and identification of the best possible solution based on various parameters which may include one of more of the following viz., the total weight, volume, power consumption, mechanical advantage, efficiency, cost (including labour) per piece once manufactured, and so on. This may include creation of unique free-hand sketches by each and every member of the group to contribute to the solution of the given problem. The best possible solution has to be finalized during one or more brainstorming sessions by the members of the student group. In case the problem is of a programming/coding type, then the first presentation may be dedicated to the understanding of the theory behind the problem related to a particular domain subject, including the drafting of an algorithm and/or flowchart, and may also include the introductory part of the programming.
    - Second review shall be based on the computerization (3D CAD model of parts and assembly), and possibly the animation, depicting the working characteristics of the proposed solution to the given problem, allocating material properties to each part, identifying mass properties of the assembled parts, and so on. Checking interference is one of the important criteria that can be used when assembling the parts. For software based projects, this may include the presentation based on the extension of the programming work so as to cover the major portion of the remaining part of the topic.

- In the second semester expected work shall be procurement of components/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester. For those selecting software based projects, this may include completing the other half of the programming related work, identifying the errors, optimizing the software code, customization, creating a graphical user interface of input and output (GUI), displaying output data in the form of graphs/tables/figures/diagrams, creation of the code in executable (.exe) format or in the form of a mobile App, etc.
  - First review shall be conducted based on the readiness of the working prototype, or programming of the remaining code for software based projects.
  - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester. This may also include the testing and validation of tests with the literature/available data/theory. For software based projects, the presentation includes the remaining work other than the programming, as described above.

- Apart from the hardware type (development of device) and software (program/coding) type of projects, the topics may also include computer based work, viz., generation of virtual laboratory (for one or more experiments) for any subject/domain of choice, or CAD modeling, analysis, optimization, and/or product design, without any relevance to developing any physical product.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including:
  - Identification of need/problem
  - Proposed final solution
  - Procurement of components/systems
  - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
  - First shall be for finalisation of problem and proposed solution
  - Second shall be for implementation and testing of solutions.

Assessment criteria of Minor Project:

1. Quality of survey/need identification
2. Clarity of problem definition based on need
3. Innovativeness/uniqueness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness/uniqueness
8. Cost effectiveness and societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual as member or leader
13. Clarity in written and oral communication

- In a **one year project**, the first semester evaluation may be based on the first six criteria as highlighted above and the remaining criteria may be used for second semester evaluation of performance of students in the minor project.
- In the case of a **half year project,** all criteria in general may be considered for evaluation of performance of students in the minor project.

Guidelines for Assessment of Minor Project Practical/Oral Examination:

- Report should be prepared as per the guidelines.
- Minor project shall be assessed through a presentation and demonstration of working model or the execution of programme code by the student project group to a panel of Internal and External Examiners preferably from industry or research organisations having experience of more than five years approved by the Head of Institution.
- Students shall be motivated to publish a paper based on the work in conferences or student competitions.

Course Code	Course Name	Credits
ME 301	**Finite Element Analysis**	**3+1**

Prerequisites:

1. Understanding of Differential equations including degree, order, boundary conditions. Solution of Ordinary Differential equations.
2. Understanding of Basic Algebra and Matrices.
3. Understanding of Solid Mechanics, thermal, fluid systems along with their governing equations and variables.
4. Modelling of parts in any software

Course Objectives:

1. To equip with the Finite Element Analysis fundamentals.
2. To apply finite element formulation for the solution of mechanical engineering problems.
3. To make the students use simulation techniques to get results for complex problems.

Course Outcomes:

Upon successful completion of this course, learner will be able to

1. Apply weighted residual methods to solve governing differential equations of the problem domain.
2. Discretize the problem domain using appropriate elements and apply boundary conditions.
3. Apply the finite element formulation to solve one-dimensional mechanical engineering problems.
4. Apply the finite element formulation to solve two-dimensional mechanical engineering problems.
5. Apply the finite element method to solve one-dimensional dynamic problems.
6. Use professional-level finite element analysis software to solve real life problems.

Theory Syllabus:

Module	Detail Content	Hrs.
1.	**Introduction:** Introduction to Finite Element Method, Weighted Residual Methods, Variational formulation of boundary value problems, Principal of Minimum Potential Energy, Ritz Method.	4
2.	**Basic concept of Finite Element Method:** Mathematical modeling of field problems in engineering with One dimensional second order equation, discretization , Element types, 1D linear and higher order elements, derivation of shape functions in local and natural coordinate systems, Stiffness matrix and force vectors, assembly of elemental matrices.	8
3.	**1D Analysis:** Application of element stiffness matrix to find Solution of problems from solid mechanics (Step bar, trusses, beams, torsion etc.), heat transfer, fluid flow etc.	8
4.	**Dynamic Analysis:** Dynamic equations of motion, consistent and lumped mass matrices, free vibration analysis.	6
5.	**2D Analysis:** Two dimensional equations, variational formulation, finite element formulation, Plane stresses and plane strain problems, body forces and thermal loads, plate and shell elements, triangular elements -	8

	shape functions, elemental matrices, stress analysis and RHS vectors, quadrilateral and higher order elements, isoparametric elements and its shape functions, Convergence and compatibility condition.	
6.	**Application of FEA:** Discussion of various case studies in different fields and its simulation in FEA software (may include special cases like composites, nonlinear analysis, multi domain analysis etc.).	5

Laboratory Syllabus:

Exercise	Detail Content	Hrs.
1	Introduction to ANSYS (APDL and Workbench)	2
2	Analysis of Rod subjected to axial Load (Step bar, taper rod)	2
3	Truss Analysis	2
4	Beam Analysis	2
5	Thermal Analysis	2
6	Modal analysis	2
7	Axis-symmetry Analysis	2
8	Convergence Study	2
9	Comparison of results while solving the same problem in 1D, 2D or 3D.	2
10	Writing a program using any programming language (Python, R, Matlab, Scilab, C++, etc.) for a finite element solution to any 1D/2D problem.	2
11	Course Project: Simulation of any assembly / Multi domain Analysis / Nonlinear analysis / Analysis of Composites etc.	4

Theory Assessment:
Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests - 40 Marks
2. Continuous evaluation- Class Test/ Assignments /Quiz/Case studies/Seminar presentation- 40 Marks

End Semester Examination: 60 Marks
Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Laboratory Assessment:
Internal Assessment: 25 marks
Term Work:

A. Minimum 6 exercises from 2-9 of the above list need to be undertaken.
B. Validation of the simulation results obtained through software with calculation.
C. Exercise 10 is compulsory. Presentation/Seminar of the study done is required.

The distribution of marks for Term work shall be as follows:

Part A : 10 marks
Part B : 5 marks
Part C : 10 marks

End Semester Practical/Oral Examination: 25 marks
A pair of Internal and External Examiners should conduct practical/viva based on contents.
Distribution of marks for practical/viva examination shall be as follows:

Practical Examination : 15 Marks
Oral Examination : 10 Marks

Books/References:

1. J. N. Reddy; An Introduction to Finite Element Method; 3rd Edition, McGraw Hill.
2. R. D. Cook, Davis S. Malkus, Michael E. Plesha and Robert J. Witt; Concepts and Applications of Finite Element Analysis; 4th Edition, Wiley.
3. S. S. Rao; The Finite Element Method in Engineering; 5th Edition, Elsevier, Butter Worth Heinemann.
4. O. C. Zienkiewicz and R. L. Taylor; The Finite Element Method, Vol. I and II, 6th Edition, Elsevier, Butter Worth Heinemann.
5. K.L. Bathe and E.L. Wilson; Finite Element Methods; Prentice Hall.
6. David V Hutton; Fundamentals of Finite element analysis; 7th Edition Tata McGraw Hill.
7. T. R. Chandrupatla and A. D. Belegundu; Introduction to Finite Elements in Engineering; 4th Edition, Pearson.
8. D. L. Logan; A first course in Finite Element Method; 5th Edition, Cengage Learning.
9. P. Seshu; Text book of Finite Element Analysis; 10th Edition, Prentice Hall of India.
10. N. S. Gokhale, S. S. Deshpande, S. V. Bedekar and A. N. Thite; Practical Finite Element Analysis; 1st Edition, Finite to Infinite.

Course Code	Course Name	Credits
ME 302	**Heat Transfer**	**3+1**

Course Objectives:

1. To understand the fundamentals of heat transfer in fluids and solids during steady state and unsteady state.
2. To Study mathematical modeling and designing concepts of heat exchangers

Course Outcomes:

Learner will be able to

1. Understand the basic laws of heat transfer
2. Identify, formulate, and solve heat transfer problems in thermal analyses of engineering systems.
3. Analyze problems and develop solution for steady state and unsteady state heat conduction problem in simple geometries
4. Understand the fundamentals of convective heat transfer process Evaluate heat transfer coefficients for natural convection and forced convection.
5. Calculate radiation heat transfer between black body and grey body surfaces.
6. Analyze heat exchanger performance and estimate an effectiveness of heat exchanger.

Theory Syllabus:

Module	Detail Content	Hrs.
1	**Basic concepts of heat transfer:** Difference between heat transfer and Thermodynamics, Physical mechanism of different modes of heat transfer, Steady and unsteady heat transfer, one dimensional, two dimensional and three dimensional heat transfer, Fourier law of heat conduction, Thermal conductivity, Thermal resistance concept in heat transfer, Thermal diffusivity, Governing law of convection, Free and forced convection.	6
2	**Conduction:** Generalized heat conduction equation in rectangular, cylindrical and spherical coordinates (only equation for cylindrical and spherical coordinates, no derivation), Steady state heat conduction through plane wall, Composite wall, cylinder, composite cylinder wall, sphere, and composite sphere wall, Critical radius of insulation in cylinder and sphere, Thermal contact resistance, Internal Heat generation concept.	7
3	**Heat transfer from Extended Surface:** Types of extended surface and its significance Governing differential equation for fin and its solution, Fin performance: Fin effectiveness and Fin efficiency, Thermowell **Unsteady state heat transfer:** Applications of unsteady state heat transfer, Lumped system Analysis, characteristic length, Biot Number, Thermal time constant and Response of a thermocouple, Heisler Charts	6
4	**Convection:** Determination of heat transfer coefficient, Dimensional Analysis, Dimensionless numbers in free and forced convection and their significance.	7

	External Flow: Velocity Boundary layer and Thermal Boundary layer, Laminar and turbulent, flow over a flat plate, Flow across cylinder and sphere, Flow across bank of tubes **Internal Flow:** Velocity Boundary layer and Thermal Boundary layer, Laminar and Turbulent, flow in tubes, General thermal analysis: Constant heat flux and constant surface temperature **Heat Pipe:** Introduction and application	
5	**Radiation:** Emissivity, transmissivity, reflectivity, absorptivity, black body, Grey body, Opaque body, Radiation intensity, Basic laws of radiation, Radiation heat exchange between black bodies, Reciprocity theorem, Shape factor algebra, Radiation heat exchange between nonblack bodies, Electrical network approach for radiation heat exchange: Radiosity and irradiation, Radiation shield	6
6	**Boiling and Condensation:** Boiling heat transfer, Pool boiling: different regimes and pool boiling curve, Flow boiling: Different Regimes and Boiling curve, Condensation heat transfer, Film condensation, Dropwise Condensation. **Heat Exchangers:** Types of heat exchangers, Overall heat transfer coefficient, Fouling factor Analysis of heat exchangers, LMTD, Effectiveness –NTU method, Correction factor Effectiveness of heat exchangers.	7

Laboratory Syllabus:

S. No.	Details	Hrs.
1	Measurement of thermal conductivity of insulating powder	2
2	Measurement of thermal conductivity of metal rod	2
3	Performance analysis of extended surfaces under free and force convection	2
4	Unsteady state heat transfer in cylinder/rod/wall	2
5	Measurement of Emissivity of Grey surface	2
6	Estimation of overall heat transfer coefficient and effectiveness of double pipe heat exchanger (parallel flow and Counter flow arrangement)	2
7	Simulation to estimate effect of various parameters on heat transfer	2
8	Heat Transfer analysis/estimation using numerical methods/computational techniques	2

Theory Assessment:
Internal Assessment for 40 marks:
Internal Assessment: 40 marks.

1. Consisting of One Compulsory Class Tests - 40 Marks
2. Continuous evaluation- Class Test/Assignments /Quiz/Case studies/Seminar presentation - 40 Marks

End Semester Examination: 60 Marks
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Laboratory Assessment:
Term Work Marks: 25 Marks

Laboratory Work (Journal Completion) : 20 Marks
Attendance : 05 Marks

End Semester Practical/Oral Examination:
Pair of Internal and External Examiners should conduct practical/viva based on contents.

Distribution of marks for practical/viva examination shall be as follows:

Practical Examination	: 15 Marks
Oral Examination	: 10 Marks
Total	: 25 Marks

Books/References:

1. Fundamentals of Heat and Mass Transfer by F.P. Incropera and D P deWitt, Wiley India, 3rd Edition.
2. Introduction to thermodynamics and Heat transfer by Yunus A Cengel 2nd Edition, McGrawHill.
3. Fundamentals of Heat and Mass Transfer, M. Thirumaleshwar, Pearson Education India,2009.
4. Introduction to Heat Transfer, Som S. K ,PHI Publication.
5. Heat Transfer by P S Ghoshdastidar, 2nd Edition, Oxford University Press.
6. Heat and Mass Transfer, by R Rudramoorthy and L Malaysamy, 2nd Edition, PEARSON.
7. Heat Transfer by J P Holman, Mcgraw Hill.
8. Heat Transfer by S P Sukhatme, University Press.
9. Heat and Mass Transfer by PK Nag, TMH.

Course Code	Course Name	Credits
ME 303	**Mechanical Measurements & Instrumentation**	**3+1**

Course Objectives:

1. To study the principles of precision measuring instruments & their significance.
2. To familiarize with the handling & use of precision measuring instruments/ equipment.
3. To Impart knowledge of architecture of the measurement system.
4. To deliver working principle of mechanical measurement system.

Course Outcomes:

Upon successful completion of this course, the learner will be able to

1. Handle, operate and apply the precision measuring instruments / equipment.
2. Analyze simple machined components for dimensional stability & functionality.
3. Classify various types of static characteristics and types of errors occurring in the system.
4. Understand the calibration process.
5. Classify and select proper measuring instruments for displacement, strain and acceleration measurements.
6. Classify and select proper measuring instruments for pressure, flow and temperature measurements.

Theory Syllabus:

Module	Detail Content	Hrs.
1.	**Metrology** 1.1 Introduction to Metrology, Need for inspection, Fundamental principles and definition, Standards of measurement, Errors in measurements, International standardization. 1.2 Limits, fits and tolerances of interchangeable manufacture, Elements of interchangeable system, Hole based and shaft based systems, Tolerance grades, Types of fits, General requirements of Go & No go gauging, Taylor's principle, Design of Go & No go gauges.	5
2.	2.1 Principles of interference, Concept of flatness, Flatness testing, Optical flats, Optical Interferometer and Laser interferometer. 2.2 Surface texture measurement: importance of surface conditions, roughness and waviness, surface roughness standards specifying surface roughness parameters - Ra, Ry, Rz, RMS value etc., Surface roughness measuring instruments. 2.3 Screw Thread measurement: Two wire and three wire methods, Floating carriage micrometer. 2.4 Gear measurement: Gear tooth comparator, Master gears, Measurement using rollers and Parkinson's Tester.	8
3.	**Mechanical Measurements & instrumentation -** 3.1 Definition, Significance of Mechanical Measurements, Classification of measuring instruments, generalized measurement system, types of inputs: Desired, interfering and modifying inputs.	5

	3.2 Static characteristics: Static calibration, Linearity, Static Sensitivity, Accuracy, Static error, Precision, Reproducibility, Threshold, Resolution, Hysteresis, Drift, Span & Range etc.	
4.	4.1 Calibration of Measuring Sensors and Instruments Principles of Calibration, Calibration process, Control of Calibration Environment 4.2 Data Acquisition & Signal conditioning: Amplifier, Conversion, Filtering, Impedance Buffering, Modulation / Demodulation, Linearization, Grounding and Isolation 4.3 Signal Processing - Introduction, Analog filters - Active & Passive filters, Digital Filters. Convertors ADC DAC.	7
5.	5.1 Displacement Measurement: Transducers for displacement, displacement measurement, potentiometer, LVDT, Capacitance. Types, Digital Transducers (optical encoder), Nozzle Flapper Transducer 5.2 Strain Measurement: Theory of Strain Gauges, gauge factor, temperature Compensation, Bridge circuit, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors 5.3 Measurement of Angular Velocity: Tachometers, Tachogenerators, Digital tachometers and Stroboscopic Methods. 5.4 Acceleration Measurement: theory of accelerometer and vibrometers, practical accelerometers, strain gauge based and piezoelectric accelerometers	7
6.	6.1 Pressure Measurement: Elastic pressure transducers viz. Bourdon tubes, diaphragm, bellows and piezoelectric pressure sensors, High Pressure Measurements, Bridge man gauge. Vacuum measurement: Vacuum gauges viz. McLeod gauge, Ionization and Thermal Conductivity gauges 6.2 Flow Measurement: Bernoulli flowmeters, Ultrasonic Flowmeter, Magnetic flow meter, rotameter 6.3 Temperature Measurement: Electrical methods of temperature measurement Resistance thermometers, Thermistors and thermocouples, Pyrometers	7

Laboratory Syllabus:

Exercise	Details	Hrs.
Group 1: Mechanical Measurements		
1	Calibration of Displacement sensors like LVDT, Potentiometers etc.	2
2	Calibration of Pressure Gauges	2
3	Calibration of Vacuum Gauges	2
4	Torque measurement using strain gauges	2
5	Experiment on different types of tachometers and stroboscope	2
6	Vibration Measurement & Calibration of Accelerometers.	2
Group 2: Metrology & Quality control		
1	Vernier Calliper, Micrometer and Bevel Protractor for linear and angular measurement	2
2	Gear measurement – Gear tooth Vernier calliper / Parkinson gear tester	2
3	Screw Thread Measurement – screw thread Micrometer, Floating carriage micrometer /bench micrometer	2
4	Optical profile projector for miniature linear / angular measurements of screw / gear or components	2
5	Comparator – Mechanical / Pneumatic type	2
6	QC charts for 50 sample readings of OD / ID of specimen and printouts	2

Theory Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests **-** 40 Marks
2. Continuous evaluation- Class Test/ Assignments /Quiz/Case studies/Seminar presentation - 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Laboratory Assessment:

Term Work Submission: 25 Marks

1. Term work shall consists of minimum Eight Experiments, taken from Two groups mentioned below
2. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.
3. Students work along with evaluation reports to be preserved till the next examination.

End Semester Practical/Oral Examination: 25 Marks

Pair of Internal and External Examiners should conduct practical/viva based on contents. Distribution of marks for practical/viva examination shall be as follows:

Practical Examination : 15 Marks
Oral Examination : 10 Marks

Books/References:

1. Engineering. Metrology, I.C. GUPTA, Dhanpat Rai Publications.
2. Engineering. Metrology, R. K. Jain, Khanna Publisher.
3. Measurement Systems: Applications and Design, by EO Doebelin,5th Edition, McGraw Hill
4. Mechanical Engineering Measurements, A. K. Sawhney, Dhanpat Rai & Sons, New Delhi
5. Instrumentation & Mechanical Measurements, A. K. Thayal

Course Code	Course Name	Credits
ME 304	**Machine Design I**	**3+1**

Prerequisites:

1. Engineering Mechanics
2. Strength of Materials
3. Materials Science and Metallurgy
4. Machine Drawing
5. Theory of Mechanisms
6. 3D-Modelling & Drafting using SolidWorks software
7. FEA simulation using ANSYS software

Course Objectives:

1. Understand the basic principles of mechanical design.
2. Understand the various types of stresses.
3. Understand the basic strength & rigidity
4. Familiarize with the use of design data book and standard codes.
5. Understand the design procedure and convert it into computer drawings.
6. Perform design calculations and simulate stresses using analysis software.

Course Outcomes:

Upon successful completion of this course, learner will be able to

1. Understand various mechanical design considerations.
2. Apply strength and rigidity for basic design of machine components.
3. Use Design data books for various component designs.
4. Acquire production drawing skills using CAD software.
5. Compare the analytical results with simulation results.

Theory Syllabus:

Module	Detail Content	Hrs.
1.	**Introduction to Machine Design:** Mechanical Engineering Design, Design methods, Aesthetic and Ergonomics consideration in design. Material properties and their uses in design. Manufacturing consideration in design. Design considerations of casting and forging. Basic principles of Machine Design, Modes of failures, Factor of safety, Design stresses, Principal stresses and strains, Theories of failures. Standards, I. S. codes, Preferred Series and Numbers. Variables stresses, reversed, repeated, fluctuating stresses.	7
2.	**Fatigue Failure:** Static and fatigue stress concentration factors, Methods of stress concentrations, Endurance limit - estimation of endurance limit. Design for Soderberg and Goodman criteria.	6
3.	**Design of curved beams and Thick Cylinders:** Curved Beams: Assumptions made in the analysis of curved beams. Design of curved beams: Bending stresses in curved beams, such as crane hook, C-frame, etc. Thick Cylinders: Design of thick cylinders subjected to an internal pressure using Lame's equation.	5

4.	**Design against Static Loads:** Cotter joint, knuckle joint, Turn Buckle, Bolted and welded joints under eccentric loading. Power Screw - Screw Presses, C- Clamps along with the Frame.	8
5.	**Design of Shafts, Keys and Couplings:** Shafts: Design under static and fatigue criteria. Keys: Types of keys and their selection based on shafting condition. Couplings: Classification of couplings. Design of split, muff couplings, flange couplings, bush pin flexible coupling.	8
6.	**Design of Springs:** Helical compression, tension springs under static and variable loads. Design of Leaf springs.	5

Laboratory Syllabus:

Module	Details	Hrs.
1.	Design exercise and drawing of Knuckle or Cotter joint	5
2.	Design exercise and drawing of Turn buckle or Screw jack	5
3.	Design exercise and drawing of bush pin type flexible coupling	5
4.	Design exercise on leaf spring	5
5.	Analysis of any one component described above, in ANSYS, and comparison of results.	5

Theory Assessment:

Internal Assessment: 40 marks.

1. Consisting of One Compulsory Class Tests - 40 Marks
2. Continuous evaluation- Class Test/ Assignments /Quiz/Case studies/Seminar presentation - 40 Marks

End-Semester Examination: 60 marks.

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Laboratory Assessment:

Term Work: 25 marks

Students have to submit signed and completed assignments based on the modules listed in the table, as a part of the term work. They can also avail NPTEL Certification for this course, for which the assignment work may be suitably reduced, at the discretion of the Instructor.

Books/References:

1. Design of Machine Elements - V.B. Bhandari, Tata McGraw Hill Publication
2. Design of Machine Elements - Sharma, Purohil. Prentice Hall India Publication
3. Machine Design by Pandya & Shah, Charotar Publishing
4. Recommended Data Books - PSG
5. Machine Design by R.C.Patel, Pandya, Sikh, Vol - I & II C. Jamnadas & Co.
6. Mechanical Engineering Design by J.E.Shigley, McGraw Hill

Course Code	Course Name	Credits
ME 305	**Professional Communication and Ethics II**	**2**

Prerequisite: Basic language skills

Course Objectives: To provide practice in

1. Drafting effective written discourse with specific emphasis on report, proposal writing and documentation of business meetings.
2. Fluent speaking, developing confidence, positive approach, responsibility, empathy and presentation skills in social, academic and professional settings.
3. Writing resume and statement of purpose for academic and professional development.
4. Fostering ethical decisions and behaviour in academic and professional settings.
5. Skillful questioning, organizing information, learning to find credible sources and verifying information from several sources.
6. Using imagination and out of the box thinking to create something unique and extraordinary.

Course Outcomes: Learners will be able to

1. Write reports,technical proposals and document business meetings with ease and accuracy.
2. Speak fluently with confidence, have a positive approach, develop empathetic skills and make effective professional presentations.
3. Demonstrate their skills in resume writing and statement of purpose.
4. Conduct themselves with zest and zeal required in academic and professional situations.
5. Acquire research skills necessary for addressing problems and finding effective solutions to it.
6. Write blogs to express their opinion with ease and also connect to the audience.

Theory Syllabus:

Module	Detailed Content	Hrs.
1	**Structure, Style and Language of Report Writing** 1.1 Introducing the purpose , aim, objective and format of report 1.2 Literature review-ability to gather and analyze information from different sources and summarize. Specific emphasis on plagiarism, use of quotation marks appropriately . 1.3 Research Methodology 1.4 Presenting data-figures, diagrams and labeling 1.5 How and why to write discussion 1.6 Citing and referencing- IEEE format 1.7 Writing an abstract	4
2	**Writing Technical Proposals** 2.1 Format 2.2 Executive summary 2.3 Defining the problem and presenting the solution 2.4 Summarizing a technical proposal	3

3	**Oral Skills for Employability** 3.1 Group Discussion- with special reference to leadership qualities, assertiveness, analyzing the topic, developing different perspectives, introducing and concluding the discussion. 3.2 Interview-with special reference to introducing oneself and answering questions with confidence. 3.3 Presentation Skills-with special reference to preparing slides, dress code, non-verbal communication including paralinguistic features, introduction and conclusion.	2
4	**Personality Development and Social Etiquettes** 4.1. Personality Development • Improving self-awareness- analyzing our own experiences, looking at ourselves through the eyes of others • Knowing and Building your own identity • Discovering and Developing your talents • Teamwork/collaboration 4.2. Social Étiquettes • Formal Dining Etiquettes • Cubicle Etiquettes • Responsibility in Using Social Media • Showing Empathy and Respect • Learning Accountability and Accepting Criticism • Demonstrating Flexibility and Cooperation • Selecting Effective Communication Channels	2
5	**Ethics and Ethical codes of conduct** 5.1Writing Resume and statement of purpose 5.2 Business and corporate activities(special emphasis on business meetings) 5.3 Personal ethics, conflicting values, choosing a moral response, the process of making ethical decisions.	2
6	**Content writing** 6.1 Research Skills 6.2 Organisational skills 6.3 Creative Writing- Blog posts, Web pages etc.	2

Lab Syllabus:

Sr. No.	Details of Assignments	Details of Activities	Hrs.
1	Written assignment on Literature Review 20 page report on technical topic-(to be included as part of term work)	Sample IEEE papers to be shared with students and train them to identify contributions of each author. These contributions can then be written in the format required in journals.	4
2	Written assignment on summarising a technical proposal, 4 page technical proposal (to be included as part of term work)	Example of summarising techniques to be demonstrated.	4

3	Oral Skills for Employability- to be included in term work.	Role play and mock interviews Mock group discussion Mock presentation	6
4	Written Assignment on Documentation of Business Meeting	Mock meetings	2
5	Written Assignment on Resume writing/ Statement of Purpose.	NA	2
6	Written Assignment on Blog Posts	NA	2

Assessment:

Term work will consist of:

1. Assignments : 10 marks
2. Group Discussion : 10 marks
3. Interviews : 5 marks
4. Report : 5 marks
5. Technical Proposal : 5 marks
6. Attendance : 5 marks
7. Presentation : 10 marks

Books/References:

1. Raman Meenakshi & Sharma Sangeeta, Communication Skills, Oxford University Press
2. Kumar Sanjay & Lata Pushp, Communication Skills, Oxford University Press
3. Virendra Singh Nirban, Krishna Mohan, RC Sharma, Business Correspondence and Report Writing

Course Code	Course Name	Credits
ME 306	**Advanced Fluid Mechanics**	**3**

Course Objectives:

1. To study application of mass, momentum and energy equations in fluid flow.
2. To study different types of turbulent model
3. To study incompressible and compressible fluid flow
4. To familiarize with dimensional analysis of Thermal and Fluid systems.

Outcomes: Upon successful completion of this course, the learner will be able to

1. Formulate and solve equations of the control volume for fluid flow systems
2. Calculate resistance to flow of incompressible fluids through closed conduits and over surfaces.
3. Select suitable turbulent model for fluid flow problem
4. Apply fundamentals of compressible fluid flows to relevant systems
5. Illustrate understanding of dimensional analysis of Fluid systems.

Module	Detail Content	Hrs.
1.	Eulerian & Lagrangian coordinates, Definition and equations for source, sink, irrotational vortex, circulation concept of circulation. Navier-Stokes equations-differential & integral approach, energy equations, governing equations for Newtonian fluids, boundary conditions Momentum of fluid in motion: impulse momentum relationship and its applications for determination of thrust for pipe bend	7
2.	Viscous Incompressible Flows: Exact solutions for Couette flow, Poiseuille flow, flow between rotating cylinders, Stokes first problem, Stokes second problem, pulsating flow between parallel surfaces, stagnation-point flow, flow over porous wall. Stokes approximation,	6
3.	Introduction to dimensional analysis of thermal and fluid systems, Methods of dimensional analysis - Buckingham π Theorem and Rayleigh's Method (Only derivations, no numerical) Boundary Layer Theory: Review of boundary layers: laminar and turbulent boundary layers; transition; separation, Blasius' solution for boundary layer	6
4.	Potential Flows: Stokes stream functions, solution of potential equation, flow in a sector, flow around a sharp edge, flow near a blunt nose force and moment on a circular cylinder and sphere, conformal transformations, Joukowski transformations, Elements of airfoil and wing theory.	6
5.	Introduction to turbulence: Transition of flows, Origin of turbulence- its consequences; Physics of turbulent motion- concept of Reynolds stress, mean flow equations, Turbulence models RANS, LES. DNS	6
6.	Compressible Fluid flow: Propagation of sound waves through compressible fluids, Sonic velocity and Mach number; Stagnation properties, Application of continuity, momentum and energy equations for steady-state conditions; Steady flow through the nozzle, Isentropic flow through ducts of varying cross-sectional area, Effect of varying back pressure on nozzle performance, Critical pressure ratio.. Application to subsonic, transonic and supersonic flow around a two-dimensional aerofoil.	7

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Advanced Fluid Mechanics, K. Muralidhar& G. Biswas, Narosa Publishing, 2005.
2. Boundary Layer Theory, H. Schlichting, 6th Edition, McGraw-Hill Inc., 1986.
3. Turbulent Flow, R. J. Garde, 2nd Edition, New Age International Publishers.
4. Foundations of Fluid Mechanics, S.W. Yuan, Prentice-Hall India Pvt. Ltd, New Delhi.
5. Modern Compressible Flow with Historical Perspective, John D. Anderson, McGraw Hill.
6. Fundamentals of Aerodynamics (2nd ed), J. D. Anderson, McGraw Hill.
7. Viscous Fluid Flow, F. M. White, 2nd Edition, McGraw-Hill, 1991.
8. Fundamentals of Fluid Mechanics , B.R. Munson, D.F. Young & T.H. Okiishi, 2nd Ed., John Wiley.
9. Introduction to Fluid Mechanics, R.W. Fox & A.T. McDonald, 5th Edition, John Wiley, 2001.

Course Code	Course Name	Credits
ME 307	**Design for Excellence**	**3**

Prerequisites:

1. Basic concepts of Design, Manufacturing and Product Management practices.

Course Objectives:

1. Learn various knowledge-based techniques in addition to low manufacturing cost, for a sound product design.
2. Understand the need of DFX and its basic principles.
3. Understand how to manage to make a transition to DFM/DFX from the traditional approach.
4. Understand methods to evaluate various product designs for DFX.
5. Learn various design guidelines for designing, based on different DFX attributes.
6. Realize the use of DFX in low quantity production, some success stories, and the merging of DFX with CAD/CAE.

Course Outcomes: Upon successful completion of this course, learner will be able to:

1. Appreciate that manufacturing is a key element in the wealth of nations and individuals, but the major contributor of total product's cost is in the design phase itself.
2. Appreciate that for best product design results, attributes in addition to DFM, are also required in current competitive market climates.
3. Understand that careful, dedicated, well-planned management of a design team is a requirement, with equal emphasis on training and education of all concerned.
4. Design the product in the conceptual stage, for various attributes of DFX.
5. Realize that computer technology and the art of programming are essential for the integration of DFX and CAD/CAE to assist in the product design process.

Module	Detail Content	Hrs.
1.	**1.1 Basic Concepts of DFM-Design for Manufacturability:** Need of DFM, History of DFM **1.2 DFM/DFX Related Approaches:** Definitions of some approaches (management systems) which are either part of DFM/DFX, related to it, or provide alternative means of improving product designs and manufacturing operations–-DFA, DFMA, manufacturability or producibility, design to cost, concurrent or simultaneous engineering or concurrent design, value Analysis or value engineering, life cycle costs, fractional factorial experiments, benchmarking, SPC, QFD, quality loss function, synchronized manufacturing, continuous improvement, TQM, FMEA, group technology.	5
2.	**2.1 Expansion & Evolution of DFM to DFX:** Desirable objectives of sound product design other than manufacturability. Objectives in conflict and in concert with manufacturability.	6
3.	**Basic Principles of DFM/DFX:** Discussion on major design principles or guidelines which guide the product designer to a more satisfactory design, and include—simplify	6

	and improve the assembly, minimize the number of parts, standardize, use processible materials etc.	
4.	**Managing a transition to DFM/DFX:** Management's role in implementing DFM/DFX, cultural change, training and indoctrination. **Applicability, Advantages and Disadvantages of some methods of evaluating product designs for DFX:** Parts count, assembly time and cost, design efficiency rating for assembly, estimated life cycle product costs, formal product cost estimate, producibility assessment (PA), disassembly time data, weighted factor matrix.	8
5.	**The Dimensions of DFX:** Improving assemblies, improving individual components, designing for higher quality, designing for -- reliability, serviceability/maintainability, safety, environment, user-friendliness, short time-to-market.	8
6.	**Other Aspects of DFX:** DFX for Low Quantity Production Some Success Stories The Future of DFX—Integration of DFX with computer	6

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Design for Excellence, by James G. Bralla, Technicraft Publication, Pennsylvania.
2. Design for Manufacturability Handbook, by James G. Bralla, 2nd Edition, McGraw Hill Publications.
3. ICoRD'15 – Research into Design Across Boundaries Volume 2 - Creativity, Sustainability, DfX, Enabling Technologies, Management and Applications, Edited by Amaresh Chakrabarti, Smart Innovation, Systems and Technologies 35, Springer.
4. Product Design for Manufacture and Assembly, by Geoffrey Boothroyd, Peter Dewhurst, and Winston Knight, 3rd Edition, CRC Press.
5. Product Development and Design for Manufacturing, by John W. Priest and Jose M. Sanchez, 2nd Edition, Quality and Reliability – 58.
6. Design for Manufacturing and Assembly: Concepts, architectures and implementation, by O. Molloy, S. Tilley and E. Warman, Springer–Science+Business Media, B.V. Publications.
7. Design for Manufacturing: A Structured Approach, by Corrado Poli, Butterworth-Heinemann Publications.

Course Code	Course Name	Credits
ME 308	**Control Systems**	**3**

Course Objectives:

1. To study concept of mathematical modelling of the control system
2. To acquaint with control system under different time domain
3. To study concepts of stability & various methods.
4. To study Multi-Input Multi-Output systems using state space
5. To study application of control systems for mechanical systems.

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

1. Design mathematical models of system/process.
2. Analyse error and differentiate various types of control systems using time domain specifications
3. Analyse various methods and problems associated with stability
4. Analyse systems using graphical methods in frequency response
5. Understand the concept of state space methods for system analysis
6. Comprehend and apply concepts of control systems in mechanical Engineering.

Theory Syllabus:

Module	Detail Content	Hrs.
1.	Introduction to the Control Problem Examples of control systems; introduction to the control problem; open loop and closed loop systems; feed-forward control structure. Differential equation models of physical systems, deriving models of physical systems (electrical, mechanical, thermal) Types of models; Impulse response model; Transfer function model for Electrical, Mechanical and Thermal systems Block diagram and Signal Flow Graph (SFG) representation of control systems; Block diagram reductions; Mason's gain formula.	06
2.	Time Response Analysis Standard test signals; Transient and steady state behaviour of first and second order systems Performance Specifications for a second order system and derivations for rise time, settling time, peak time, peak overshoot and steady state error Steady State errors in feedback control systems and their types, Error constants and type of system.	07
3.	Stability Analysis in Time Domain Concepts of Stability: Concept of absolute, relative and robust stability; Routh stability criterion. Root Locus Analysis: Root-locus concepts; General rules for constructing root-locus; Root-locus analysis of control systems.	08
4.	Stability Analysis in Frequency Domain Introduction: Frequency domain specifications, Response peak and peak resonating frequency; Relationship between time and frequency domain specifications of system; Stability margins. Bode plot: Magnitude and phase plot; Method of plotting Bode plot; Stability margins on the Bode plots; Stability analysis using Bode plot.	08

	Nyquist Criterion: Polar plots, Nyquist stability criterions; Nyquist plot; Gain and phase margins.	
5.	**State-space Analysis** Concept of state variables; State-space model; Canonical forms; Conversion between canonical forms using similarity transforms. Solution of state-space equation; Eigen-values and eigenvectors; Stability in state-space; Concept of controllability and observability. **Controllers**: Concept of ON/OFF controllers; Concept of P, PI, PD and PID Controllers	06
6.	**Advances in Control Systems:** Introduction to Robust Control, Adaptive Control and Model Predictive control. **Applications of Control system** Analysis of Spring mass damper system,Analysis of motor controller (DC, Stepper, PMSM, Induction motor),Analysis of cruise control system	04

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Text Books:

1. M. Gopal, "Control Systems: Principles and Design", 3rd edition, Tata McGraw Hill, 2008.
2. Richard Dorf, Robert Bishop, "Modern Control Systems", 11th edition, Pearson Education, 2008

Reference Books:

1. Golnaraghi Farid, B. C. Kuo, "Automatic Control Systems", 10th edition, McGraw Hill, 2017.
2. K. Ogata, "Modern Control Engineering", 6th edition, Prentice Hall, 2010.
3. I.J. Nagrath, M. Gopal, "Control System Engineering", New Age International, 2009.
4. Norman Nise, "Control Systems Engineering", Wiley, 8th edition, 2019.

Course Code	Course Name	Credits
ME 391	**Minor Project III**	**2**

Course Objectives:

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4. To inculcate the process of self-learning and research.

Course Outcomes: Learner will be able to…

1. Identify problems based on societal /research needs.
2. Apply knowledge and skill to solve societal problems in a group.
3. Develop interpersonal skills to work as a member of a group or leader.
4. Draw the proper inferences from available results through theoretical/ experimental/simulations.
5. Analyse the impact of solutions in societal and environmental context for sustainable development.
6. Use standard norms of engineering practices
7. Excel in written and oral communication.
8. Demonstrate capabilities of self-learning in a group, which leads to life-long learning.
9. Demonstrate project management principles during project work.

Guidelines for Minor Project:

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do surveys and identify needs, which shall be converted into a problem statement for minor-project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Student groups shall submit an implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of the minor project.
- A log book has to be prepared by each group, wherein the group can record weekly work progress, and the guide/supervisor can verify and record notes/comments.
- Faculty supervisors may give inputs to students during minor project activity; however, focus shall be on self-learning.
- Students in a group shall understand the problem effectively, propose multiple solutions and select the best possible solution in consultation with the guide/supervisor.
- Students shall convert the best solution into a working model using various components of their domain areas and demonstrate.
- The solution has to be validated with proper justification and the report has to be compiled in the standard format.
- With the focus on self-learning and innovation, addressing societal problems and entrepreneurship quality development within the students through the Minor Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students. i.e. Minor Project 1 in semester III and IV. Similarly, Minor Project 2 in semesters V and VI may be considered. In other words, based on the individual students' or group's capability, with the mentor's recommendations, if the proposed Minor Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group

can be allowed to work on the extension of the Minor Project, in even semester with suitable improvements/modifications.

- Alternatively, student groups can work completely on a new project idea in the even semester, bearing no resemblance with the topic of odd semester. This policy can be adopted on a case to case basis.

Assessment:
Term Work - 25 marks
Mid Semester Evaluation - 25 marks
Practical/Oral Examination - 25 marks

Guidelines for Assessment of Minor Project:
Term Work

- The review/ progress monitoring committee shall be constituted by heads of departments of each institute. The progress of the minor project to be evaluated on a continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In the first semester the entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on the presentation given by the student group.
    - If the problem is based on development of a mechanism or a simple device for attaining a desired objective, the first presentation shall be reviewed based on generation of multiple feasible solutions to the given problem and identification of the best possible solution based on various parameters which may include one of more of the following viz., the total weight, volume, power consumption, mechanical advantage, efficiency, cost (including labour) per piece once manufactured, and so on. This may include creation of unique free-hand sketches by each and every member of the group to contribute to the solution of the given problem. The best possible solution has to be finalized during one or more brainstorming sessions by the members of the student group. In case the problem is of a programming/coding type, then the first presentation may be dedicated to the understanding of the theory behind the problem related to a particular domain subject, including the drafting of an algorithm and/or flowchart, and may also include the introductory part of the programming.
    - Second review shall be based on the computerization (3D CAD model of parts and assembly), and possibly the animation, depicting the working characteristics of the proposed solution to the given problem, allocating material properties to each part, identifying mass properties of the assembled parts, and so on. Checking interference is one of the important criteria that can be used when assembling the parts. For software based projects, this may include the presentation based on the extension of the programming work so as to cover the major portion of the remaining part of the topic.

- In the second semester expected work shall be procurement of components/systems, building of working prototype, testing and validation of results based on work

completed in an earlier semester. For those selecting software based projects, this may include completing the other half of the programming related work, identifying the errors, optimizing the software code, customization, creating a graphical user interface of input and output (GUI), displaying output data in the form of graphs/tables/figures/diagrams, creation of the code in executable (.exe) format or in the form of a mobile App, etc.
    - First review shall be conducted based on the readiness of the working prototype, or programming of the remaining code for software based projects.
    - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester. This may also include the testing and validation of tests with the literature/available data/theory. For software based projects, the presentation includes the remaining work other than the programming, as described above.
- Apart from the hardware type (development of device) and software (program/coding) type of projects, the topics may also include computer based work, viz., generation of virtual laboratory (for one or more experiments) for any subject/domain of choice, or CAD modeling, analysis, optimization, and/or product design, without any relevance to developing any physical product.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including:
    - Identification of need/problem
    - Proposed final solution
    - Procurement of components/systems
    - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
    - First shall be for finalisation of problem and proposed solution
    - Second shall be for implementation and testing of solutions.

Assessment criteria of Minor Project:

1. Quality of survey/need identification
2. Clarity of problem definition based on need
3. Innovativeness/uniqueness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness/uniqueness
8. Cost effectiveness and societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual as member or leader
13. Clarity in written and oral communication

- In a **one year project**, the first semester evaluation may be based on the first six criteria as highlighted above and the remaining criteria may be used for second semester evaluation of performance of students in the minor project.
- In the case of a **half year project,** all criteria in general may be considered for evaluation of performance of students in the minor project.

Guidelines for Assessment of Minor Project Practical/Oral Examination:

- Report should be prepared as per the guidelines.
- Minor project shall be assessed through a presentation and demonstration of working model or the execution of programme code by the student project group to a panel of Internal and External Examiners preferably from industry or research organisations having experience of more than five years approved by the Head of Institution.
- Students shall be motivated to publish a paper based on the work in conferences or student competitions.

Course Code	Course Name	Credits
ME 309	**Mechatronics**	**3+1**

Course Objectives:

1. To study key elements of Mechatronics system and its integration
2. To familiarise concepts of sensors characterization and its interfacing with microcontrollers
3. To acquaint with concepts of actuators and its interfacing with microcontrollers
4. To study discrete control logics in PLC systems and its industrial applications
5. To acquaint with control of mechanical operations involving pneumatic, electric, hydraulic and electronic systems

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

1. Design a mechatronics system
2. Identify the suitable sensor and actuator for a mechatronics system
3. Demonstrate use of automated controls using pneumatic and hydraulic systems.
4. Demonstrate applicability of PLC in process industry
5. Identity and learn different types of controllers
6. Understand data acquisition and signal conditioning.

Theory Syllabus:

Module	Detail Content	Hrs.
1.	**Introduction of Mechatronics** and its block diagram representation Key elements of mechatronics, Applications of Mechatronics domestic, industrial etc. Representation of mechatronic system in block diagram and concept of transfer function for each element of mechatronic system, Reduction methods and its numerical treatment for represented block diagram	06
2.	**Selection of Sensors & Actuators Sensors:** Criteria for selection of sensors based on requirements, principle of measurement, sensing method, performance chart etc. (Displacement, temperature, acceleration, force/pressure) based on static and dynamic characteristics. Actuators: Selection of actuators based on principle of operation, performance characteristics, maximum loading conditions, safety etc. Principle and selection of mechano-electrical actuators (1) DC motors (2) Stepper Motors (3) Solenoid Actuators (4) Servo Motors (5) BLDC	08
3.	**Pneumatics and hydraulics**: Hydraulic and pneumatic devices-Different types of valves , Actuators and auxiliary elements in Pneumatics & hydraulics , their applications and use of their ISO symbols Synthesis and design of circuits (up to 3 cylinders)–pneumatic, electro pneumatics and hydraulics Design of Electro-Pneumatic Circuits using single solenoid and double solenoid valves; with and without grouping	10
4.	**PLC and its applications:** Process industries versus discrete manufacturing industries, Continuous versus discrete control, Computer process control, Forms of computer process control Discrete control using PLC- discrete process control, Programmable logic controller, its architecture,ladder digs, Ladder Logic Programming for different types of logic gates, Latching, Timers, Counter, Practical Examples of Ladder Programming	06

5.	**Control System** Control system design and analysis by Root Locus Method, Control system Design by Frequency response method, stability margin, Nyquist diagram, Bode diagram P, I and D control actions, P, PI, PD and PID control systems, Transient response:- Percentage overshoot, Rise time, Delay time, Steady state error, PID tuning (manual), Zigler Method	06
6.	**Data Acquisition, Signal Conditioning & Microcontroller System** **Theory:** Concept of Bit accuracy/width and Sampling speed, sampling theorem, aliasing, Nyquist criteria, ADC (Analog to Digital Convertor) Successive approximation method and sample and hold circuitry, DAC (Digital to Analog Convertor) R-2R circuit and DAC resolution Signal Filters: Low pass, High Pass and Band Pass with circuit diagrams for simple cases	04

Laboratory Syllabus:

Exercise	Details	Hrs.
Group 1: Sensors & Actuators		
1	Theoretical & Experimental Implementation of Interfacing of Sensors using microcontroller and determination of sensor characteristics such as Static Characteristics (Sensitivity, Accuracy, Range, Resolution etc.), Dynamic Characteristics (Transient Response and Frequency Response)	2
2	Measurement and Calibration of Load / Force (It is suggested to determine all characteristics of sensor mentioned in previous experiments)	2
3	Measurement, Calibration and Comparison of Temperature Sensors (Thermocouple, RTD and Thermistor) (It is suggested to determine all characteristics of sensor mentioned in previous experiments)	2
4	Interfacing of Stepper Motor with microcontroller and its programming for Rotational or XY table (It is suggested to program to vary the position of rotary or XY table and compare the positioning accuracy using standard calibrated angular or linear sensor)	2
5	Interfacing of DC Motor with microcontroller and its programming for characterization of DC motor setup (It is suggested to program to vary the speed of DC motor and determine its load-speed characteristics)	2
Group 2: Automation		
1	Designing sequential operation for two cylinders using electro-hydraulic circuits	2
2	Designing sequential operation for two cylinders using electro-pneumatic circuits	2
3	Development of pneumatic circuits to understand pneumatic components and their working	2
4	IOT: Real time interfacing of sensors (temperature, humidity, position, level etc.) and actuator (stepper motor, dc motor, servo motor etc.) with microcontroller and Ethernet shield and controlling the actuator and monitoring of sensor output remotely using internet.	2
5	Robotics: Real Time demonstration of line following robot using standard robotic kit	2
6	Demonstration and study of functions of components of the robotics arm.	2

Theory Assessment:
Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests **-** 40 Marks
2. Continuous evaluation- Assignments /Quiz/Case studies/Seminar presentation- 40 Marks

End Semester Examination: 60 Marks
Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Laboratory Assessment:
Term Work Submission: 25 Marks

1. Term work shall consists of minimum Eight Experiments, taken from Two groups mentioned above
2. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.
3. Students work along with evaluation reports to be preserved till the next examination.
4. Course projects can be given in groups of 2-3 students to build practical systems for mechatronics / Robotics / Automation application using arduino / Festo training kit etc.

The distribution of marks for Term work shall be as follows:

Part A : 10 marks (Experiments)
Part B : 5 marks (Attendance)
Part C : 10 marks (Course Project)

End Semester Practical/Oral Examination: 25 Marks
Pair of Internal and External Examiner should conduct practical/viva based on contents.
Distribution of marks for practical/viva examination shall be as follows:

Practical Examination : 15 Marks
Oral Examination : 10 Marks

Books/References:-

1. Mechatronics System Design , Shetty and Kolk, Cengage Learning, India Edition
2. Mechatronics - Electromechanics and Control Mechanics , Mill Springer-Verlag
3. Mechatronics - Electronic Control Systems in Mechanical Engineering , Bolton Pearson education
4. Mechatronics - Electronics in products and processes , Bradley, et al. Chapman and Hall
5. Pneumatic Circuits and Low Cost Automation by Fawcett JR
6. Electromechanical Design Handbook , Walsh, McGraw-Hill
7. Electro-mechanical Engineering - An Integrated Approach , Fraser and Milne
8. Handbook of Electromechanical Product Design , Hurricks Longman, John Wiley, Addison Wesley.
9. Modeling and control of Dynamic Systems, Macia and Thaler, Cengage Learning, India Edition
10. Hydraulics and Pneumatics for Production: Stewart
11. Hydraulic Valves and Controls: Pippenger
12. Fundamentals of pneumatics: Festo series

Course Code	Course Name	Credits
ME 310	**Machine Design II**	**3+1**

Prerequisites:

1. Machine Design-I
2. Theory of Machines
3. Strength of Materials

Course Objectives:

1. To design and analyse various machine components considering strength, wear and thermal considerations.
2. To understand the selection of various components based on catalogues/design data books.
3. To apply computer based techniques in the design and analysis of machine components, and create drawings.

Course Outcomes: Upon successful completion of this course, learner will be able to

1. Design various gears based on strength, wear and thermal considerations.
2. Design bearings and select for a particular load and life.
3. Understand the basic principles of cams and their design.
4. Use 3D modeling and analysis software to create computerized designs and create the drawing database.

Theory Syllabus:

Module	Detail Content	Hrs.
1.	**Gears:** Design of spur, helical, bevel and worm gears with strength, wear and thermal considerations. Design of two stage gear box.	10
2.	**Rolling Contact Bearings:** Types of rolling contact bearings, Static and dynamic load carrying capacities, equivalent bearing load, load-life relationship, selection of bearing life, selection of rolling contact bearings from manufacturer's catalogues, selection of bearing for cyclic loads and speeds—bearing with probability of survival.	6
3.	**Sliding Contact Bearings:** Design of hydrodynamically lubricated bearings (self-contained), Introduction to hydrostatic bearings, types and selection of bearings.	6
4.	**Belt, Flywheel & Chain Drives:** Belt Drive: Materials and construction of flat and V belts, geometric relationships for length of belt, power rating of belts, concept of slip & creep, initial tension, effect of centrifugal force, maximum power condition, Selection of Flat and V-belts from manufacturer's catalogue. Flywheel: Energy stored in flywheel, maximum fluctuation of speed, maximum fluctuation of energy. Chain Drive: Types of chains and its geometry, selection criteria for chain drive.	6
5.	**Cams and Followers:** Design of Cam and Roller follower mechanisms with spring and shaft.	5

6.	**Brakes and Clutches:** Brakes: Design of single, double shoe brakes, introduction to hydraulic and pneumatic brakes. Clutches: Introduction, types, basic theory of plate clutches, design of single plate, multi-plate clutches, with spring, lever design and thermal, wear considerations.	6

Laboratory Syllabus:

Module	Details	Hrs.
1.	Design and drawing on two stage gear box	12
2.	Design and drawing on cam and follower	6
3.	Design and drawing of single plate clutch	8

Theory Assessment:

Internal Assessment: 40 marks.

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/ Assignments / Quiz/ Case studies/ Seminar presentation of 40 Marks

End-Semester Examination: 60 marks.

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Laboratory Assessment:

Term Work: 25 marks.

Students have to submit signed and completed assignments based on the modules listed in the table, as a part of the term work. They can also avail NPTEL Certification for this course, for which the assignment work may be suitably reduced, at the discretion of the Instructor.

Viva-você: 25 marks.

Viva-você exam shall be conducted at the end of the course.

Books/References:

1. Design of Machine Elements - V.B. Bhandari, Tata McGraw Hill Publication
2. Design of Machine Elements - Sharma, Purohit. Prentice Hall India Publication
3. Machine Design by Pandya & Shah, Charotar Publishing
4. PSG Design Data Book
5. Machine Design by R.C. Patel, Pandya, Sikh, Vol-I & II C. Jamnadas & Co
6. Mechanical Engineering Design by J.E. Shigley, McGraw Hill

Course Code	Course Name	Credits
ME 311	**Power Engineering**	**3+1**

Course Objectives:

1. To familiarize with the working of S.I. and C.I. engines and its important systems
2. To study utilization of thermal energy in Steam turbine and gas turbine
3. To study boilers, boiler mountings and accessories

Course Outcomes: Learner will be able to

1. Demonstrate the working of different systems and processes of S.I. and C.I. engines
2. Demonstrate working cycles of gas turbines
3. Understand different types of jet propulsion engines
4. Differentiate boilers, boiler mountings and accessories and Calculate boiler efficiency
5. Draw velocity triangles of impulse/reaction turbines and calculate performance parameters/efficiency.

Theory Syllabus:

Module	Detail Content	Hrs.
1	**I C Engine:** Cycle of operation in Four stroke and Two-stroke I C engines and their comparative study; Actual working cycle, Valve Timing Diagram. **S. I Engine:** Mixture requirements, Fuel-Air ratio, Fuel supply system: Simple carburetor, Injection systems: single point and multi point, Introduction to Ignition Systems, Combustion phenomenon in SI Engines, Ignition delay, Flame propagation, Pressure-Crank angle diagram, Abnormal combustion, Detonation and Knocking, Factors affecting combustion and detonation, performance analysis, heat balance sheet.	**08**
2	**C. I. Engines:** Fuel Injection Systems, Combustion phenomenon in C I engines, Stages of combustion, Delay period, Knocking, Pressure-Crank angle diagram, Factors affecting combustion and knocking, performance analysis, heat balance sheet.	**06**
3	**Gas Turbines** Applications of gas turbine, Actual Brayton cycle, open and closed cycle gas turbine, methods to improve efficiency and specific output, open cycle with intercooling, reheat, and regeneration, Effect of operating variable on thermal efficiency and work ratio	**06**
4	**Jet Propulsion Engines** Classification of jet propulsion engines, Thrust, Thrust power, Propulsive efficiency and thermal efficiency, Afterburner, Introduction to Turbojet, Turbofan, Ram jet, Turboprop and Rocket engine	**05**
5	**Steam Generators** Fire tube and Water tube boiler, Low pressure and high-pressure boilers, once through boiler, examples, and important features of HP Boilers Mountings and accessories, Equivalent evaporation of boilers, Boiler performance, Boiler efficiency	**07**

6	**Steam Turbine** Basic of steam turbine, Classification, compounding of turbine, Impulse turbine – velocity diagram, Condition for max efficiency, Reaction turbine - velocity diagram, degree of reaction, Parson's turbine, Condition for maximum efficiency	**07**

Laboratory Syllabus

List of Experiments

1. Morse Test on petrol engine
2. Speed Test on petrol or/and diesel engine
3. Load Test on diesel engine (engines)
4. Demonstration of Boilers
5. Demonstration of Boiler mountings and accessories
6. Visit to Thermal Power Plant/Hydroelectric Power Plant/Gas Turbine Power Plant

Theory Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/Assignments /Quiz/Case studies/Seminar/ presentation of 40 Mark**s**

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Laboratory Assessment:

Term Work Marks: 25 Marks

Laboratory Work (Journal Completion)	: 15 Marks
Attendance	: 05 Marks
Industrial Visit Report	: 05 Marks

End Semester Practical/Oral Examination:

Pair of Internal and External Examiners should conduct practical/viva based on contents.
Distribution of marks for practical/viva examination shall be as follows:
Oral Examination: 25 Marks

Reference Books:

1. Internal Combustion Engine, Mathur and Sharma
2. Internal Combustion Engine, V Ganesan, TMH
3. Internal Combustion Engines, Willard W.Pulkrabek, Pearson Education
4. Internal Combustion Engine, Gills and Smith
5. Internal Combustion Engines Fundamentals, John B. Heywood , TMH
6. Thermal Engineering, R K. Rajput, Laxmi Publication
7. Thermal Engineering, Kothandraman, Domkundwar, Arora, Dhanpatrai & Sons
8. Steam and gas turbine, R Yadav
9. Introduction to Thermal Systems Engineering: Thermodynamics, Fluid Mechanics, and Heat Transfer, Michael J. Moran

Course Code	Course Name	Credits
ME 312	**Advanced Heat Transfer**	**3**

Course Objectives:

1. Solve multidimensional practical heat conduction problems using conduction shape factors.
2. Know the primary considerations in the selection of heat exchangers.
3. Analyze natural convection inside enclosures such as double-pane windows

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

Able to evaluate heat conduction in solids with temperature dependent thermal conductivity.

1. Able to derive a relation for the heat transfer coefficient in laminar film condensation over a vertical plate.
2. Able to derive the governing equations of natural convection, and obtain the dimensionless Grashof number by non-dimensionalizing them.
3. Able to determine the friction factor and Nusselt number in fully developed turbulent flow using empirical relations, and calculate the pressure drop and heat transfer.
4. Able to explain the mechanism and application of film cooling mechanism.
5. Able to design the heat exchanger for the specific requirements.

Module	Detail Content	Hrs.
1.	**Steady heat conduction:** Heat conduction considering variable thermal conductivity, bio heat transfer equation, heat transfer in common configuration. **Transient Heat Conduction:** transient heat conduction in large, plane walls, long cylinders, and spheres with spatial effects,	6
2.	**Thermal Radiation:** Radiation exchange between two and many diffuse gray surfaces, radiation transfer through passages, radiation transfer through gases – equation of transfer, gas radiation properties, effective beam lengths for an isothermal gas, radiation exchange between an isothermal gas and a black enclosure.	6
3.	**Convection Heat Transfer – Natural Convection:** Dimensionless parameters of natural convection, approximate analysis of laminar natural convection on a vertical plate, empirical correlation for various shapes, rotating cylinders, disks and spheres, natural convection in enclosed spaces, combined force and natural convection, **Convection Heat Transfer – Forced Convection:** Forced convection inside tubes and ducts, analysis of laminar forced convection in a long tube, analysis of coutte flow for laminar forced convection, velocity distribution in turbulent flow through a pipe, empirical correlations, flow across a single circular cylinder, forced convection over exterior surfaces, heat transfer enhancement.	7
4.	**Condensation :** Heat Transfer Correlations for Film Condensation - the average heat transfer coefficient for the case of laminar film condensation over vertical plate, inclined plate, vertical tubes, horizontal tubes, horizontal tube banks, effect of presence of non-condensable gases in condensers, film condensation inside horizontal tubes.	6

5.	**Heat Exchangers:** Energy balances and overall heat transfer coefficient, exchanger energy balance, overall heat transfer coefficient, Single stream steady flow heat exchanger – analysis of an evaporator, Two stream steady flow heat exchangers, Regenerators, Elements of heat exchanger design surface selection for compact heat exchanger, economic analysis.	7
6.	**Special Heat Transfer:** Heat transfer in high velocity flows, heat transfer in rarefied gases, transpiration and film cooling, ablative cooling, Heat Pipes, Liquid cooling, thermoelectric coolers, electro-hydrodynamic flow and synthetic jet	6

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:-

1. D.P. Incropera, P.P. and Dewitt, Fundamentals of Heat and Mass Transfer, Wiley Eastern
2. Adrian Bejan, Convective Heat Transfer, Wiley India.
3. Cengel Y A, Heat Transfer – A Practical Approach, McGraw Hill
4. Kays, W.M. and M.E. Crawford, Convective Heat and Mass Transfer, McGraw-Hill (1993).
5. Siegel and Howell, Thermal Radiation, McGraw Hill. 6. Kraus A.D., Aziz, A., and Welty, J., Extended Surface Heat Transfer, McGraw Hill
6. Adrian Bejan, Allan D. Krams, Heat Transfer Handbook, John Wiley & Sons. 8. J. P. Holman, Heat Transfer, McGraw Hill
7. Heat Transfer by A F Mills and V Ganeshan, Pearson education, second edition, 2009

Course Code	Course Name	Credits
ME 313	**Experimental Methods for Thermal and Fluid Systems**	**3**

Course Objectives:

1. To convince the importance of experimentation
2. To familiarize the various instruments
3. To enable the students to design the experiments
4. To develop the instrument selection skill.

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

1. Able to plan and execute the experiment.
2. Learn the different strategies of experiments.
3. Able to select the electrical measurements and sensing devices.
4. Able to select and measure the flow, pressure and thermal conductivity.
5. Able to calibrate the instruments.
6. Able to measure the heat flux.

Module	Detail Content	Hrs.
1.	Experiment versus simulation, need of experimentation, Experimental planning and analysis of results: Importance of experiments in engineering and science, stages of typical experiment, Experimental planning, literature survey and equipment identification, test section design, fabrication and instrumentation, test facility calibration and measurements, Analysis of Results: and Data reduction, Using Excel to present and analyse data, spreadsheets for data analysis.	6
2.	Design of experiments: Strategy of experimentation, Typical applications of experimental design, Types of experiments, guidelines for designing experiments, experiment design factors & protocol and examples. Analysis of Experimental Data, Causes and Types of Experimental Errors, Error Analysis on a Commonsense Basis, Uncertainty Analysis and Propagation of Uncertainty Graphical Analysis and Curve Fitting, Choice of Graph Formats	7
3.	Basic electrical measurements and sensing devices, basic analog & digital meters, power supplies, signal conditioning, digital voltmeter, output recorders, counters-time and frequency measurements, difference between analog and digital instruments. Temporal response of probes and transducers: measurement system model, system response, amplitude response, frequency response, zeroth, first, and second order systems; examples of thermocouple response, anemometer. Probe compensation in the frequency domain.	6
4.	Flow measurements: Positive displacement and flow obstruction methods, flow measurement by drag effects, magnetic flow meters, flow visualisation methods, the shadowgraph. Thermal conductivity measurements, thermal conductivity of liquids and gases, heat flux meters, detection of thermal radiation, detection of nuclear radiation	6
5.	Probes and transducers: Pressure transducers; noise measurement Velocity - Pitot static tube (low as well as high speeds), 5-hole probe,	6

	Hotwire anemometer, CCA, CTA, Laser Doppler velocimetry, Particle image velocimetry. Temperature measurement: thermocouples, RTD, thermister, infrared thermography, Heat flux measurement.	
6.	Calibration of measuring sensors and instruments, Principles of calibration, control of calibration environment, calibration chain and traceability, calibration records,	6

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. C. Tropea, A.L. Yarin, and J.F. Foss, Editors, Springer Handbook of Experimental Fluid Mechanics, 2007.
2. T.G. Beckwith and N.L. Buck, Mechanical Measurements, Addison-Wesley, MA (USA), 1969.
3. H.W. Coleman and W.G. Steele Jr., Experiments and Uncertainty Analysis for Engineers, Wiley & Sons, New York, 1989.
4. E.O. Doeblin, Measurement Systems, McGraw-Hill, New York, 1986.
5. R.J. Goldstein (Editor), Fluid Mechanics Measurements, Hemisphere Publishing Corporation, New York, 1983; second edition, 1996.
6. J. Hecht, The Laser Guidebook, McGraw-Hill, New York, 1986.
7. B.E. Jones, Instrumentation Measurement and Feedback, Tata McGraw-Hill, New Delhi, 2000.
8. M. Lehner and D. Mewes, Applied Optical Measurements, Springer-Verlag, Berlin, (1999).
9. F. Mayinger, Editor, Optical Measurements: Techniques and Applications, SpringerVerlag, Berlin, 1994.
10. D.C. Montgomery, Design and Analysis of Experiments, John Wiley, New York, 2001.
11. A.S. Morris, Principles of Measurement and Instrumentation, Prentice Hall of India, New Delhi, 1999.
12. F. Natterer, The Mathematics of Computerized Tomography, John Wiley & Sons, New York, 1986.
13. P.K. Rastogi, Ed., Photomechanics, Springer, Berlin, 2000.
14. M. Van Dyke, An Album of Fluid Motion, The Parabolic Press, California, 1982
15. Langari, R., Morris, A. S. (2015). Measurement and Instrumentation: Theory and Application. Netherlands: Elsevier Science.
16. Wright, L. M., Han, J. (2020). Experimental Methods in Heat Transfer and Fluid Mechanics. United States: CRC Press.
17. Kirkup, L. (2019). Experimental Methods for Science and Engineering Students: An Introduction to the Analysis and Presentation of Data. United Kingdom: Cambridge University Press.
18. Experimental Methods in Heat Transfer and Fluid Mechanics By Je-Chin Han, Lesley M. Wright, CRC Press.

Course Code	Course Name	Credits
ME 314	**Reliability Engineering**	**3**

Prerequisites:

1. Industrial Engineering and Management

Course Objectives:

1. Demonstrate the approaches and techniques to assess and improve process and/or product quality and reliability.
2. Illustrate the basic concepts and techniques of modern reliability engineering tools.

Course Outcomes: Upon successful completion of this course, learner will be able to

1. Understand and apply the concept of Probability to engineering problems
2. Apply various reliability concepts to calculate different reliability parameters
3. Estimate the system reliability of simple and complex systems
4. Carry out a Failure Mode Effect and Criticality Analysis

Theory Syllabus:

Module	Detailed Content	Hrs.
1	**Probability theory:** Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem. Probability Distributions: Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance. Measures of Dispersion: Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness, Kurtosis.	06
2	**Reliability Concepts:** Reliability definitions, Reliability functions, Importance of Reliability, Quality Assurance and Reliability. Failure Data Analysis: Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTTF in terms of failure Density, Mean time in failure in integral form. Mean time between failure (MTBF).	06
3	**Reliability Hazard Models**: Hazard rate, derivative of the Reliability functions in terms of the hazard rate, Hazard Models – Bathtub curve Constant Failure Rate, linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution MTTF in terms of failure Density, Mean time in failure in integral form functions and reliability analysis.	08
4	**System Reliability:** System Configurations: Series, parallel, mixed configuration, k- out of n structure, Complex systems, Markov models.	06
5	**Reliability Improvement:** Reliability improvement of component, Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis. System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method	06

6	**Maintainability and Availability:** Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.	08

Theory Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. L.S. Srinath, “Reliability Engineering”, Affiliated East-West Press (P) Ltd., 1985.
2. Charles E. Ebeling, “Reliability and Maintainability Engineering”, Tata McGraw Hill.
3. B.S. Dhillion, C. Singh, “Engineering Reliability”, John Wiley & Sons, 1980.
4. P.D.T. Conor, “Practical Reliability Engineering”, John Wiley & Sons, 1985.
5. K.C. Kapur, L.R. Lamberson, “Reliability in Engineering Design”, John Wiley & Sons.
6. Murray R. Spiegel, “Probability and Statistics”, Tata McGraw-Hill Publishing Co. Ltd.

Course Code	Course Name	Credits
ME 315	**Failure Analysis**	**3**

Prerequisites: Basic knowledge of the following subjects:

1. Engineering Mathematics
2. Strength of Materials
3. Theory of Elasticity
4. Theory of Plasticity
5. Machine Design

Course Objectives:

1. Students will be able to identify, document, and research materials related failures while understanding differences between manufacturing, design defects and/or product degradation or misuse.
2. Students will become familiar with and have access to materials characterization equipment as part of a hands-on project.
3. Students will be familiar with a general review of stress analysis, modes of failure, engineering materials and will shift into identifying failures, fractography, failure research publications and litigation/liability issues.

Course Outcomes: Upon successful completion of this course, learner will be able to:

1. Understand factors responsible for failure of materials.
2. Differentiate fracture modes and failure mechanisms for ductile, brittle, fatigue, creep, corrosion and wear failure.
3. Determine fracture toughness of brittle and ductile materials.
4. Predict life of materials under fatigue loading.
5. Analyze failure through case studies and select tools for failure analysis.

Module	Detail Content	Hrs.
1.	**Introduction:** Importance of failure analysis at design stage, modes of mechanical failure, introduction to linear elastic fracture mechanics	7
2.	**High Cycle Fatigue**: Introduction, fatigue loading, Stress Cycles, the S-N curves, effect of mean stress on fatigue, multi axial fatigue stresses, using multi axial fatigue failure theories.	7
3.	**Low-Cycle Fatigue**: Introduction, the strain cycling concept, the strain life curve and low cycle fatigue relationships, the influence of nonzero mean strain and nonzero mean stress, cumulative damage rule in low-cycle fatigue.	7
4.	**Fracture Mechanics**: Introduction, the Linear damage theory, cumulative damage theories, life prediction based on local stress-strain and fracture mechanics concepts, service loading simulation and full scale fatigue testing, damage tolerance and fracture control.	8
5.	**Creep, Stress Rupture and Fatigue**: Introduction, prediction of long-term creep behaviour, theories for predicting creep behaviour, creep under uniaxial state of stress and multi axial state of stress, cumulative creep concept, combined creep and fatigue.	7

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. F. Madoyag, Metal Fatigue Design and Theory.
2. L. Sors, Fatigue Design of Machine Components, Pergamon Press.
3. S. T. Rolfe and J. M. Barson, Fracture and Fatigue Control Structures, Prentice Hall.
4. David Broek, Elementary Engineering Fracture Mechanics, Noordnoff.
5. G. E. Dieter, Mechanical Metallurgy, Tata McGraw Hill Book Co., New Delhi.

Course Code	Course Name	Credits
ME 316	**Micro Electro Mechanical Systems**	**3**

Course Objectives:

1. To provide a basic knowledge of MEMS processing steps and processing modules.
2. To provide information on various MEMS materials and their characteristics
3. To demonstrate the use of semiconductor based processing modules used in the fabrication of a variety of sensors and actuators (e.g. pressure sensors, accelerometers, etc.) at the micro-scale.
4. To provide an understanding of basic design and operation of MEMS sensors and transducers.
5. To provide understanding of MEMS reliability and Device characterization.

Course Outcomes:

Upon successful completion of this course, the learner will be able to

1. Understand basics of MEMS technology
2. Knowledge of various MEMS materials
3. Understand the underlying fundamental principles of MEMS devices including physical operation, mathematical modeling and fabrication.
4. Design and simulate MEMS devices and systems using standard simulation tools.
5. Develop different concepts of micro system sensors and actuators for real-world applications.
6. Understand MEMS Device characterization parameters

Module	Detail Content	Hrs.
1.	**Introduction to MEMS** Introduction to MEMS & Real world Sensor/Actuator examples (DMD, Air-bag, pressure sensors). MEMS Sensors in Internet of Things (IoT), BioMedical Applications, Optical MEMS	4
2.	**MEMS Materials and Their Properties** Materials (eg. Si, SiO2, SiN, Cr, Au, Ti, SU8, PMMA, Pt, SOI-GEI); Important properties: Young modulus, Poisson's ratio, density, piezoresistive coefficients, TCR, Thermal Conductivity, Material Structure. Understanding Selection of materials based on applications	8
3.	**MEMS Fab Processes – 1** Understanding MEMS Processes & Process parameters for: Cleaning, Growth & Deposition, Ion Implantation & Diffusion, Annealing, Lithography. Understanding selection of Fab processes based on Applications	8
4.	**MEMS Fab Processes – 2** Understanding MEMS Processes & Process parameters for: Wet & Dry etching, Bulk & Surface Micromachining, Die, Wire & Wafer Bonding, Dicing, Packaging. Understanding selection of Fab processes based on Applications	8
5.	**MEMS Devices** Architecture, working and basic quantitative behaviour of Cantilevers, Microheaters, Accelerometers, Pressure Sensors, Micromirrors in DMD, Inkjet printer-head. Understanding steps involved in Fabricating above devices	8

6.	**MEMS Device Characterization** Piezoresistance, TCR, Stiffness, Adhesion, Vibration, Resonant frequency, & importance of these measurements in studying device behavior, MEMS Reliability	4

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. An Introduction to Microelectromechanical Systems Engineering; 2nd Ed - by N. Maluf, K Williams; Publisher: Artech House Inc
2. Practical MEMS - by Ville Kaajakari; Publisher: Small Gear Publishing
3. Microsystem Design - by S. Senturia; Publisher: Springer
4. Analysis and Design Principles of MEMS Devices - Minhang Bao; Publisher: Elsevier Science
5. Fundamentals of Microfabrication - by M. Madou; Publisher: CRC Press; 2 edition
6. Micro Electro Mechanical System Design - by J. Allen; Publisher: CRC Press
7. Micromachined Transducers Sourcebook - by G. Kovacs; Publisher: McGraw-Hill

Course Code	Course Name	Credits
ME 317	**Signal Processing**	**3**

Course Objectives:

1. To identify, classify and analyse various types of signals and systems
2. To analyse time Domain analysis of continuous and discrete time signals and systems.
3. To Analyse the Continuous signals in frequency domain using Fourier series and Fourier Transform.
4. To Analyse the Discrete signals in frequency domain using Fourier series and Fourier Transform.
5. To analyse, formulate and solve problems on frequency domain analysis of continuous time systems using Laplace Transform.
6. To analyse, formulate and solve problems on frequency domain analysis of discrete time systems using Z- Transform

Course Outcomes:

Upon successful completion of this course, the learner will be able to

1. Classify and analyse various types of signals and systems.
2. Determine convolution integral and convolution sum.
3. Analyse the continuous time signals in frequency domain using Fourier series and Fourier Transform.
4. Analyse the discrete time signals in frequency domain using Fourier series and Fourier Transform.
5. Analyse, formulate and solve problems on frequency domain analysis of continuous time systems using Laplace Transform.
6. Analyse, formulate and solve problems on frequency domain analysis of discrete time systems using Z- Transform.

Module	Detail Content	Hrs.
1.	**Introduction of Continuous and Discrete Time Signals and systems:** Introduction to Signals: Definition of Signals , Representation of continuous time signals and discrete time signals, Sampling theorem, sampling of continuous time signals Basic Elementary signals , Arithmetic operations on the signals- Time Shifting, Time scaling, Time Reversal of signals Classification of Continuous time signals and Discrete time signal Introduction to Systems: Definition of Systems , Classification of Continuous time systems and Discrete time systems Applications of Signals and Systems	7
2.	**Time domain analysis of continuous time and discrete time systems** **Linear Time Invariant (L**TI) systems, Impulse signal and Properties of impulse signal, impulse response, step response, Convolution integral and Convolution sum for analysis of LTI systems, properties of convolution integral/sum, impulse response of interconnected systems Correlation of Signals: Auto-correlation and Cross correlation of Continuous time signals and Discrete time signal	6

3.	**Frequency domain analysis of continuous time signals :**Fourier series (FS) representation of periodic Continuous Time (CT) signals, Trigonometric and Exponential Fourier series Frequency Domain Analysis of aperiodic Signals-Introduction, Properties of Fourier Transform, Inverse Fourier Transform	6
4.	**Frequency Domain Analysis of Discrete Time signals** Discrete Time Fourier Series, Evaluation of DTFS coefficients, Magnitude and Phase Spectrum of Discrete time periodic signals, Discrete Time Fourier Transform – Definition of DTFT, Determination of magnitude and phase functions using DTFT, Properties of DTFT	6
5.	**Frequency domain analysis of continuous time system using Laplace transform-** Definition of Laplace Transform (LT), Region of Convergence (ROC), and Properties of Laplace transform, Inverse Laplace transform. Analysis of continuous time LTI systems using Laplace Transform: Causality and stability of systems in s-domain, Total Response of the system, Relation between LT and FT	6
6.	**Frequency domain analysis of discrete time system using Z-transform** System Realization structure using DT system - definition of unilateral and bilateral Z Transform, Region of Convergence (ROC),Properties of Z-Transform, Inverse Z-Transform Analysis and characterization of the LTI system using Z transform: Transfer Function and difference equation, plotting Poles and Zeros of a transfer function, impulse and step response, causality, stability, Total response of a system. Relation between Laplace Transform and Z–Transform.	8

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. NagoorKani, “Signals and Systems”, Tata McGraw Hill, Third Edition, 2011
2. Tarun Kumar Rawat, “Signals and Systems”, Oxford University Press 2016.
3. Simon Haykin and Barry Van Veen, “Signals and Sytems”, John Wiley and Sons, Second Edition,2004.
4. Hwei. P Hsu, “Signals and Systems”, Tata McGraw Hill, Third edition, 2010
5. Rodger E Ziemer, William H. Tranter and D. Ronald Fannin, “Signals and Systems”, Pearson Education, Fourth Edition 2009.
6. Alan V. Oppenhiem, Alan S. Willsky and S. Hamid Nawab, “Signals and Systems”, Prentice-Hall of India, Second Edition, 2002.

Course Code	Course Name	Credits
ME 318	**Advanced Composites and Polymeric Materials**	**3**

Prerequisites:

1. Chemistry of Engineering materials
2. Materials science and metallurgy

Course Objectives:

1. To equip students with fundamental knowledge of polymeric and composite materials.
2. To achieve an understanding of principles of design in plastics and composites, and to explore the multiple new opportunities .

Course Outcomes:

Upon successful completion of this course, learner will be able to

1. Differentiate the behaviour and specialties of orthotropic materials.
2. Apply theory of elasticity and mechanics of orthotropic materials and behavior under bi-axial stress conditions.
3. Understand the concept of design optimization with proper material selection and its application.
4. Choose or design a material system to reduce the weight of a car and improve its fuel efficiency.
5. Make a good selection of materials for engineering applications

Module	Detail Content	Hrs.
1.	Introduction to composite materials, evolution and applications in engineering. Characteristics and classification of composite materials; Fibrous, laminated and particulate composites. Basic terminologies; volume fraction and weight fraction. Laminae and laminates. Different fibres, matrices and their properties. Advantages and disadvantages of polymer matrix composites, metal matrix composites and ceramic matrix composites. Mechanical properties of unidirectional composite lamina. Longitudinal and transverse Young modulus, shear modulus, Poisson ratio.	7
2.	Empirical relationship of Halpin-Tsai. Longitudinal and transverse Strength. Composites under compressive loading. Properties of angle ply lamina. Transformation of Young moduli, shear modulus. Concept of coupling coefficients. General and special orthotropic materials. Psai Pagano invariants Strength of orthotropic lamina. Biaxial strength theories. Maximum strength, maximum strain theory. Tsai-Hill maximum work theory. Tsai Wu tensor theory.	6
3.	Applications of the above theories to pressure vessels, composite shafts etc. Codes and engineering representation of Laminates. Macro mechanical behavior of a laminate. Laminate stiffness for different types; symmetric, anti-symmetric, cross ply laminates. Stresses in different laminae in a laminate.	6
4.	High Performance plastics and Composites in Automobile Industry, Processing of polymer composites, Hand-layup, Spray-layup, Compression molding Injection molding. Reaction injection molding, Autoclaving, Resin transfer molding, Filament winding, Pultrusion.	6

	Sheet molding, Pre-pegging	
5.	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, Drilling of polymer composites. Conventional vs ultrasonic drilling, Remedies for reducing drilling induced damages,	6
6.	Applications of advanced composites and polymers -Aerospace and biomedical field.Case studies on development of new systems for improved performance.Emerging 3D printable composites and polymer matrix composites	6

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Mallick, P. K. , “Fibre-Reinforced Composites, CRC press,” New York, 2007
2. Jones, R.M., “Mechanics of Composite Materials,” Mc Graw Hill, New Delhi
3. Broutman and Agarwal, “Analysis and Performance of Composite materials”, John Willey and Sons, New York
4. Ehsan Bafekrpour, “Advanced Composite Materials:Properties and Applications2017
5. Sohel Rana; Raul Fangueiro,”Advanced composite materials for aerospace engineering : processing, properties and applications,Woodhead Publishing,2016

Course Code	Course Name	Credits
ME 319	**Biomaterials & Tissue Engineering**	**3**

Prerequisites:

1. XII Biology
2. XII Chemistry
3. Chemistry of materials

Course Objectives:

1. To understand the role of materials in development of implants
2. To know the biocompatibility of different implant materials
3. To understand the the use of scaffolds
4. To use nanotechnology to develop new tissues

Course Outcomes: Upon successful completion of this course, learner will be able to

1. Differentiate and understand methods for categorisation of biomaterials.
2. Understand common use of biomaterials as metals, ceramics and polymers and its chemical structure, properties and morphology.
3. Develop nature motivated systems for human body
4. Design new strategies for validation and testing of biomaterials
5. Design and develop alternatives to bone implant materials

Module	Detail Content	Hrs.
1.	Basic concepts: General overview of components in the human body used to construct tissue. Introduction to Biomaterials-Classification based on materials classes, based on host response and their applications on human body-Importance of Regenerative medicine	6
2.	Biomimetics -approach, biomimetic polymers,Lessons from nature, Role of surface modification/tecturing. methods of surface modifications and texturing	6
3.	Structural and mechanical properties for scaffold design,Biomaterials for scaffold making,Processing techniques for scaffolds ,Scaffolds applications in human	8
4.	Bone tissue Engineering-current applications and trends. Synthesis of artificial bones,advantages and disadvantages of the processing route	5
5.	Nanobiotechnology-enabled tissue engineering strategies-Gold nanoparticles in cancer drug,Role of Nanogenotoxicology Studies in Safety Evaluation of Nanomaterials	6
6.	Invitro and Invivo studies of biomaterials-methods used for invitro and invivo studies with some case studies	5

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Biomaterials,an Introduction-J.Park,R.S.Lakes, 1979
2. Nanotechnology Applications for Tissue Engineering, -Sabu Thomas,Yves Grohens,Neethu Ninan, 2015
3. Biomaterials Science and Engineering-Rosario Pignatello,2011
4. Biomaterials Science - Ratner, Hoffman, Schoen, Lemons (Elsevier; ISBN 0-12-582461)
5. Biomaterials - Temenoff and Mikos (Pearson Prentice Hall; ISBN 0-13-009710-1)

Course Code	Course Name	Credits
ME 320	**Manufacturing Analytics**	**3**

Course Objectives:

1. To understand different manufacturing systems and its performance measures
2. To acquaint students with cellular manufacturing system
3. To familiarize students with flexible manufacturing system
4. To understand synchronous manufacturing and theory of constraints
5. To understand discrete and continuous manufacturing
6. To familiarize students with modelling and simulation of manufacturing systems and softwares used

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

1. Analyse different manufacturing systems for its performance measures
2. Design of cellular manufacturing system
3. Illustrate loading and scheduling problems in FMS
4. Apply theory of constraints to improve the process performance
5. Develop simulation models of the manufacturing system

Module	Detail Content	Hrs.
1.	Models of manufacturing systems, including transfer lines and flexible manufacturing systems, multistage manufacturing process Calculation of performance measures, including throughput, in-process inventory, and meeting production commitments; real-time control of scheduling; effects of machine failure, set-ups, and other disruptions on system performance. Data analytics tools	06
2.	Cellular manufacturing, cell formation methods: Rank order clustering, similarity coefficient and optimization based,	06
3.	Flexible Manufacturing Systems, Concepts, FMS loading problems, FMS scheduling problems	06
4.	Synchronous Manufacturing, Principles of SM, Theory of Constraints and Linear Programming, Scheduling	06
5.	Event verses activity, General principles of event-driven simulation, Use of Pseudo-Random numbers in simulation of queuing systems, Simulation of manufacturing systems and other examples	08
6.	Introduction to modeling and simulation concepts, System analysis and components, Simulation terminology, Model of a system and types of models, Discrete *verses* continuous systems, Static and Dynamic System simulation, Pros and cons of simulation. Simulation of manufacturing and material handling systems, Modeling downtime and failures, Case studies Introduction to simulation software and languages for manufacturing and material handling like Extend, Areana, Technomatix etc	10

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests - 40 Marks
2. Continuous evaluation- Class Test/ Assignments /Quiz/Case studies/Seminar presentation- 40 Marks

End Semester Examination: 60 Marks
Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:-

1. Modeling and Analysis of Manufacturing Systems by Ronald G. Askin, Charles R. Standridge
2. Production Planning and Inventory Control by Seetharama L Narasimhan, Dennis W.McLeavey and Peter J Billington
3. Discrete-Event System Simulation by Jerry Banks, Carson and Nelson, Prentice Hall of India Pvt. Ltd.
4. Simulation Modelling and Analysis by Law and Kelton, McGraw Hill, New York.

Course Code	Course Name	Credits
ME 321	**Optimization Techniques**	**3**

Course Objectives:

1. To Understand the need and origin of the optimization methods.
2. To understand various linear, nonlinear and other optimization techniques.
3. To understand various multi criterion and multi-objective decision making methods.
4. To understand recent tools in optimization

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

1. Identify and apply calculus method to single variable problem
2. Formulate the problem as LPP and analyse the sensitivity of a decision variable.
3. Apply various linear and non-linear techniques for problem solving in various domain.
4. Apply multi-objective decision making methods for problem in manufacturing environment and other domain.
5. Apply multi criterion decision making methods for problem in manufacturing environment and other domain.
6. Apply Design of Experiments for Optimization

Module	Detail Content	Hrs.
1.	Basic Concepts: Statement of the Optimization Problem, Basic Definitions, Optimality Criteria for Unconstrained Optimization, Optimality Criteria for Constrained Optimization, Engineering Application of Optimization, Classification of Optimization Problems Classical Optimization Techniques: Single variable optimization	6
2.	Linear Programming Problem: Formulation, Simplex method, Big M Method, Two Phase, Primal to Dual, Dual Simplex method, Sensitivity Analysis and applications of LP (Transportation and Assignment Models)	7
3.	Integer Programming, Model: Gomory's cutting plane method, Branch & Bound Technique. Non L.P. Model: Lagrangian method & Kuhn tucker Method, Newton's method Discrete Event Simulation: Generation of Random Variable, Simulation Processes, Monte-Carlo Technique.	7
4.	Multi Objective Decision making (MODM) Methods: Introduction to Multi objective optimization, Traditional Techniques such as, quadratic programming, geometric programming, Numerical on goal programming and dynamic programming. Introduction to Non-traditional optimization Techniques such as Genetic Algorithm, particle swarm, genetic algorithms, simulated annealing and Techniques based on Neural network & Fuzziness.	7
5.	Multi Criterion Decision-making (MCDM) Methods: Introduction to multi criterion optimization Simple Additive Weighting (SAW) Method Weighted Product Method (WPM) Analytic Network Process (ANP) Analytic Hierarchy Process (AHP) Method	6

	TOPSIS Method PROMETHEE	
6.	Robust Design Methods: DOE and Taguchi techniques Full Factorial Design: The basics of "full factorials", ANOVA, Factorial effects and plots, and Model evaluation Fractional Factorial Design: The one-half fraction and one-quarter of the 2^k design, The general 2^{k-p} fractional factorial design Application of related software (Mini Tab or MATLAB)	7

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. S.S. Rao, "Engineering Optimization - Theory and Practice", John Wiley and Sons Inc.
2. Ranjan Ganguli, "Engineering Optimization - A Modern Approach" Universities Press
3. Pablo Pedregal, "Introduction to Optimization", Springer
4. L.C. Jhamb, "Quantitative Techniques Vol. 1 and 2", Everest Pub. House
5. Pierre D.A., "Optimization, Theory with Application", John Wiley & sons.
6. Decision Making in the Manufacturing Environment Using Graph Theory and Fuzzy Multiple Attribute Decision Making by R V Rao (Springer Publication).
7. Neural Computation and Self-Organizing Maps by Ritter, H., Martinetz, T., & Schulten, K., Addison-Wesley Publishing Company
8. Design and analysis of experiments by Douglas C.Montgomery (John Wiley & Sons Inc.)

Course Code	Course Name	Credits
ME 322	**Wind Energy & Conversion Systems**	**3**

Course Objectives:

1. Understand the technologies that are used to harness the power of the wind.
2. Develop an intuitive understanding of wind turbine design criterion and its conversion system.
3. Discuss the positive and negative aspects of wind energy in relation to natural and human aspects of the environment.

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

1. Explain the existing wind energy potential..
2. Analyse the various aerodynamic loads and its design criterion on wind turbine systems.
3. Describe the existing Wind Energy Conversion System.
4. Analyze the control mechanism of wind turbines.
5. Understand the application of wind energy with case studies and its environmental impacts.

Module	Detail Content	Hrs.
1.	**Basics of Wind Energy Technology** Wind statistics- Measurements and data Presentation, Historical developments, latest developments, state of art of wind energy technology, turbine rating, economic analysis of wind turbine, Indian scenario and worldwide developments, present status and future trends. Wind turbine aerodynamics.	8
2.	**Characteristics of Wind Energy** Nature of atmospheric winds- Wind resource characteristics and assessment– Anemometry, speed frequency distribution, effect of height, wind rose, Weibull distribution, atmospheric turbulence, gust wind speed, effect of topography. Effect of Reynolds's number, actuator disc, Betz coefficient, design of wind turbine blade, effect of stall and blade tip speed ratio and coefficient of torque.	8
3.	**Wind Energy Conversion System (WECS)** Rotor Selection, Annual Energy Output, HAWT, VAWT, Rotor Design Considerations-Number of Blades, Blade Profile -2/3 Blades and Teetering, Coning- Upwind/Downwind, Power Regulation, Yaw System-Tower, Synchronous and Asynchronous Generators and Loads, Integration of Wind Energy Converters to Electrical Networks, Inverters- Testing of WECS, WECS Control System - Requirements and Strategies.	10
4.	**Control Mechanisms** Pitch control, yaw control, Electrical and Mechanical aerodynamic braking, teeter mechanism. Wind turbine dynamics with DC and AC generators: induction and synchronous generators, variable speed operation, effect of wind turbulence. Case study of design of wind mill.	7
5.	**Wind Energy Application** Wind pumps - Performance analysis, design concept and testing, Principle of WEG- Stand alone, grid connected and hybrid applications of WECS,	7

	Economics of wind energy utilization, Wind energy in India- Case studies, environmental impacts of wind farms.	

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Spera D.A., Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, ASME Press, NY 1994.
2. Martin OL Hansen: Aerodynamics of Wind Turbines, 2nd ed. Earthscan, London.
3. B.H.Khan: Non Conventional Energy Sources, Tata McGraw-Hill Education, 2006.
4. Johnson, G.L., Wind Energy Systems, Prentice Hall, 1985.
5. Martin OL Hansen: Aerodynamics of Wind Turbines, 2nd ed. Earthscan, London.
6. L. L. Freris, Wind Energy Conversion systems, Prentice Hall, UK, 1990.
7. Steve Parker, “Wind power”, Gareth Stevens Publishing, 2004.

Course Code	Course Name	Credits
ME 323	**Thermal Energy Storage Systems and Applications**	**3**

Course Objectives:

1. Learn various thermal energy storage methods.
2. To understand impact of various energy storage on environment.
3. To learn mathematical modelling of thermal storage systems

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

1. Choose the best suited method from available methods of energy storage to reduce impact on environment.
2. Carry out Energy and Exergy Analyses of Thermal Energy Storage Systems.
3. Understand recent advancements in energy storage technologies.

Module	Detail Content	Hrs.
1.	**Energy storage systems :-** Introduction , Energy Demand , Energy Storage , Energy Storage Methods , Hydrogen for Energy Storage, Comparison of Energy Storage Technologies.	04
2.	**Thermal Energy Storage (TES) Methods and Environmental Impact** Introduction to Thermal Energy, Thermal Energy Storage, Solar Energy and TES Methods , Sensible and Latent , Cold Thermal Energy Storage (CTES), Seasonal TES. **Thermal Energy Storage and Environmental Impact:-** Introduction , Energy and the Environment Major Environmental Problems, Environmental Impact and TES Systems and Applications , Potential Solutions to Environmental Problems , Sustainable Development.	08
3.	**Thermal Energy Storage and Energy Savings:-** Introduction, TES and Energy Savings , Additional Energy Savings Considerations for TES , Energy Conservation with TES: Planning and Implementation , Some Limitations on Increased Efficiency , Energy Savings for Cold TES	04
4.	**Energy and Exergy Analyses of Thermal Energy Storage Systems** Introduction , Theory: Energy and Exergy Analyses , Thermodynamic Considerations in TES Evaluation , Exergy Evaluation of a Closed TES System , Appropriate Efficiency Measures for Closed TES Systems , Importance of Temperature in Performance Evaluations for Sensible TES Systems , Exergy Analysis of Aquifer TES Systems , Exergy Analysis of Thermally Stratified Storages , Energy and Exergy Analyses of Cold TES Systems , Exergy Analysis of Solar Ponds.	08
5.	**Numerical Modeling and Simulation of Thermal Energy Storage Systems** Introduction, Approaches and Methods, Selected Applications , Numerical Modeling, Simulation, and Analysis of Sensible TES Systems, Numerical Modeling, Simulation, and Analysis of Latent TES Systems, Illustrative Application for a Complex System: Numerical Assessment of Encapsulated Ice TES with Variable Heat Transfer Coefficients.	08
6.	**Recent Advances in TES Methods, Technologies, and Applications:-** Introduction , Recent TES Investigations , Developments in TES Types and Performance , Micro- and Macro-Level Advances in TES Systems	08

	and Applications, Micro-Level Advances in TES Systems, Macro-Level Advances in TES Systems and Applications , Performance Enhancement Techniques, Innovative Applications of TES Systems, Advanced Applications of Exergy Methods.	

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Thermal Energy Storage: Systems and Applications, 2nd Edition , Ibrahim Dincer, Marc A. Rosen , John Wiley & Sons
2. Exergy Method: Technical and Ecological Applications: No.18 (Developments in Heat Transfer) by J. Szargut , WIT Press
3. Thermal Design and Optimization 1st Edition, by Adrian Bejan, George Tsatsaronis, Michael J. Moran John Wiley & Sons, Inc
4. Advances in Thermal Energy Storage Systems , Methods and Applications by Luisa F. Cabeza, Woodhead Publishing,
5. Thermal Energy Storage Technologies for Sustainability: Systems Design, Assessment and Applications by S. Kalaiselvam Dr. (Author), R. Parameshwaran, Academic Press
6. Thermal Energy Storage Analyses and Designs by Pei-Wen Li (Author), Cho Lik Chan , Academic Press.
7. Latent Heat-Based Thermal Energy Storage Systems: Materials, Applications, and the Energy Market**,** by Amritanshu Shukla (Editor), Atul Sharma (Editor), Pascal Henry Biwolé , CRC Press
8. Thermal, Mechanical, and Hybrid Chemical Energy Storage Systems 1st Edition, by Klaus Brun, Timothy C. Allison, Richard Dennis, Academic Press

Course Code	Course Name	Credits
ME 324	**Vehicle Systems**	**3**

Course Objectives :

1. To study basic and advanced automotive systems.
2. To study working of different automotive systems and subsystems.
3. To study different types of frames and vehicle layout.
4. To have a basic idea about how automotive systems are developed.

Course Outcomes: Learner will be able to…

1. Interpret underlying mechanics of the automotive systems.
2. Compare different chassis and transmission systems.
3. Select an automotive system for diverse automotive applications.
4. Understand different Vehicle Body systems and layouts.
5. Understand the working of different Vehicle Systems and Subsystems.
6. Comprehend the different technological advances in vehicle systems.

Theory Syllabus:

Module	Content	Hrs.
1	**Frames and Axles** Frames-Layouts,types,material,construction,loads acting Front and Rear axles – Types of Front Axles and Stub axles , Construction and Materials **Automotive Clutch**- Necessity of clutch in a automobile, Working and Construction of Single plate,Multi-plate,Centrifugal,Semi Centrifugal, Electromagnetic clutches, Fluid Flywheel	05
2	**Automotive Transmission**- Purpose and Elements of Gear Box, Characteristic Curves, Types-Sliding mesh, Constant Mesh, Synchromesh, Determination of gear ratios for vehicles, **Hydrodynamic Transmissions**-Torque converter - Principle - constructional details, Multistage torque converters and Polyphase torque converters. **Epicylclic Gearboxes used in automatic transmissions-** Principle of Planetary gear trains-Wilson,Cotal electromagnetic transmission, Continuously Variable Transmission-Types and Operation of typical CVT, Automotive Powertrain, Powertrain Analysis and Transmission Matching	10
3	**Drive Line**: UV joint, CV joint, Propeller Shaft construction and arrangement, Elements of drive line, 2WD, 4WD, Part time and Full time 2WD and 4WD.Driving thrust and its effects, Torque reaction and Side thrust, Hotchkiss drive, Torque tube drive, Radius rods, Stabilizers **Final Drive** –Types of Final drive gears and Bearing **Differential** –Principle, Constructional details of Differential unit,Housing,Non slip differential and differential locks, gears and bearing	06
4	**Steering**-Introduction to steering systems, Manual Steering, Ackerman and Davis Steering Mechanisms, Steering Linkages Different types of Steering gear boxes, Reversible and Irreversible steering, Slip angle,	06

	Over and under steer Power steering systems, Front Wheel Geometry, Wheel alignment	
5	**Brakes**- Introduction to Brake System, Components of Brake System, Hydraulic Brake, Air Brake, Antilock Brake System, Braking Analysis.	06
6	**Suspension**- Introduction to Suspension System, Components of Suspension System, Dependent and Independent Suspension, Types of Suspension Springs-Single leaf, Multileaf spring, Coil, Torsion Bar, Rubber, Pneumatic and Hydro elastic suspension spring systems. **Wheels and Tyres**- Tire requirement, tire characteristics, Constructional detail and retreading, tire dimensions and specifications, Types of wheels and Hubs.	06

Laboratory Syllabus:

Term Work : (Comprises both A & B)

A. List of Experiments

1. Dismantling and reassembling of Clutch.
2. Dismantling and reassembling Gear box.
3. Dismantling and reassembling of the Propeller Shaft.
4. Dismantling and reassembling of Differential.
5. Dismantling and reassembling of Steering gear linkages and steering gear box.
6. Dismantling and reassembling any one type of braking system.

B. Case Study

Case study and detail report explaining all systems and subsystems on any two of following

A. Passenger Vehicle
B. 2/3 Wheeler
C. Off Road Vehicles
D. Military vehicles

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Text Books:

1. Newton, Steed & Garret, Motor Vehicles, Butterworth Heinemann.
2. N. K. Giri, Automotive Mechanics, Khanna Publishers.
3. D. Crolla, D. E. Foster, T. Kobayashi and N. Vaughan (Editors-in-Chief), Encyclopedia of Automotive Engineering, Parts 1-6, Wiley, 2015.

Books/References:

1. Crouse. W. H, Automotive Chassis and Body, McGraw Hill New York.
2. Jack Erjavec, Automotive Technology – A systems approach, Cengage Learning.
3. M. J. Nunny, Automotive Technology, SAE Publication.

Course Code	Course Name	Credits
ME 325	**Automotive Chassis and Body Systems**	**3**

Course Objectives:

1. To Understand fundamentals of Vehicle Body design
2. To Study different vehicle structural design and their requirements.
3. To Study Vehicle Aerodynamics.
4. To Study different vehicle body structures and Loads acting on them.
5. To study various materials related to body structures

Course Outcomes: Learner will be able to

1. Apply aerodynamics principles while vehicle body designs.
2. Apply Aesthetic and Ergonomic principles while designing vehicle body.
3. Differentiate different vehicle body styles.
4. Select material for different vehicle components.
5. Identify and draw various types of body design according to shape and frame structures.
6. Design passenger and commercial vehicle bodies for different loading conditions.

Module	Content	Hrs.
1	**Aerodynamics** Vehicle Body Styles, Vehicle drag and types, Various types of forces and moments, Effect of forces and moments, Side wind effect on forces and moments, Body optimization techniques to reduce drag, Wind tunnels-Principle of operation and types, Wind tunnel testing such as: Flow visualization techniques, Air flow management test - measurement of various forces and moment by using wind tunnel.	07
2	**Car Body Details** Types of Car Bodies,Visibility,Drivers Visibility, Improvement in visibility and test for visibility, Driver Seat design, Car body construction, Various panels used in car bodies Safety -Safety aspects during design, Safety equipment, Design criteria, Prototype making, Initial tests, crash test on full models, Dummies and Instrumentation.	06
3	**Bus Body Details** Types of bus body: based on capacity, distance travelled and based on construction:Mini bus, Single decker,Double decker,Two level and articulated, Bus body layout-Floor height, Engine location, Entry and exit location, seating dimensions. Constructional details-Conventional and Integral, Frame construction, Double skin construction, metal sections types,	06
4	**Commercial vehicle detail** Types of commercial vehicle bodies-Flat platform, drop side, fix side, tipper body, tanker body, Trailer body, Light commercial vehicle body types, Dimensions of driver seat in relation to controls, Drivers cab design and Regulations Special commercial vehicles: Refrigerated vehicles, paramedic ambulances, pickup van.	06

5	**Body Materials, Trim and Mechanisms** Types of materials used in body construction-Sheet steel, timber, plastics, GRP, Carbon fiber, fibreglass, Shape memory alloys, technologies to reduce NVH properties of materials, Corrosion- anti corrosion methods, Selection of paint and painting procedure and paint problems. Body trim items and Body mechanisms, Body repair tools - Hand tools, power tools, repairing sheet metal, repairing plastic body fillers, passenger compartment service.	07
6	**Vehicle structure and Body design** Loads on frames, Construction and cross sections of frame, Basic requirement of strength and stiffness, Vehicle structure types, Demonstration of Simple structural surface (SSS),Idealized structure-structure surface, shear panel method, Layout of design, preliminary design, vehicle body weight analysis and Vehicle Weight distribution **Body loads** Symmetric and asymmetrical vertical loads in car, longitudinal loads, Different loading situations, Calculation of loading cases, Stress analysis of vehicle body structure under bending and torsion.	07

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Text Books:

1. J.Powloski-“Vehicle Body Engineering”-Business Books Ltd, London,1989
2. John Fenton-“Vehicle Body Layout and analysis-Mechanical Engg. Publications Ltd, London, 1982.
3. J.Reimpell-“The Automotive Chassis: Engineering Principles “Reed Elsevier and Professional publishing Ltd, 2001.

Books/References:

1. Crouse. W. H, Automotive Chassis and Body, McGraw Hill New York.
2. Wolf Heinrich Hucho, Aerodynamics of Road Vehicles, SAE International, USA
3. Giles J.C Body Construction and Design, Illife Books Butterworth & Co., 1971

Course Code	Course Name	Credits
IL 360	**Entrepreneurship**	**3**

Course Objectives:

1. To understand the basic concepts of entrepreneurship.
2. To understand the role of entrepreneurship in economic development
3. To understand the importance of opportunity recognition and internal and external analyses to the success of a business venture
4. To enable the learners to know the factors contributed in failure of the enterprise

Course Outcomes: Learner will be able to

1. Analyse the business environment in order to identify business opportunities
2. Identify the elements of success of entrepreneurial ventures
3. Evaluate the effectiveness of different entrepreneurial strategies,
4. Interpret their own business plan

Module	Detailed Contents	Hrs
1	Conceptual definition of entrepreneurs and entrepreneurship, Advantages and Disadvantages of Being an Entrepreneur , Entrepreneurial motivation, Entrepreneurial characteristics	8
2	Recognizing, assessment and Exploiting the Opportunity, Conducting Internal and External Analyses, Determining the Feasibility of the Concept, Selecting a Marketing Strategy	6
3	Entrepreneurial Business Types A. Overview of Franchising and Their Advantages and Disadvantages B. Overview of Buyouts & Their Advantages and Disadvantages C. Overview of Family Businesses and Their Advantages and Disadvantages	6
4	The Overall Business Plan, Purpose of the Business Plan, Components of the Business Plan, Presentation of the Business Plan, Matching the Business Plan to the Needs of the Firm	6
5	The Marketing Plan, Conducting a Market Analysis, Understanding the Target Market, Reaching the Target Market through Locale and Engagement	8
6	Entrepreneurial failure, early stage failure, late stage failure	6

Assessment:

Internal Assessment: 40 marks
End Semester Examination: 60 Marks

Reference Books:

1. Fundamentals of Entrepreneurship by H. Nandan, PHI
2. Entrepreneurship by Robert Hisrich, Michael Peters, Dean Shepherd, Sabyasachi Sinha, Mc Graw Hill
3. Why startups fail: A new roadmap for entrepreneurial success by Tom Eisenmann

Course Code	Course Name	Credits
IL 361	**IPR and Patenting**	**3**

Course Objectives:

1. To introduce fundamental aspects of Intellectual property Rights to learner who are going to play a major role in development and management of innovative projects in industries.
2. To get acquaintance with Patent search, patent filing and copyright filing procedure and applications, and can make career as a patent or copyright attorney.
3. To make aware about current trends in IPR and Govt. steps in fostering IPR,

Course Outcomes: Learner will be able to…

1. Understand the importance of IPR, types of Patent type and its importance in industries.
2. Able to search, draft and file the patent and copyright application to patent office.
3. Learn the recent trends of IPR and can open the way for the students to catch up Intellectual Property (IP) as a career option:
   a) R&D IP Counsel in research organization
   b) Government Jobs – Patent Examiner
   c) Private Jobs
   d) Patent agent and Trademark agent.

Module	Detail Content	Hrs.
1	**Overview of Intellectual Property:** Introduction and the need for intellectual property right (IPR) - Kinds of Intellectual Property Rights: Patent, Copyright, Trade Mark, Design, Geographical Indication, Plant Varieties and Layout Design – Genetic Resources and Traditional Knowledge – Trade Secret - IPR in India : Genesis and development – IPR in abroad - Major International Instruments concerning Intellectual Property Rights: Paris Convention, 1883, the Berne Convention, 1886, the Universal Copyright Convention, 1952, the WIPO Convention, 1967,the Patent Co-operation Treaty, 1970, the TRIPS Agreement, 1994	9
2	**Patents:** Patents - Elements of Patentability: Novelty, Non-Obviousness (Inventive Steps), Industrial Application - Non - Patentable Subject Matter - Registration Procedure, Rights and Duties of Patentee, Assignment and licence, Restoration of lapsed Patents, Surrender and Revocation of Patents, Infringement, Remedies & Penalties - Patent office and Appellate Board	7
3	**Copyright:** Nature of Copyright - Subject matter of copyright: original literary, dramatic, musical, artistic works; cinematograph films and sound recordings - Registration Procedure, Term of protection, Ownership of copyright, Assignment and licence of copyright - Infringement, Remedies & Penalties – Related Rights - Distinction between related rights and copyrights	6
4	**Trademark:** Concept of Trademarks - Different kinds of marks (brand names, logos, signatures, symbols, well known marks, certification marks and service marks) - Non-Registrable Trademarks - Registration of Trademarks - Rights of holder and assignment and licensing of marks - Infringement, Remedies & Penalties - Trademark's registry and appellate board.	6
5	**Patent Acts:** Section 21 of the Indian Patent Act, 1970 (and corresponding Rules and Forms) with specific focus on Definitions, Criteria of Patentability,	9

	Non-Patentable Subject Matters, Types of Applications, and Powers of Controllers. Section 25 - Section 66 of the Indian Patent Act, 1970 with specific focus on the Oppositions, Anticipation, Provisions of Secrecy, Revocations, Patent of Addition, and Restoration of Patents. Section 67 - Section 115 of the Indian Patent Act, 1970 with specific focus on Patent Assignments, Compulsory Licensing, Power of Central Government, and Infringement Proceedings. Section 116 - Section 162 of the Indian Patent Act, 1970 with specific focus on Convention/PCT Applications, Functions of Appellate Board and other Provisions. Amendment Rules 2016 with emphasis on important revisions to examination and Hearing procedures; provisions for start-ups and fees.	
6	**Indian IP Policy:** India`s New National IP Policy, 2016 – Govt. of India step towards promoting IPR – Govt. Schemes in IPR – Career Opportunities in IP – IPR.	3

Assessment:
Internal Assessment: 40 marks
End Semester Examination: 60 Marks

Books/References:

1. Nithyananda, K V. (2019). Intellectual Property Rights: Protection and Management. India, IN: Cengage Learning India Private Limited.
2. Neeraj, P., & Khusdeep, D. (2014). Intellectual Property Rights. India, IN: PHI learning Private Limited.
3. Ahuja, V K. (2017). Law relating to Intellectual Property Rights. India, IN: Lexis Nexis.
4. World Intellectual Property Organisation. (2004). WIPO Intellectual property Handbook. Retrieved from https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub _489.pdf

Course Code	Course Name	Credits
IL 362	**Introduction to Bioengineering**	**3**

Course Objectives:

1. To understand and analyze the human body as a mechanical assembly of linkages and describe the fundamentals of biomechanics.
2. To Study the deformability, strength, visco elasticity of bone and flexible tissues, modes of loading and failure and describe the types and mechanics of skeletal joints.
3. To describe movement precisely, using well defined terms (kinematics) and also to consider the role of force in movement (kinetics).
4. To teach students the unique features of biological flows, especially constitutive laws and boundaries.
5. To teach students approximation methods in fluid mechanics and their constraints.
6. To consider the mechanics of orthopedic implants and joint replacement , mechanical properties of blood vessels and Alveoli mechanics

Course Outcomes: Learner will be able to

1. Apply a broad and coherent knowledge of the underlying principles and concepts of biomechanics, particularly in the fields of kinematics and kinetics as applied to human and projectile motion.
2. Understand and describe the properties of blood , bone and soft tissues like articular cartilage tendons and ligaments.
3. Gain broad knowledge about the mechanics of moving systems and familiarity with human anatomy to competently analyze gross movement of the human body.
4. Be able to computationally analyze the dynamics of human movement from the most commonly used measurement devices in the field, such as motion capture and force platform systems.
5. Use knowledge gained to competently interpret the current understanding of human movement and present recommendations for further study.

Module	Detail Content	Hrs.
1	**Introduction:** Definition of Biomechanics, Selected Historical highlights, The Italian Renaissance, Gait century, Engineering Physiology & Anatomy	6
2	**Tissue Biomechanics:** Bone structure & composition mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, Maxwell & Voight models – anisotropy. Structure and functions of Soft Tissues: Cartilage, Tendon, Ligament, and Muscle	8
3	**Joints Biomechanics:** Skeletal joints, forces and stresses in human joints, Analysis of rigid bodies in equilibrium, free body diagrams, types of joint, biomechanical analysis of elbow, shoulder, hip, knee and ankle.	7
4	**Biomaterials:** Brief Anatomy, Bone, cartilage, ligament, tendon, Muscles, biofluid their physical properties	6
5	**Implants:** General concepts of Implants, classification of implants, Soft tissues	6
6	Application of advanced engineering techniques to the human body, case studies.	6

Assessment:
Internal Assessment: 40 marks
End Semester Examination: 60 Marks

Books/References:

1. Nigg, B.M.and Herzog, W., "BIOMECHANICS of Musculo skeleton system", John Willey & Sons, 1st Edition.
2. Saltzman, W.L., "BIOMEDICAL ENGINEERING: Bridging medicine and Technology", Cambridge Text, First Edition.
3. Winter, D., "BIOMECHANICS and Motor Control of Human Movement", WILEY Interscience Second edition
4. Prof. Ghista,Biomechanics, Private Publication UAF, 2009
5. White &Puyator, Biomechanics, Private publication UAE, 2010
6. R. M. Kennedy, A textbook of Biomedical Engineering, GTU, 2010
7. Richard Shalak & ShuChien, Handbook of Bioengineering,
8. Sean P. Flanagan, Flanagan, Biomechanics: A case based Approach, Jones & Bartlett Publishers, 2013
9. Y. C. Fung, Yuan-Cheng Fung, Biomechanics: mechanical Property of living Tissue, Springer, 1996.
10. Carol A. Oatis, The Mechanics and Pathomechanics of Human Movement, Lippincott Williams & Wilkins, 2010

Course Code	Course Name	Credits
IL 363	**Product Design**	**3**

Course Objectives:

1. To familiarize with fundamental product design concepts
2. To acquaint with product design methodologies
3. To understand product design needs and issues in industry

Course Outcomes: Learner will be able to

1. Demonstrate product design and development process.
2. Analyze a product in perspective of aesthetic and ergonomic considerations.
3. Illustrate considerations of Design for Manufacturing and Assembly in product development.
4. Apply appropriate tools and techniques in the design of solutions that are usable and functional for various applications.
5. Design the products as per the customer/industry requirements
6. Apply principles of economy and demonstrate legal and social issues pertaining to product development.

Module	Detail Content	Hrs.
1	Product definition, specification, Phases of product development: conceptual, embodiment and detailed design, product and technology development cycle, Concept generation and evaluation methods, product architecture, Product life cycle Management with case studies, Product analysis. Creativity and Idea generation technique, importance of Quality Dimensions: Performance, Features, aesthetics, Ergonomics, Reliability, Sustainability, Serviceability, Brand value, Value Vs cost, Importance of shape, color, feature & Resemblance.	06
2	Design Factors: Ergonomics, Aesthetics, Anthropometry, Comforts, Economic factors Axiomatic design principles and case studies. Design Thinking, Design by Innovation and collaboration Material and Process selection Methods, Expert systems. Computer Database Approach, performance indices decision matrix, AHP and fuzzy approach, Introduction to material and process selection software.	06
3	Design for Manufacturing (DFM) and Design for Assembly (DFA) Designs for Maintainability and Reliability and some methods for reliability assessment, Designs for Environment, Design for Robustness: Taguchi Designs & Design of Experiments (DOE).	08
4	Product Design Tools and Techniques: Value Engineering / Value Analysis: definition, methodology- FAST, Benchmarking, Supplier involvement robust design, QFD, Design & process FMEA. Reverse Engineering, Concurrent engineering & Sequential engineering, Case studies.	08

5	Product Development Cycle and Importance of Prototyping. Types of prototypes. Principal and advantages & Different Type of Generative Manufacturing process, Viz. Stereo lithography. FDM, SLS etc. Factors Concerning to RP: Consideration for Adoptions, Advantages, Accuracy and Economic Consideration. Introduction to Assembly Modeling, Top-Down and Bottom-Up Approaches of AM, Mating Conditions, representation Schemes. Generation of Assembly Sequences. Case studies	06
6	Economics of Product Development: Product costing, Principals of Economy, Engineering Economy and Design Process, Economic Analysis, Inflation, Time Value of Money, Numerical on Internal Rate of Return and Net Present Value (NPV) method. Legal and social issues, Patents and IP acts.	06

Assessment:
Internal Assessment: 40 marks
End Semester Examination: 60 Marks

Reference Books:

1. Product Design and Manufacturing by A.K.Chitale, R.C.Gupta, PHI.
2. Product Design and Development by Ulirich Karl T. and Eppinger Steven D, McGraw Hill.
3. Engineering Design by Dieter George E., McGraw Hill.
4. Handbook of Product Design for Manufacturing by Bralla, James G, McGraw Hill.
5. Product Design by Kevin Otto & Kristin Wood

Course Code	Course Name	Credits
IL 364	**Visual Art**	**3**

Course Objectives:

1. To enable learners to develop aesthetic judgement, visual perception, critical thinking skills in the different forms of art and understand its application.
2. To promote the concept of visual design and understand the different meanings assigned to colours, its impact and problems.
3. To provide the opportunity and scope to use the image editing software for creating images for Web and Video.
4. To inculcate the basic skills required in drawing and painting through exposure in nature and study of still objects.
5. To train students to express their feelings and write imaginatively.
6. To prepare the learners for the use of clay modelling techniques and its industrial applications.

Course Outcomes: Learner will be able to

1. Acquire the skills necessary for aesthetic judgement, visual perception and critical thinking required in different forms of art.
2. Demonstrate the understanding of the concept of visual design with respect to the different meanings assigned to colours and the problems associated.
3. Illustrate effective use of image editing software for creating images for the Web and Video.
4. Determine the importance of drawing and painting with respect to nature and still objects.
5. Perform successfully in expressing their feelings creatively.
6. Develop the techniques required for clay modelling and sculpture for industrial use.

Module	Detail Content	Hrs.
1	History of Art and Architecture- Changing needs and forms of art from the Palaeolithic period to The Renaissance period with special reference to Roman, Indian and Chinese art	4
2	Introduction and concepts of visual design with special emphasis on the psychological impact of colour	5
3	Introduction to image editing software, tools, application and creating Images for Web and Video. With special reference to Adobe Photoshop	7
4	Fundamentals of Drawing- study of forms in nature, study of objects and study from life, creative painting- basic techniques, tools and equipment, medium of painting.	6
5	Creative writing- Movie critique, book reviews, Poems, short plays and skits, Humorous Essays, Autobiography and short stories.	7
6	Creative sculpture- Introduction to clay modelling techniques, study of natural and man-made objects in clay, Sculpture with various materials - Relief in Metal Sheets – Relief on Wood – Paper Pulp - Thermocol. Sculpture with readymade materials.	7

Assessment:
Internal Assessment: 40 marks
End Semester Examination: 60 Marks

Reference Books:

1. Gill Martha. (2000). Color Harmony Pastels: A Guidebook for Creating Great Color Combinations. Rockport Publishers.
2. Janson, Anthony F. (1977). History of art, second edition, H.W. Janson. Instructor's manual. Englewood Cliffs, N.J.: Prentice-Hall.
3. Brommer, Gerald F. (1988). Exploring Drawing. Worcester, Massachusetts: Davis Publications.
4. Wendy Burt Thomas. (2010). The Everything Creative Writing Book: All you need to know to write novels, plays, short stories, screenplays, poems, articles, or blogs: All You Need ... - Stories, Screenplays, Blogs and More. Fw Media; 2nd edition.
5. Élisabeth Bonvalot. (2020). Sculpting Book: A Complete Introduction to Modeling the Human Figure.

Course Code	Course Name	Credits
IL 365	**Journalism, Media and Communication studies**	**3**

Course Objectives:

1. Provide a good grounding in the basic concepts of Journalism, Mass communication and Media.
2. Familiarize learners with reporting and editing practices.
3. Teach students to write editorials, feature articles, interviews, reviews, criticism etc.
4. To inculcate the skills required for writing in online newspapers, blogs, email and cell phone.
5. To prepare the learners for understanding the importance of Press laws and Ethics.
6. To train learners in advertising techniques and Public Relation Communication

Course Outcomes: Learner will be able to

1. Acquire conceptual and theoretical knowledge of Journalism, Mass Communication and Media Studies and learn to think critically about issues and topics of the subject.
2. Demonstrate the understanding of reporting and editing from Newspaper and the Organization.
3. Perform successfully in writing effective editorials, featured articles reviews etc.
4. Illustrate the skills required for writing in online newspapers, blogs, emails etc.
5. Determine the importance of Press Laws and Ethics.
6. Develop an understanding of the techniques required for advertising and Public Relation Communication.

Module	Detail Content	Hrs.
1	Introduction to Journalism, Communication, Media and Cultural Studies- Basics of Mass communication, Pioneers of Indian Journalism, Introduction to newspapers, magazines and other publications. Introduction to broadcast journalism with special reference to television	5
2	Reporting and Editing Practices-Reporting different news, stories from Newspaper, and Organization. Principles of editing, rewriting, and translation	7
3	Writing for Print- Newspaper Content Writing Opinion pieces, editorials, feature articles, interviews, profiles, reviews, criticism etc.	7
4	Writing for Media- Introduction to New Media Writing for Online newspapers Blogs Cell phone Communication E-mail	6
5	Press Laws and Ethics- Origin and definition of Law, Law and Morality, Types of Law – Civil and Criminal, Press Legislations, Freedom of the Press Defamation Contempt of Court	4
6	Public Relations and Advertising- Introduction to Public Relations Stages of PR Communication with Public Need and Meaning of Advertising, Advertising strategies and Sales Promotion	7

Assessment:
Internal Assessment: 40 marks
End Semester Examination: 60 Marks

Books/References:

1. Rangaswamy, Parthasaratihi, (1985). *Journalism in India*, Sterling Publication, New Delhi.
2. Jeffrey, Robin, (2009). *India's Newspaper Evolution*, Oxford University Press, Delhi.
3. Singh, Devvrat. (2012). *Indian Television: Content, Issues and Challenges*, HarAnand Publications Delhi.
4. Daryl L. Frazell, George Tuck. (1996). *Principles of Editing: A Comprehensive Guide for Students and Journalists Principles of Editing: A Comprehensive Guide for Students and Journalists.* McGraw-Hill
5. Barry Newman. (2015). *News to Me: Finding and Writing Colorful Feature Stories*. Paperback
6. The Associated Press. (2017). *The Associated Press Stylebook: and Briefing on Media Law*. Revised, Updated Edition. Paperback.
7. Kristina Halvorson. (2012) *Content Strategy for the Web*, 2nd Edition. New Riders

Course Code	Course Name	Credits
IL 366	**Computational Physics**	**3**

Course Objectives:

1. To expose the students to the vast field of computational physics.

Course Outcomes: Learner will be able to

1. To understand various approaches of simulating physical systems on a computer.
2. To choose the correct method to solve a computational problem.

Module	Detail Content	Hrs.
1	**Introduction to Statistical Mechanics :** Thermodynamics and kinetic theory, specification of state of system, Concept of ensemble, phase space, microcanonical ensemble (NVE), statistical concept of temperature, canonical ensemble (NVT), equipartition theorem, Maxwell-Boltzmann velocity distribution, grand canonical ensemble (μVT), chemical potential	6
2	**Molecular Dynamics (MD):** Integrating equation of motion of a few variables, role of molecular dynamics (MD), the basic machinery, Lennard-Jones potentials modeling physical system, boundary conditions, time integration algorithm	7
3	Starting a simulation, simulation of microcanonical (NVE) and canonical ensemble (NVT), controlling the system (temperature, pressure), thermostats and barostats, equilibration, running, measuring and analyzing MD simulation data, measurement of statistical quantities, interatomic potentials, force fields.	7
4	**Monte Carlo (MC) Method :** Random number: Definition, True and Pseudo random number generators (RNG), uniform and non-uniform RNG, Linux RNG, testing a RNG.	6
5	**Monte Carlo simulations :** Buffon's needles, MC Integration, hit and miss (estimation of pi and e), stochastic processes, sample mean integration, importance sampling, Markov Chain, Metropolis method, master equation, introduction to 2D-Ising model. **Random walk:** 1-D and 2-D random walk, calculation of rms displacement.	7
6	Introduction to Simulations of quantum systems	3

Assessment:

Internal Assessment: 40 marks

End Semester Examination: 60 Marks

Books/References:

1. Statistical Physics – Vol. 5 (from the series of Berkeley Physics Course)
2. Introduction to Computational Physics by Tao Pang (Cambridge University Press)
3. An Introduction to Computer Simulation Methods : Applications to Physical Systems by Harvey Gould and
4. Jan Tobochnik, (Pearsom Publications)
5. Understanding Molecular Simulations by Frenkel and Smit (Academic Press)

Course Code	Course Name	Credits
IL 367	**Polymers and Polymeric Materials**	**3**

Course Objectives:

1. To impart a scientific approach and to familiarize the applications of polymeric materials in the field of engineering.
2. The student with the knowledge of the basic polymer science will understand and explain scientifically the various problems related to polymeric materials in the industry/engineering field.
3. To develop abilities and skills that are relevant to the study and practice of polymer science and engineering.

Course Outcomes: Learner will be able to

1. To understand and analyze various polymeric materials and to establish the structure property relationship.
2. To select the proper polymeric material for specific industrial applications.
3. To become familiarized with various characterization techniques related to polymeric materials.

Module	Detail Content	Hrs.
1	**Basic understanding of Polymeric aspects:** Monomers, functionality, degree of polymerizations, classification of polymers, glass transition, melting transition, criteria for rubberiness, polymerization methods: addition and condensation; metallocene polymers and other newer techniques of polymerization, copolymerization, monomer reactivity ratios and its significance, different copolymers, random, alternating, azeotropic copolymerization, block and graft copolymers, concept of average molecular weight, determination of number average, weight average	9
2	**Polymer Technology:** Compounding of plastics, Polymer compounding-need and significance, different compounding ingredients for rubber and plastics, crosslinking and vulcanization	5
3	**Polymer Processing:** Fabrication of plastics by different moulding process, Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, extrusion, pultrusion, calendaring, rotational molding, thermoforming, rubber processing in two-roll mill, internal mixer	6
4	**Polymer blends:** Thermo- dynamical aspects of polymer blends and its miscibility, Role of compatibilizer, Composition based structure (dispersed and co-continuous), properties and its application, choice of polymers for blending, thermodynamics, phase morphology, polymer alloys, polymer eutectics, plastic-plastic, rubber-plastic and rubber-rubber blends	6
5	**Polymer composites:** Fundamentals of polymer composites, Advanced polymer nanocomposites, Fillers used for polymer composites, Effect of processing condition and composition, Polymer composites structure,	6

	characterisation and design, physical and chemical modification of polymer composites. 1-D and 2-D random walk, calculation of rms displacement.	
6	**Testing of Polymeric Materials:** Samples preparation, Mechanical-static and dynamic tensile, flexural, compressive, abrasion, endurance, fatigue, hardness, tear, resilience, impact, toughness. Conductivity-thermal and electrical, dielectric constant, dissipation factor, power factor, electric resistance, surface resistivity, volume resistivity, swelling, aging resistance, establishment of structure property relationship	7

Assessment:
Internal Assessment: 40 marks
End Semester Examination: 60 Marks

Books/References:

1. “Fundamentals of Polymer Engineering” by Anil Kumar and Rakesh Gupta.
2. “ Principles of Polymer Systems” by F Rodriguez.
3. “ Polymer Science” by V R Gorwankar.
4. “ Textbook of Polymer Science” by F W Billmeyer. 5. “ Polymer Chemistry” by P C Heimenz.

Course Code	Course Name	Credits
IL 368	**Vehicle Safety**	**3**

Course Objectives:

1. To familiarize basic concepts of vehicle safety.
2. To familiarize accident reconstruction analysis methods
3. To acquaint with different issues related to vehicle safety in India

Course Outcomes: Learner will be able to

1. Comprehend Vehicle design from safety point of view.
2. Apply concepts of accident reconstruction analysis in real world.
3. Enumerate interrelationship among occupant, restraint systems and vehicles in accidents.
4. Illustrate role and significance of seat in Rear crash safety
5. Demonstrate different active and passive safety systems available in vehicles
6. Contribute to the society by being proactive to the cause of safety on roads and in vehicles

Module	Detailed Contents	Hrs.
1	Introduction to vehicle safety-the integrated approach and its classification SAVE LIVES- by WHO, Importance of Risk evaluation and communication, Concepts of Universal design, India's BNVSAP and its outcomes	6
2	Crash and distracted driver, Human error control, Crash Testing, Use of Dummies, evolution and build of dummies. Relevance of Star ratings, NCAPs around the world-Accident Data, Biomechanics and Occupant Simulation, Vehicle Body Testing, Dynamic Vehicle Simulation Tests Occupant Protection, Compatibility, Interrelationship Among Occupants, Restraint Systems and Vehicle in Accidents	7
3	Significance of Rear Crash Safety, Role of seat in Rear crash safety, Self-aligning head restraints, Pedestrian Protection testing and systems , Under run Protection Devices	5
4	Introduction to Accident Analysis Reconstruction methods, Skid distances and Critical speed from Tire Yaw marks, Reconstruction of Vehicular Rollover Accidents, Analysis of Collisions, Reconstruction Applications Impulse Momentum Theory, Crush Energy, Photogrammetry for accident constructions	8
5	Anti-Lock braking system, Electronic Stability Program, Low tire pressure warning system, Collision avoidance systems	4
6	Basic Vehicle Operations and Road/Helmet Safety Activity	5

Assessment:

Internal Assessment: 40 marks

End Semester Examination: 60 Marks

References Books:

1. Automotive vehicle safety by George Peters and Barbara Peters, CRC Press, 2002.
2. Vehicle Accident Analysis and Reconstruction Methods by Raymond M. Brach and R. Matthew Brach, SAE International, Second Edition, 2011.
3. Role of the seat in rear crash safety by David C. Viano, SAE International, 2002.
4. Automotive Safety Handbook by Ulrich W. Seiffert and LotharWech, SAE International, 2007.
5. Public Safety Standards of the Republic of India

Course Code	Course Name	Credits
IL 369	**Maintenance of Electronics Equipment**	**3**

Lab Objectives:

1. To demonstrate use of different types of hand tools
2. To understand testing of different active and passive components mounted on PCB
3. To understand functionality TTL and CMOS digital IC tester
4. To demonstrate computer assembling, troubleshooting and software installation
5. To understand/demonstrate concept of circuit diagram of LED/LCD TV, DTH and mobile phone troubleshooting
6. To understand concept of medical equipments

Lab Outcomes:

1. Demonstrate use of different types of hand tools
2. Understand testing of different active and passive components mounted on PCB
3. Understand functionality TTL and CMOS digital IC tester
4. Demonstrate computer assembling, troubleshooting and software installation
5. Understand/demonstrate concept of circuit diagram of LED/LCD TV, DTH and mobile phone troubleshooting
6. Understand concept of medical equipments

Sr. No.	Detailed Lab/Tutorial Description	Hrs.
1	Demonstrate use of various hand held tools.	2
2	Test the performance of different passive electronic components (fixed/variable)	2
3	Test the performance of active electronic components like general purpose transistor/FET/MOSFET/SCR/ DIAC/TRIAC with DMM and CRO OR Components Tester	4
4	Verify the functionality of TTL and CMOS Digital IC's using IC tester	4
5	Explore a datasheet of minimum any five electronics components and analog/ Digital IC's.	2
6	Draw the given regulated power supply circuit/ SMPS (from any television/fridge/ computer system/ laboratory etc)	2
7	Identify basic sections of a personal computer/Laptop	2
8	Demonstrate Assembling of Personal Computer/Laptop	4
9	Troubleshoot the booting process of computer system and install different hardware associated with computer (HDD, LAN Card, Audio System etc)	4
10	Study Installation of Software and Configure Internet	4
11	Explore circuit diagram of LED/LCD TV.	2
12	Demonstrate Installation of DTH system	4
13	Demonstrate installation Solar power system	4
14	Practice steps for mobile troubleshooting	4
15	Visit to Medical Equipment Industry/Laboratory	8

Assessment:
Internal Assessment: 40 marks
End Semester Examination: 60 Marks

Books/References:

1. Troubleshooting and Maintenance of Electronics Equipment, Singh K. Sudeep, Katson Book ,New Delhi ,II edition , Reprint 2014
2. Mobile repairing Books, Manohar Lotia, BPB Publication, New Delhi , latest edition
3. Troubleshooting Electronic Equipment: Includes Repair and Maintenance, Second Edition, Khandpur R. S. , Tata McGraw-Hill Education, New Delhi ,India , latest edition.
4. Data Books, National semiconductor.

Course Code	Course Name	Credits
ME 392	**Major Project I**	**3**

Course Objectives:

1. To acquaint with the process of undertaking literature survey or market survey or feasibility study /industrial visit and identifying the problem
2. To familiarize the process of problem solving in a group
3. To acquaint with the process of applying basic engineering fundamental in the domain of practical applications
4. To inculcate the process of research

Course Outcomes: Learner will be able to

1. Do literature surveys based on market or feasibility study/industrial visit and identify the problem.
2. Apply basic engineering fundamentals in the domain of practical applications
3. Cultivate the habit of working in a team
4. Attempt a problem solution in the right approach.
5. Correlate the theoretical and experimental/simulations results and draw the proper inferences
6. Prepare project reports as per guidelines and with proper references/citations.
7. Exhibit and explain project ideas/models at various platforms.

Guidelines for Project

- Students should do literature survey/Market survey/ feasibility study/visit industry/analyze current trends and identify the problem for Project and finalize the project title in consultation with Guide/Supervisor.
- Students should use multiple literatures and understand the problem.
- Students should attempt a solution to the problem by experimental/simulation methods.
- The solution to be validated with proper justification and report to be compiled in standard format.

Assessment:

Project I should be assessed based on following points

1. Quality of problem selected
2. Clarity of Problem definition and Feasibility of problem solution
3. Relevance to the specialization
4. Clarity of objective and scope
5. Breadth and depth of literature survey
6. Societal importance
7. Presentation skill/ Question-answer session.

Project I should be assessed through a presentation by the student project group to a panel of Internal and External examiners appointed by the Head of the Department/Institute of respective Programme.

Course Code	Course Name	Credits
ME 401	**Production Planning and Systems**	**3**

Course Objectives:

1. To provide an exposure to Production Planning & Systems and its significance in Manufacturing Industries
2. To give exposure to forecasting methods, aggregate planning and capacity planning techniques.
3. To give insights of various inventory control techniques and system approach of MRP
4. To give exposure to production scheduling and sequencing so as to optimize resources
5. To understand heuristics methods for design of manufacturing system.

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

1. Illustrate production planning functions and manage manufacturing functions in a effective way
2. Forecast the demand of the product and prepare an aggregate plan
3. Apply inventory management techniques to control inventory
4. Develop MRP systems for any manufacturing firm
5. Apply production planning techniques to optimize resources
6. Apply heuristic methods for design of manufacturing systems.

Module	Detail Content	Hrs.
1.	Production systems- components and types, need for PPC, functions of PPC, relationship of PPC with other functions Production planning techniques: Linear Programming Problems, Simplex, Big Methods, Sensitivity Analysis Various issues of interest: Assembly Line, Repetitive batch manufacturing, Cellular manufacturing, FMS, JIT, CIM	6
2.	**Forecasting, Aggregate planning, Capacity planning** Forecasting: Need for forecasting, role of forecasting in PPC, Qualitative and Quantitative methods of forecasting, Forecasting Errors and Forecasting Bias Aggregate planning: Concept of aggregate planning, decision rules, strategies and methods Capacity Planning: Measurement of capacity, Measures of capacity, Factors influencing effective capacity, short range, medium range and long range capacity planning, Rough cut capacity planning.	8
3.	**Inventory Control:** Basic concepts of inventory, Types of inventory, purpose of holding stock and influence of demand on inventory, Costs associated with Inventory management. Inventory Models: Deterministic models - instantaneous stock replenishment model, Production model, planned shortages and price discount model, Probabilistic models- fixed quantity system(Q-system) and Fixed period system (p-system) Selective Inventory Control techniques - ABC analysis, HML analysis and VED analysis	8
4.	MRP, MRP II, ERP Material Requirement planning(MRP) and Manufacturing Resource	6

	Planning (MRP-II) General concepts, types of demands, Inputs to MRP, MRP objectives, outputs of MRP, Estimation of planned order releases, Lot sizing decisions, Benefits and Limitations of MRP II Enterprise Resource Planning (ERP): Evolution, features, purpose of modeling an enterprise, information mapping, generic model of ERP, Modules in ERP, Methodology of implementation, critical success factors of ERP, Case studies of success and failure of ERP implementations, ERP packages	
5.	Production Scheduling and Sequencing Scheduling: Inputs for scheduling, loading and scheduling devices, factors influencing scheduling, scheduling techniques, use of Gantt Charts and basic scheduling problems. Project scheduling by using elements of network analysis PERT & CPM, cost analysis & crashing, resource leveling Sequencing: Product sequencing, dispatching, progress report & expediting and control, Johnson's sequencing algorithms	6
6.	Decision making in design of manufacturing systems: Various heuristics in Line Balancing, Group Technology and Plant layout and simulation of manufacturing systems.	6

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. D. D. Bedworth and J. E. Bailey (1983), Integrated Production Control System-Management, Analysis and Design, John Wiley.
2. E. A. Elsayed and T. O. Boucher (1985), Analysis and Control of Production Systems, Prentice Hall.
3. P. F. Bestwick and K. Lockyer (1982), Quantitative Production Management, Pitman Publications.
4. A. C. Hax and D. Candea (1984), Production and Inventory Management, Prentice Hall.
5. L. A. Johnson and D. C. Montgomery (1974), O.R. in Production Planning, Scheduling and Inventory Control, John Wiley and Sons.
6. H. Noori and R. Radford (1995), Production and Operations Management, McGraw Hill Inc.
7. S. Nahmias (1997), Production and Operations Analysis, R. Irwin.
8. R. B. Chase, N. J. Aanilano and F. R. Jacobs (1999), Production and Operations Management- Manufacturing and Services, Tata McGraw Hill, Second Edition.
9. K. Hitomi (1996), Manufacturing Systems Engineering, Viva Books Pvt. Ltd, India.
10. M. Pinedo and X. Chao (1999), Operations Scheduling, McGraw Hill.
11. Production Planning and Control Samuel Eilon.
12. Production Planning and Control, W. Boltan-Longman Scientific & Technical
13. Production Systems- Planning, Analysis & Control, James. L. Riggs-John Wiley &Sons

14. Manufacturing Planning and Control Systems, Thomas E. Vollman, William L.Berry& Others- Galgotia Publishers
15. Manufacturing Process Planning and Systems Engineering, Anand Bewoor-Dreamtech Press
16. Production and Operations Management, S.N.Chary- TMH publishing company
17. Automated Production System by M P Groover, PHI

Course Code	Course Name	Credits
ME 402	**Refrigeration & Air Conditioning**	**3+1**

Course Objectives:

1. To study the fundamental and operating principles of Air Refrigeration, Vapour Compression and Vapour Absorption systems.
2. To study components of refrigeration and air conditioning systems.
3. To study controls and applications of Refrigeration & Air Conditioning.

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

1. Demonstrate fundamental principles of refrigeration and air conditioning.
2. Understand conventional and alternative refrigerants
3. Identify and locate various components of the refrigeration and air conditioning system
4. Illustrate various air conditioning processes using psychrometric chart
5. Design Air Conditioning system using cooling load calculations.
6. To design a duct system using different duct design methods.

Theory Syllabus

Module	Detail Content	Hrs.
1.	**Introduction to Refrigeration:** Methods of refrigeration, First and Second Law applied to refrigerating machines, Carnot refrigerator, Carnot heat pump, unit of refrigeration, Co-efficient of Performance, Energy Efficiency Ratio (EER), and BEE star rating. Air refrigeration systems: Bell Coleman cycle., Applications Aircraft air refrigeration systems: Need for aircraft refrigeration, Simple, Bootstrap including evaporative cooling, reduced ambient, Regenerative air-cooling system, Comparison of these systems based on DART rating.	7
2.	**Vapour Compression Refrigeration System**: Simple vapour compression cycle, Effect of liquid sub cooling & superheating, effect of evaporator and condenser pressures, methods of subcooling, use of P-h charts, Actual VCR cycle, Use of P-h Charts, **Refrigerants and Components of VCRS:** Desirable properties of refrigerants, ASHRAE numbering system for refrigerants. Thermodynamic, Chemical and Physical properties, secondary refrigerants, ODP and GWP, Montreal protocol and India's commitment, Recent substitutes for refrigerants. Types of Compressors, condensers, evaporators, expansion devices	8
3.	**Vapour Absorption Refrigeration System**: Vapour Absorption Refrigeration, Importance of VAR system, COP of ideal VAR system, Ammonia-water VAR system, Lithium Bromide – Water VAR system, Electrolux refrigeration system. **Non-Conventional Refrigeration Systems** Thermoelectric refrigeration, Thermoacoustic refrigeration, Vortex Tube refrigeration	6
4.	**Psychrometry:** Need for air conditioning, Principle of psychrometry, Psychrometric properties, chart and processes, air washers, requirements of comfort air conditioning, Summer and Winter Air conditioning	5

5.	**Design of Air Conditioning Systems**: Different Heat sources: adiabatic mixing of two air streams, Bypass factor, sensible heat factor, RSHF, GSHF, ERSHF, Room apparatus dew point and coil apparatus dew point, Ventilation and infiltration, Inside and Outside Design condition, Cooling Load estimation, Human Comfort, Thermal exchange of body with environment, Effective temperature, Comfort chart, Comfort zone Introduction to Unitary Products viz. Room/Split and Packaged Air Conditioners, Indoor Air Quality, Green Buildings.	6
6.	**Duct Design:** Friction chart for circular ducts, Equivalent diameter of a circular duct for rectangular ducts, Static pressure regain and equal pressure drop methods of duct design, Factors considered in air distribution system, Air distribution systems for cooling and heating. **Controls and Applications of Refrigeration & Air Conditioning**: Controls – HP/LP Cutoff, Thermostats, Humidistats, Interlocking control, Electronic controllers. Ice plant – food storage plants – dairy and food processing plants, Food preservation, Freeze Drying, A/c in textile, printing pharmaceutical industry and Hospitals, Liquefaction of LNG, Liquefaction of gases (cryogenics), Deep Sea water air-conditioning.	7

Laboratory Syllabus

S.No.	Details	Hrs.
1.	Trial Experiment on Simple VCR System	2
2.	Trial on Cooling Tower	2
3.	Trial on Air conditioning system	2
4.	Trial on Ice Plant	2
5.	Simulation Experiment on VCR system using simulation software.	2
6	Industrial Visit	

Theory Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Laboratory Assessment:

Term Work : 25 marks

Laboratory Work (Journal Completion) : 15 Marks
Attendance : 05 Marks
Industrial Visit Report : 05 Marks

End Semester Practical/Oral Examination:

Pair of Internal and External Examiners should conduct practical/viva based on contents.
Distribution of marks for practical/viva examination shall be as follows:
Oral Examination: 25 Marks

Books/References:

1. Refrigeration & Air Conditioning by C. P. Arora, McGraw Hill Education (I) Pvt Limited, New Delhi
2. Refrigeration & Air Conditioning – W F Stoecker and J W Jones, Tata McGraw Hill
3. Principles of Refrigeration – R J Dossat, Wiley Eastern Publication
4. Refrigeration & Air Conditioning - R. S. Khurmi and J K Gupta, Eurasia Publishing House Pvt Ltd. New Delhi
5. Refrigeration and Air Conditioning – Manohar Prasad, New Age Int (P) Ltd.
6. Basic Refrigeration & Air Conditioning - P.N. Ananthanarayanan, Fourth Edition, Tata McGraw Hill
7. ASHRAE Handbook of Fundamentals
8. ASHRAE Handbook of Systems
9. ASHRAE Handbook of Equipment
10. ISHRAE Refrigeration Handbook
11. ISHRAE HVAC Databook

Course Code	Course Name	Credits
ME 403	**Thermal Design of Electronic Equipment**	**3**

Course Objectives:

1. To teach students about modes of heat transfer in electronic devices.

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

1. Gain in depth knowledge of designing cooling systems for electronic equipment.
2. Design a system that withstands high pressure.
3. Understand fluid dynamics in electronic equipment design.
4. Understand the effect of various modes of heat transfer on designing a system.

Module	Detail Content	Hrs.
1.	Introduction: Introduction to modes of heat transfer in electronic equipments conduction, convection and radiation. Theoretical power dissipation in active devices like CMOS device, Junction FET, Power MOSFET. Theoretical power dissipation in passive devices like Interconnect , resistor, capacitor	08
2.	Conductive heat transfer: Introduction, Thermal conductivity, thermal resistance, conductivity in solids and fluids. Steady state conduction: Conduction in simple geometry like plain wall without heat generation, conduction through cylinder and spheres without heat generation. Conduction in complex geometries like multidimensional analytic method, multidimensional graphical method. Conduction: transient-lumped capacitance method. Thermal Contact Resistance in Electronic Equipment Interfaces: Simplified contact resistance model, geometry of contacting surface.	08
3.	Fluid dynamics for electronic equipments: Introduction. Hydrodynamics properties of fluid: compressibility, viscosity and surface tension. Fluid statistics: Relationship between pressure and density. Fluid dynamics: streamline & flow fields, One and two dimensional flow. Incompressible fluid flow: One dimensional flow-Euler and Bernoulli's equation. Incompressible fluid flow: laminar and turbulent flow. Electronic chassis flow:	08
4.	Convection heat transfer in electronic equipments: Introduction , properties of air, boundary layer theory, Forced convection laminar flow, forced convection in turbulent flow: circular and non circular tubes. Forced convection external flow: Laminar and forced convection flow over flat plate. Forced convection flow along populated circuit boards. Natural convection: flat plate, vertical fins, horizontal and vertical cylinder, spheres, cones.	08
5.	Radiation heat transfer in electronic equipments: Introduction, radiation equations, surface characteristics like absorptance, emittance and reflectance. Calculation of estimated diffuse view factors, Environmental effects:- solar radiation and atmospheric radiation.	08

6.	Heat transfer with phase change and combined mode of heat transfer: Introduction:-dimensionless parameters in boiling and condensation, modes of boiling liquids, evaporation. Conduction in series and parallel, conduction and convection in series, radiation and convection in parallel, Overall heat transfer coefficient. Selection of cooling technique: Ranges of cooling rates of different cooling methods, selection criteria; Experimental techniques used for thermal measurements; Reliability issues: importance, bathtub curve.	08

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Younes Shabany, Heat Transfer: Thermal Management of Electronics, CRC Press Inc, 2010.
2. Ravi Kandasamy and Arun S. Mujumdar, Thermal Management of Electronic Components, Lambert Academic Publishing, 2010.
3. Dave S. Steinberg, Cooling Techniques for Electronic Equipment, Wiley, 1991.
4. Sung Jin Kim, Sang Woo Lee, Air Cooling Technology for Electronic Equipment, Taylor & Francis, 1996.
5. Rao R. Tummala, Fundamentals of Microsystems Packaging, McGraw-Hill, 2001.
6. Yunus A. Cengel, Heat Transfer: A Practical Approach. McGraw-Hill, 2003.
7. Thermal Design of Electronic Equipment by Ralph Remsburg , CRC Press
8. Richard K. Ulrich & William D. Brown Advanced Electronic Packaging - 2nd Edition : IEEE Press, 1995.

Course Code	Course Name	Credits
ME 404	**Computational Methods in Thermal Engineering**	**3**

Course Objectives:

1. To impart knowledge on numerical methods that will come in handy to solve numerically the problems that arise in Thermal Engineering.
2. To study and apply numerical solution techniques for the partial differential equations governing the Thermal engineering problems.
3. To study the mathematical structure which could be used to describe the behaviour and results of most numerical methods commonly used in Thermal Engineering. Problems.
4. To write code for some real-life Thermal Engineering problems.

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

1. Solve mass, momentum, and energy governing equations in thermal Engg using numerical methods.
2. Identify live Initial value problems and boundary value problems arise in thermal engineering and use suitable numerical methods to solve them.
3. Write codes for thermal engineering problems in MATLAB, C, C++ and also to solve thermal engineering problems by using any commercial CFD package.

Module	Detail Content	Hrs.
1.	Root finding: Algebraic and transcendental equation: Bisection method, Fixed point, Regula-Falsi method, Newton-Raphson method, Rate of convergence, Merits, and demerits of methods	7
2.	Solution of simultaneous Linear Algebraic Equations: Motivation, Gauss elimination, Pitfalls of Gauss Elimination method, LU factorization, Iterative methods: Jacobi method, Gauss-Seidel method, Relaxation method	6
3.	Interpolation and Curve Fitting: Motivation, Polynomial forms, Linear interpolation, Lagrangian interpolation, Newton's divided difference interpolation, Finite difference operators, Newton's forward and Newton's backward difference interpolation, Regression analysis- linear regression, Least-square method, Fitting of non-linear curves, Polynomial functions, Multiple linear regression.	7
4.	Initial Value Problems: Modified Euler's Method, Runge-Kutta method of fourth order, Solution of simultaneous differential equations and higher order equations.	6
5.	Boundary-value Problems: Motivation, Shooting method, Finite difference method, Finite difference representation of differential equations, Elliptic, Parabolic and Hyperbolic Partial Differential Equations and their solutions using finite difference schemes, Explicit and Implicit schemes. Applications of finite difference methods to thermal engineering problems.	7
6.	Finite Volume Method, Finite element method, 1d, 2-d and 3-d steady and unsteady flow and thermal problem. The role of simulation in the design of thermal systems	6

Students must understand the practical applications of Computational methods by solving the following assignments.

1. Writing codes for 1-d and 2-d steady and unsteady thermal problem in MATLAB, C, C++
2. Solving 1d, 2-d and 3-d steady and unsteady flows and thermal problem using any commercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX etc.

Note:

- Total six Assignments (One from each module).
- Out of this at least one assignment should be solved by coding in the prog language and/or on use of commercial packages as described above.

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous Evaluation : Assessment on the completion of assignments and Internal Oral based on assignments (at the time of assessment of assignments) : 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Computer Based Numerical and Statistical Techniques, Manish Goyal, Laxmi Publications (P) Ltd, New Delhi
2. Numerical Methods in Engineering, Salvadori M G, Baron M L, Prentice-Hall
3. Numerical Methods for Engineers, Chapra S C, Candle R P, 2nd Ed, McGraw-Hill, New York
4. Applied Numerical Analysis, Gerald CF, Wheatley PO, 6thedition, Pearson Education, 1999
5. Numerical Mathematics and Computing, Cheney W., Kincaid D., 5thedition, Thomson / BrooksCole, 2004.
6. Numerical Methods for Partial Differential Equations, William F. Ames, 2nd Edition, Academic Press, 1977

Course Code	Course Name	Credits
ME 405	**Design of Mechanical Systems**	**3**

Prerequisites:

1. Engineering Mechanics
2. Material Science
3. Strength of Materials
4. Machine Design-I
5. Machine Design-II

Course Objectives:

1. To learn and apply system design concepts.
2. To study the design of various mechanical systems.

Course Outcomes: Upon successful completion of this course, learner will be able to:

1. Understand the difference between mechanical component design and mechanical system design.
2. Understand the concept of optimum design and its importance in system design.
3. Design a hoisting mechanism.
4. Design material handling system.
5. Design an internal combustion engine.
6. Design a machine tool gear box.

Module	Detail Content	Hrs.
1.	**Component Design and System Design:** Concept of a component design, concept of system design, how component design and system design are different, various phases of system design.	2
2.	**Optimum Design:** Objectives of Optimum design, Johnson's method of optimum design, primary design equations, subsidiary design equations and limit equations. Optimum design with normal specifications for simple machine elements like tension bar, transmission shaft, spring etc. Introduction to redundant specifications.	4
3.	**Design of EOT crane:** Calculation of safe stress, selection of wire rope and calculation of rope life, Selection of pulley, Design of pulley axel and selection of bearing for pulley. Selection of hook and check for safety at critical cross section, Selection of bearing for hook, design of hook shaft, Design of Shackle plate.	8
4.	**Design of Material handling systems (Conveyor Belts):** Calculation of belt width and Thickness , Driving force and power, selection of motor and pulleys, Design of idlers.	6
5.	**Design of an IC Engine:** Design of Cylinder, piston, connecting rod and crankshaft.	8
6.	**Design of Machine tool gear box:** Introduction to machine tool gearboxes, design and its applications, basic considerations in design of drives, determination of variable speed range, graphical representation of speed and structure diagram, ray diagram, selection of optimum ray diagram, gearing diagram.	8

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/ Assignments / Quiz/ Case studies/ Seminar presentation of 40 Marks

End Semester Examination: 60 marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the syllabus.

Use of standard design data books like PSG Data Book, Machine Design Data Book by Mahadevan, Design of engine parts by Khandare S.S and Kale A.V., are permitted at the examination and shall be supplied by the college.

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Books/References:

1. Rudenko - 'Material Handling Equipment' M.I.R. publishers, Moscow.
2. Bhandari V.B., "Design of Machine Elements", Tata McGraw Hill
3. Design Data Book, P.S.G. College of Technology, Coimbatore
4. Design and analysis of new flexible and safe fork lifts https://repository.library.northeastern.edu
5. Optimum design of mechanical elements, Ray C Johanson
6. Design data book by Kale Khandare
7. Design data book by Mahadevan
8. N K Mehta- 'Machine Tool Design' Tata McGraw Hill
9. Shigley- 'Mechanical engineering Design', Tata McGraw Hill
10. IS 11592:2000, Indian Standard for selection and design of belt conveyors-Code of practice.
11. IS 3177:1999(reaffirmed 2004), code of practice for electric overhead travelling cranes and gantrycranes other than steel work cranes

Course Code	Course Name	Credits
ME 406	**Engineering Vibrations**	**3**

Prerequisites:

1. Strength of Materials
2. Differential and Integral Calculus
3. Ordinary Differential Equations
4. Elementary Matrix theory

Course Objectives:

1. Formulate linear mathematical models of free (damped and undamped) vibration systems using Newton's second law or energy principles.
2. Solve free undamped multi-degree of freedom vibration problems using exact and numerical techniques to derive natural frequencies, and draw corresponding mode shapes.
3. Understand the behaviour of 1 degree of freedom vibration systems under harmonic excitation.
4. Understand the basic principles of balancing of rotating and reciprocating masses using analytical and graphical approaches.
5. Conduct experiments on free undamped and damped, one degree of freedom vibration systems, for comparing and validating the time period of small vibrations/oscillations.
6. Perform virtual experiments using Sakshat Virtual Laboratory.

Course Outcomes: Upon successful completion of this course, learner will be able to:

1. Develop mathematical models of vibration systems using various methods.
2. Balance an existing unbalanced rotating/reciprocating system completely/partially.
3. Program using scientific mathematical software or using basic programming software, to obtain the necessary plots in time and frequency domains, and interpret the results thus obtained.
4. Perform vibration measurement using accelerometer, DAQ and LabView software or similar.
5. Perform simulation of experiments through Sakshat Virtual Laboratory interface.
6. Comprehend the application of condition monitoring and fault diagnosis on a live project/case study based on rotating machinery equipment.

Theory Syllabus:

Module	Detail Content	Hrs.
1.	**1.1 Basic concepts of vibrations:** Vibration and oscillation, causes and effects of vibrations, vibration parameters—spring, mass, damper; damper models, Vibration Terminology—periodic motion, non-periodic motion, aperiodic motion, Simple harmonic motion (SHM), degree of freedom, static equilibrium position, vibration classification, steps involved in vibration analysis.	7
2.	**2.1 Free undamped one degree of freedom vibration systems:** Formulation of differential equation or undamped natural frequency by Newton's second law or D'Alembert's principle, and by various energy principles, for longitudinal, transverse, and torsional vibration systems. Springs in series and parallel combination, inclined springs, effect of spring's self-mass in calculating system's natural frequency.	7

3.	**3.1 Free damped one degree of freedom vibration systems:** Viscous damping: Underdamped, critically-damped, overdamped systems, Logarithmic decrement for underdamped system. Dampers in series and parallel combination, inclined dampers. Coulomb damping.	6
4.	**4.1 Forced vibration of one degree of freedom systems:** Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (viscous damping only). **4.2 Isolation and Transmissibility:** Force Transmissibility, motion Transmissibility, typical vibration isolators & mounts. **4.3 Vibration measuring instruments:** Principle of seismic instruments. Vibrometer, accelerometer, velometer with and without measurement errors. Principle of frequency-measuring instruments. Fullarton tachometer, Frahm's reed tachometer.	7
5.	**5.1 Free undamped multi-degree of freedom vibration systems:** Eigenvalues and eigenvectors for linear and torsional systems (limited to a maximum of three degrees of freedom), Holzer method for linear and torsional unbranched systems, Two rotor system. Maxwell's reciprocal theorem, Influence Coefficient, Dunkerley's and Rayleigh's methods for estimating fundamental frequency of transverse vibration.	6
6.	**6.1 Balancing of Rotating and Reciprocating Masses:** Static and dynamic balancing of multi-rotor systems. Approximate analytical method for finding acceleration of reciprocating piston (mass of connecting rod and crank neglected). Primary and secondary unbalanced forces, in-line engines, V-engines (excluding radial engines). Direct and reverse crank method. **6.2 Rotor Dynamics** Critical speed of a single rotor - undamped and damped. **6.3 Condition Monitoring and Fault Diagnosis** At least one case study in detail based on conditioning monitoring and fault diagnosis on rotating machinery equipment.	6

Laboratory Syllabus:

Sr. No.	Title of the Experiment	Hrs.
1.	Determining the undamped natural frequency / time period of free undamped vibrations/oscillations of the following systems, theoretically and experimentally: (a) Simple spring-mass system (b) Simple pendulum (c) Compound pendulum (d) Single rotor-shaft system (e) Bifilar suspension system	10
2.	Free damped torsional oscillations.	2
3.	Forced vibration of one degree of freedom system, subjected to frequency-squared excitations (rotating unbalance).	2
4.	Computer program on frequency-domain plots of dimensionless steady-state amplitudes for various values of damping ratio.	2
5.	Vibration measurement of rotating machinery using accelerometer, DAQ system and LabView software; or similar.	2
6.	Balancing of rotating masses.	2
7.	Virtual Laboratory Experiments using Sakshat VLab portal.	2

Theory Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/ Assignments / Quiz/ Case studies/ Seminar presentation of 40 Marks

End-Semester Examination: 60 marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Mechanical Vibrations - S. S. Rao - Pearson Education
2. Mechanical Vibrations - G. K. Grover
3. Fundamentals of Mechanical Vibrations - S. Graham Kelly - Tata McGraw Hill
4. Mechanical Vibrations - Schaum's outline series - S.Graham Kelly- McGraw Hill
5. Mechanical Vibrations - Den, Chambil, Hinckle
6. Mechanical Vibrations - J.P. Den Hartog - McGrawhill Book Company Inc.
7. Introduction to Dynamics and Control - Leonard Meirovitch - Wiley, New York
8. Elements of Vibration Analysis - Leonard Meirovitch - McGraw-Hill, New York
9. Principles of Vibrations - Benson H. Tongue - Oxford University Press.
10. Theory of Vibrations with Applications - W. Thomson - Pearson Education
11. Vibrations - Balakumar Balachandran, Edward Magrab - CENGAGE Learning.
12. Vibration Monitoring, Testing, and Instrumentation (Mechanical Engineering Series) - Clarence W. deSilva - CRC Press.
13. Vibration Testing: Theory and Practice - Kenneth G. McConnell, Wiley.
14. Modal Testing: A Practitioner’s Guide - Peter Avitabile - Wiley.

Course Code	Course Name	Credits
ME 407	**Robotics**	**3**

Course Objectives:

1. To study the basics of robotics and its control
2. To study various design principles of robotics through kinematic analysis, workspace analysis, and trajectory planning
3. To study applications of robots in industrial inspection and material handling
4. To study the role of a robot as a humanoid

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

1. Demonstrate the basic functioning of a robot
2. Identify various components of robots
3. Carryout kinematic analysis, workspace analysis, and trajectory planning for a robot
4. Identify suitable sensors/actuators for robot
5. Select an appropriate robot for given industrial inspection and material handling systems.
6. Illustrate various aspects of a robot as a humanoid

Module	Detail Content	Hrs.
1.	**Introduction** Definition of robot, Evolution of robots, Laws of robots, International Robotic Standards, Types of robots, Selection of robots, Robot Classifications, Degrees of freedom, Robot configuration, Accuracy and repeatability, Specification of a robot, Robot feedback controls: Point to point control and Continuous path control, Control system for robot joint, Adaptive control, Drives and transmission systems, End effectors, Applications of robots, Social & Economical Benefits.	08
2.	**Kinematics of Robots** Direct: Link coordinates D-H Representation, The ARM equation, Direct kinematic analysis for Four axis, SCARA Robot and three, five, and six axis Articulated Robots. Inverse: The inverse kinematics problem, General properties of solutions, Tool configuration, Inverse kinematics of four axis SCARA robot and three and five axis Articulated robot. Mobile Robot Kinematics Introduction, Kinematic models and constraints, Representing robot position, Forward kinematic models, Wheel kinematic constraints, Robot kinematic constraints, Mobile robot maneuverability, Degree of mobility, Degree of steerability, Mobile robot workspace, Degree of freedom, Holonomic robots, Path and trajectory considerations, Motion control, Open loop control, Feedback control.	10
3.	**Workspace Analysis and Trajectory Planning** Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, Joint space technique - Continuous path motion, Interpolated motion, Straight line motion and Cartesian space technique in trajectory planning.	08
4.	**Robotic vision systems -** Image representation, Object recognition and categorization, Depth measurement, Image data compression, Visual inspection, Segmentations, Software considerations	06
5.	**Robots for Inspection and Material Handling** Concepts of material handling, Principles and considerations in material handling systems design, Conventional material handling systems - Industrial trucks,	08

	Monorails, Rail guided vehicles, Conveyor systems, Cranes and Hoists, Advanced material handling systems, Automated guided vehicle systems, Automated storage and retrieval systems, Barcode technology, Radio frequency identification technology.	
6.	**Humanoids** Wheeled and legged, Legged locomotion and balance, Arm movement, Gaze and auditory orientation control, Facial expression, Hands and manipulation, Sound and speech generation, Motion capture/Learning from demonstration, Human activity recognition using vision, touch, and sound, Vision, Tactile Sensing, Models of emotion and motivation, Performance, Interaction, Safety and robustness, Applications, Case studies.	08

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests **-** 40 Marks
2. Continuous evaluation- Class Test/Assignments /Quiz/Case studies/Seminar presentation- 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:-

1. Yoram Korean, “Robotics for engineers”, McGrew Hill Co.
2. M.P. Groover, M. Weiss, R.N. Nagel, and N.G. Odrey, “Industrial Robotics Technology programming and Applications”, McGraw-Hill,
3. Robotics: Fundamental Concepts and Analysis by Ashitava Ghosal, Oxford University Press
4. R.K. Mittal and I.J. Nagrath, “Robotics and Control”, TMH Publications
5. Robert J. Schilling, “Fundamentals of Robotics Analysis and Control”, PHI Learning
6. Bijay K. Ghosh, Ning Xi, T.J. Tarn, Control in Robotics and Automation Sensor – Based integration, Academic Press

Course Code	Course Name	Credits
ME 408	**Modelling and Simulation**	**3**

Course Objectives:

1. To understand the significance of modeling
2. To highlight the importance of simulation

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

1. Demonstrate a clear understanding of model for any system
2. Analyze any model for the given system.
3. Realize any system with the help of model and the tool for simulation
4. Demonstrate the simulation skill for any given system
5. Use modern Engineering tools to solve engineering problems.

Theory Syllabus:

Module	Detail Content	Hrs.
1.	**System Modeling** 1.1 Types of model Static and dynamic physical and mathematical model 1.2 Step response method two ,three and four parametric model	05
2.	**Mathematical Model** 2.1 Necessity of mathematical modeling, principles of mathematical modeling 2.2 Dimensional analysis, scale	08
3.	**Approximating and validating models** 3.1 Taylor's formula, algebraic approximations, Numerical approximations 3.2 Validating models	08
4.	**Analysis and control of the systems** 4.1 Solution Techniques for Ordinary Differential Equations, Free Response and Eigenvalues 4.2 State-space Equations: Converting to state space, simulating the models using any simulation	05
5.	**Examples of System Models** 5.1 Exponential growth and decay – radioactive decay, capacitor charging discharging 5.2 Freely vibrating pendulum, spring-mass oscillator	08
6.	**System Simulation** 6.1 Techniques of simulations, The Monte-Carlo Method 6.2 Types of system Simulation 6.3 Continuous System Simulation: Analog and Hybrid method 6.4 Probability concepts in simulation	05

Laboratory Syllabus:

Sr. No.	Experiment Title
1	Circuit Design with Circuit simulation tools
2	Tools used in control system and instrumentation like Labview
3	Programming with Embedded tools
4	FPGA/CPLD programming tools
5	Modeling with autocad tools

6	Mathematical modeling tools like Scilab/Matlab
7	Tools for implementation of Real Time Operating System
8	Tools used for communication

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/ Assignments / Quiz/ Case studies/ Seminar presentation of 40 Marks

End Semester Examination: 60 marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the syllabus.

Books/References:

1. Clive L. Dym, “Principles of Mathematical Modeling” Academic Press, Second Edition
2. Dean C. Karnopp, Donald L. Margolis, Ronald C. Rosenberg, “System Dynamics: Modeling, Simulation, and Control of Mechatronic Systems,” 5th Edition, Wiley
3. Geoffrey Gordon , “ System Simulation” Prentice Hall India
4. Karl J Astrom, Tore Huggland “ PID Controllers” 2nd Edition
5. Fundamentals of Process Control Theory, Paul Murrill, ISA

Course Code	Course Name	Credits
ME 409	**Nanotechnology, Nanostructures and Nanomaterials**	**3**

Prerequisites:

1. XII Chemistry
2. Chemistry of Engg Materials
3. Materials And Metallurgy

Course Objectives:

1. To make the students understand the fabrication of nanostructures for advanced devices.
2. Provide and train the students about nanomaterial synthesis and thin film deposition techniques

Course Outcomes: Upon successful completion of this course, learner will be able to

1. Demonstrate an understanding of the properties of materials with strong dependence on size.
2. Demonstrate an understanding of approaches to engineer nanomaterials and nanostructures
3. Develop applications of nanomaterials with a focus on fundamentals, fabrication, characterization, and applications.
4. Understand and apply vacuum technology for nanomaterial synthesis.
5. Know various deposition techniques at the atomic and molecular level
6. Acquire knowledge about structure and properties of thin films.

Module	Detail Content	Hrs.
1.	Structure and property – 2D and 3D system. Specific surface to volume ratio and surface energy,Top-down approach: photolithography, e-beam lithography and soft lithography . Bottom-up approach: shape controlled synthesis of nanomaterials.	6
2.	Length of nanoscales: metal, semiconductor and magnetic nanoparticles. Light and electrons: optical and electron microscopy. Near field imaging: near field optical microscopy and scanning probe microscopy.	5
3.	Deposition techniques for nanocoatings and structure.Particularities and versatility of physical vapor deposition (PVD), chemical vapor deposition (CVD), laser-, electron- and ion-assisted technologies	5
4.	Fundamentals, Advantages and limitations of Chemical vapor deposition (CVD) techniques; Different kinds of CVD techniques- Metal Organic (MO) CVD, Photoassisted CVD, Thermally activated CVD, Plasma enhanced (RF, μ-Wave) CVD, Low pressure (LP) CVD, Atmospheric pressure (AP) CVD etc,.	6
5.	Definition of thin films- Environment (Gas phase and plasma) for thin film deposition, Deposition parameters and their effects on film growth; Physical parameters for evaluation of thin filmsSurface roughness; Density; Stress in thin films; Adhesion; Stoichiometry.	6
6.	Recent development of nanomaterials and safe nanotechnology, hazards with handling and transportation of nano materials	4

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. No Small Matter: Science on the Nanoscale: Felice C. Frankel and George M. Whitesides, The Belknap Press of Harvard University Press, 2009 .
2. Introductory Nanoscience: Physical and Chemical Concepts: Masaru Kuno, Garland Science; 1 edition (August 19, 2011)
3. Hari Singh Nalwa, Handbook Of Nanostructured Biomaterials And Their Applications In Nanobiotechnology, Journal of Nanoscience and Nanotechnology, 2005.
4. J. George, Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005.
5. G.A. Ozin and A.C. Arsenault, Nanochemistry: A chemical approach to nanomaterials, Royal Society of Chemistry, 2009.

Course Code	Course Name	Credits
ME 410	**Electrical, Magnetic and Optoelectronic Materials**	**3**

Prerequisites:

1. XII Physics
2. Elementary knowledge of Solid State Physics

Course Objectives:

1. To introduce students to different classes of engineering materials
2. To introduce students to the basic principles that help in understanding why a material behaves in a certain fashion.
3. To introduce students about materials used as sensors and actuators.

Course Outcomes: Upon successful completion of this course, learner will be able to

1. Acquire knowledge of electrical, magnetic and optical properties of available materials.
2. Choose appropriate material in designing engineering components.
3. Understand the basic principles involved in working of various sensors and actuators.
4. Provide basic knowledge so that learners can appreciate the importance of discovery of new materials.
5. Use appropriate safety procedures in handling various materials, sensors and actuators.

Module	Detail Content	Hrs.
1.	**Electrical Materials: Part 1** Origin of electrical conductivity, Conductors, Insulators, Semiconductors, Electrical contact materials, Dielectrics, Polarizability, Permittivity, Behavior of dielectrics in DC and AC fields, Solid dielectrics (organic and inorganic), Liquid dielectrics (mineral and synthetic oils) and Gaseous dielectrics (Sulphur hexafluoride etc.)	7
2.	**Electrical Materials: Part 2** Ferroelectric materials, high dielectric materials, low dielectric materials, capacitors, super capacitors, Piezoelectric materials, Ferroelectric Materials, Multiferroics. Superconductors, Magnetic levitation, Electroactive polymers, Ionic conductors.	7
3.	**Magnetic Materials: Part 1** Atomic structure and origin of magnetism, Magnetization, Permeability, Susceptibility, Curie-Weis law, Classification of magnetic materials, Diamagnetic materials, Paramagnetic materials, Ferromagnetic materials, Anti-ferromagnetic materials, Magnetization curve, Hysteresis loop, Soft Magnets, Hard Magnets.	6
4.	**Magnetic Materials: Part 2** Methods of measuring magnetic field (Magnetic Resonance, Hall effect), Magnetocaloric Materials, Magnetic refrigeration, Magneto resistive materials, Magnetostrictive materials, Magnetic polymers, Soft magnetic composites, Ferrofluids.	6
5.	**Optoelectronic Materials: Part 1** Characteristics of optoelectronic devices, Direct and in-direct gap semiconductors, Semiconductors for LED, Photodetectors etc.	7

	Semiconductor Lasers, Laser Materials, Materials for optical fibers, Photonic materials, Semiconductor nano-structures.	
6.	**Optoelectronic Materials: Part 2** Liquid crystals for display, Organic optoelectronic materials, Dye synthesized solar cells, Metal halide perovskite optoelectronic materials, Metamaterials, Negative refractive index materials.	6

Assessment:

Internal Assessment: 40 marks.

1. One compulsory in-semester class test of 40 marks. At least 40% of the syllabus shall be completed before conducting the test.
2. One assignment or mini-project of 40 marks.

End-Semester Examination: 60 marks.

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Engineering Materials by Kenneth G. Budinski (Prentice Hall of India)
2. Introduction to Material Science for Engineers by James F Shackelford
3. Introduction to magnetic materials, B. D. Cullity, C. D. Graham,(Wiley)
4. Fundamentals and applications of magnetic materials by Krishnan, Kannan M, (Oxford University Press)
5. Electrical Engineering Materials by A J Dekker
6. Dielectric Materials: Properties and Applications (Lecture Notes) http://tiiciiitm.com/profanurag/Physics-Class/Unit-2-DM.pdf
7. Electrical Engineering Materials: Lecture Notes by: Prof. Ramesh Chandra Prusty (https://www.vssut.ac.in/lecture_notes/lecture1426861925.pdf)
8. Optoelectronic Devices and Materials by Stephen J. Sweeney and Jayanta Mukherjee (in Springer Handbook of Electronic and Photonic Materials)
9. Basic Optoelectronics and LED—Lecture notes of Haldia Institute of Technology (hithaldia.in › sas_faculty › Lecture Note_EI_503A)
10. Contemporary Optoelectronics Materials, Metamaterials and Device Applications (Editors: Shulika, Oleksiy, Sukhoivanov)
11. Optoelectronics Materials and Techniques by P Predeep (Intech Publications)
12. Organic Optoelectronic Materials, (Ed) Yongfang Li

Course Code	Course Name	Credits
ME 411	**Logistics & Supply Chain Management**	**3**

Course Objectives:

1. To understand the fundamentals of supply chain management and Logistics
2. To develop an understanding related to Supply Chain Performance and related aspects
3. To understand Inventory management in supply chain
4. To learn tools and techniques used in logistics, transportation, warehousing and outsourcing decisions.
5. To develop critical understanding towards digitization in supply chain management and sustainability
6. To develop analytical and critical understanding for planning and designing supply chain network.

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

1. Demonstrate a sound understanding of Logistics and Supply Chain Management concepts and their role in today's business environment.
2. Identify the drivers of supply chain performance and risks in supply chain management.
3. Apply various techniques of inventory management and rank the items using inventory management technique
4. Apply various strategies and techniques to minimize overall logistics cost
5. Understand the role of digitization in supply chain management leading to sustainability
6. Apply various mathematical models/tools to design the supply chain network

Module	Details	Hours
1.	**Introduction:** Objectives of a Supply Chain Management, Stages of Supply chain, Value Chain Process, Cycle view of Supply Chain Process, Key issues in SCM, logistics & SCM, Supply Chain Drivers /decisions and obstacles, Supply chain strategies, strategic fit, Best practices in SCM, Obstacles of streamlined SCM. Supplier Selection, Supplier quality audits, Contract management, Non-Disclosure Agreement (NDA), Make & Buy Decision while in-out sourcing	4
2.	**Supply Chain Performance:** Bullwhip effect and reduction, Performance measurement: Dimension, Tools of performance measurement, SCOR Model. Demand chain management, Global Supply chain- Challenges in establishing Global Supply Chain, Factors that influences designing Global Supply Chain Network. Supply Chain Risk Management **(**Risks involved in supply chain which includes – Supplier Financial Risk, Performance Risk, Compliance Risk, Country specific Risk, Cyber Security.	8

	Supplier performance measurement – (Delivery & Quality performance, schedule adherence, Goods receipt compliance etc), Supplier Capacity Analysis, Supplier Score card.	
3.	**Inventory management:** Definition of Inventory, Inventory types & functions; EOQ Model and Buffer Stock, Assumptions, Instantaneous Replenishment case, Demand and production rate are different, when backorders are allowed, Buffer Stock and ROL. Replenishment systems (Q and P system) Inventory Control- ABC Analysis, Numerical problems on ABC analysis, VED Analysis	6
4.	**Logistics Management and outsourcing:** Evolution, Objectives, Components and Functions of Logistics Management, Distribution related Issues and Challenges; Gaining competitive advantage through Logistics Management, Transportation- Functions, Costs, and Mode; Network and Decision, Containerization, Cross docking. Warehousing: Concept and types, Warehousing strategy, Warehouse facility location & network design Part Packaging, Use of Returnable pallets, ASN – Advance Shipment Notification. Reverse logistics: Outsourcing - Nature and concept, Strategic decision to Outsourcing, Third party logistics(3PL), Fourth party logistics(4PL), Cold chain operations in Supply chain.	8
5.	**Digitization in supply chain Management and Sustainability:** IT in supply chain - Role of IT in a supply chain, The supply chain IT framework, Application of Bar coding, Significance of SAP/RFID, The future of IT in the supply chain, Supply chain IT in practice, TMS (Transport Management System), WMS (Warehouse Management System) Green supply chain management, Supply Chain sustainability, Supply Chain sustainability index measurement with case studies. Social aspects of supply chain (CSR), Environment aspects of supply chain (CO2 emission), resource utilization, recycling.	4
6.	**Supply Chain Network Design:** Factors influencing distribution network design, Supply chain resilience, Design options for distribution network, Introduction to mathematical modelling, considerations in modelling SCM systems, Overview of the models, Models on transportation, Transportation problem, Vehicle routing problem, Travelling salesman problem, Capacitated transhipment problem, shortest path problem. Value Stream Mapping (VSM), Order Fulfillment Process Flow, understanding the terms related to Supply chain- Lead Time, Takt Time ,Minimum Order Quantity (MOQ), Manufacturing Critical Path Time (MCT)	6

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Text/Reference Books: -

1. R.P. Mohanty, S.G. Deshmukh, Essentials of Supply Chain management, Phoenix publishing House Pvt Ltd.
2. S.K. Bhattacharya, Logistics Management, Pearson Publication
3. Sunil Chopra, P. Meindl, Supply Chain Management, Pearson Education Asia.
4. Martin Christopher, Logistics and Supply Chain Management, Pitman Publishing.
5. Bowon Kim, Mastering Business in Asia. Supply Chain Management, John Wiley & sons (Asia) Pte Ltd.
6. Michael Hugos, Essentials of Supply Chain Management, John Wiley and Sons
7. Rahul V Altekar, Supply Chain Management: Concepts and cases, PHI
8. D. Simchi-Levi, P. Kaminsky, E. Simchi-Levi, and Ravi Shankar, Designing and Managing the Supply Chain concepts, Strategies and Case studies, Third Edition, Tata McGraw Hill, New Delhi, 2008.

Course Code	Course Name	Credits
ME 412	**Quality Engineering**	**3**

Course Objectives:

1. To understand the concept of Quality.
2. Demonstrate the approaches and techniques to assess and improve process and/or product quality and reliability
3. Introduce the principles and techniques of Statistical Quality Control

Course Outcomes: Upon successful completion of this course, learner will be able to:

1. To realize the importance and significance of quality
2. Illustrate basic concepts and statistical methods in quality control
3. Illustrate the different sampling techniques in quality control
4. Use control charts to analyze for improving the process quality
5. Acquire basic knowledge of total quality management

Module	Detail Content	Hrs.
1.	**Introduction** Different Definitions and Dimensions of Quality, Historical Perspective (From Evolution of Quality Control, Assurance and Management to Quality as Business Winning Strategy), Contribution of Renowned Quality Gurus (Their Philosophies and Impact on Quality).Introduction to Quality, Classification of Quality Tools, Quality of Design, Quality of Conformance, Compromise between Quality and Cost,	4
2.	**Quality Engineering and Management Tools, Techniques & Standards** 7 QC tools, 7 New Quality Management Tools, 5S Technique, Kaizen, Poka-Yoke, Quality Circle, Cost of Quality Technique, Introduction to Quality Management Standards – ISO : 9000, ISO:14000, QS:9000 (Concept, Scope, Implementation Requirements & Barriers, and Benefits), Introduction to National and International Quality Awards (Malcolm Baldrige National Quality Award – MBNQA, The Deming Prize Rajiv Gandhi National Quality Award)	8
3.	**Total Quality Management** Basic Philosophy, Approach, Implementation Requirements & Barriers. **Designing for Quality** Introduction to Concurrent Engineering, Quality Function Deployment (QFD) and Failure Mode and Effect Analysis (FMEA) – Concept, Methodology and Application (with case studies).	8
4.	**Introduction to Design of Experiments** Introduction , Methods, Taguchi approach, Achieving robust design, Steps in experimental design **SQC & SQC tools** Statistics in Quality control, Variables and Attributes data, Process Capability, Control charts for variables and for attribute data($\bar{X}$ and R-Chart, p-chart np-chart, c-chart, Uchart), Applications of SQC in engineering – case studies **Sampling Techniques**	8

	Advantages of Sampling Inspection, operating characteristic (OC) curve. Choosing OC curve for appropriate sampling plan, acceptance sampling	
5.	**Contemporary Trends in Quality Engineering & Management** Just in time (JIT) Concept, Lean Manufacturing, Agile Manufacturing, World Class Manufacturing, Total Productive Maintenance (TPM), Bench 10 20 Marking, Business Process Re-engineering (BPR), Six Sigma - Basic Concept, Principle, Methodology, Implementation, Scope, Advantages and Limitation of all as applicable.	8
6.	**Quality in Service Sectors** Characteristics of Service Sectors, Quality Dimensions in Service Sectors, Measuring Quality in Different Service Sectors.	4

Theory Assessment:
Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks
Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Quality Assurance and Total Quality Management (ISO 9000, QS 9000 ISO 14000) by K C Jain and A K Chitale, Khanna Publishers
2. Quality Control & Application by B. L. Hanson & P. M. Ghare, Prentice Hall of India
3. Total Quality Management by Dale H. Besterfield, Carol Besterfield-Michna, Glen H. Besterfield and Mary Besterfield-Sacre, Pearson Educaiton
4. Quality Management by Kanishka Bedi
5. Total Quality Management – Dr. S. Kumar, Laxmi Publication Pvt. Ltd.
6. Total Quality Management by K C Arora, S K Kataria & Sons
7. Statistical Quality Control by M. Mahajan, Dhanpat Rai & Co. (P) Ltd.

Course Code	Course Name	Credits
ME 413	**Sustainable/Zero Energy Buildings**	**3**

Course Objectives:

1. To study fundamental concepts of solar building design and energy systems.
2. To study the process involved in site selection of green buildings.
3. To study various energy efficient materials for green building construction.
4. To study various ASHRAE and IGBC standards.

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

1. Understand the benefits of green building.
2. Understand various heat transfer processes that increase cooling load in a building.
3. Understand various methods adopted for Occupant Comfort and Wellbeing.

Module	Detail Content	Hrs.
1.	Introduction to Green Buildings: Definition of green buildings and sustainable development, typical features of green buildings, benefits of green buildings towards sustainable development. Green building rating systems – GRIHA, IGBC and LEED, overview of the criteria as per these rating systems.	08
2.	Site selection and planning: Criteria for site selection, preservation of landscape, soil erosion control, minimizing urban heat island effect, maximizing comfort by proper orientation of building facades, day lighting, ventilation, etc. Water conservation and efficiency: Rainwater harvesting methods for roof & non-roof, reducing landscape, water demand by proper irrigation systems, water efficient plumbing systems, water metering, waste-water treatment, recycle and reuse systems.	08
3.	Energy Efficiency: Environmental impact of building constructions, Concepts of embodied energy, operational energy and life cycle energy. Methods to reduce operational energy: Energy efficient building envelopes, efficient lighting technologies, energy efficient appliances for heating and air-conditioning systems in buildings, zero ozone depleting potential (ODP) materials, wind and solar energy harvesting, energy metering and monitoring, concept of net zero buildings.	08
4.	Heat transfer processes in buildings:- Thermal conductivity, resistance, transmittance, surface characteristics, surface coefficient, heat capacity, insulation. Calculation of principle building energy gains and losses. Estimation of building energy performance for heating and cooling for different climatic contexts. Importance of energy to human development, conventional and renewable energy sources – supply, uses and environmental impact. Assessment future growth in energy demand, availability, potential for sustainable development. Sustainable issues of planning, building design and development.	08
5.	Building materials: Methods to reduce embodied energy in building materials: (a) Use of local building materials (b) Use of natural and renewable materials like bamboo, timber, rammed earth, stabilized mud blocks, (c) use of materials with recycled content such as blended	08

	cements, pozzolana cements, fly ash bricks, vitrified tiles, materials from agro and industrial waste. (d) reuse of waste and salvaged materials. Waste Management: Handling of construction waste materials, separation of household waste, on-site and off-site organic waste management.	
6.	Indoor Environmental Quality for Occupant Comfort and Wellbeing: Day-lighting, air ventilation, exhaust systems, low VOC paints, materials & adhesives, building acoustics. Codes related to green buildings: NBC, ECBC, ASHRAE, UPC etc, Energy Conservation Act 2001	06

Assessment:

Internal Assessment for 40 marks:

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. IGBC Green Homes Rating System, Version 2.0., Abridged reference guide, 2013, Indian Green Building Council Publishers.
2. GRIHA version 2015, GRIHA rating system, Green Rating for Integrated Habitat Assessment.
3. Alternative building materials and technologies by K.S. Jagadish, B.V. Venkatarama Reddy and K.S. Nanjunda Rao.
4. Non-Conventional Energy Resources by G. D. Rai, Khanna Publishers.
5. Sustainable Building Design Manual, Vol.1 and 2, TERI, New Delhi 2004.
6. Mike Montoya, Green Building Fundamentals, Pearson, USA, 2010.
7. Charles J. Kibert, Sustainable Construction – Green Building Design and Delivery, John Wiley & Sons, New York, 2008.
8. Regina Leffers, Sustainable Construction and Design, Pearson / Prentice Hall, USA, 2009.
9. Faber, Oscar and Kell, J.R. Heating and air-conditioning of buildings. 2002.
10. Thomas, Randall & Fordham Max Sustainable urban design:an environmental approach" 2003.
11. Edwards, Brian and Hyett, Paul Rough guide to sustainability
12. Langston, Craig A. and Ding, Grace Sustainable practices in the built environment 2001.
13. Givoni Baruch,"Passive and Low Energy Cooling of Buildings",VNR, New YorK, 1994.
14. Martin J Gainsborough, Radford and Helen Bennets, T J Williamson, "Understanding Sustainable architecture", Spon Press, London, 2003.

Course Code	Course Name	Credits
ME 414	**Energy Systems Modelling & Analysis**	**3**

Course Objectives:

1. To study and understand energy system models
2. To study and understand analysis parameters and trade-off

Course Outcomes: Learner will be able to

1. Develop the model for energy system
2. Evaluate the parameters for analysis
3. Build the complete model for local energy system

Theory Syllabus:

Module	Detail Content	Hrs.
1	Introduction to energy system modelling, usage, cost and efficiency, Classification of energy system models, Process system Engineering, Energy economics	10
2	Architecture of energy system, Taxonomy of energy system models,	07
3	Analytical approach to modelling, Top-down models, Bottom-up models, Hybrid models	07
4	Analysis of energy systems, integration of renewable sources with conventional energy systems	10
5	Energy infrastructure, planning, trade-off	07
6	Energy Internet: Overview, Concept, Model Structure, and Mechanism	07

Laboratory Syllabus:

Experiment	Name of Experiments	Hrs.
1	1. A case study on energy economics	4
2 and 3	Any two of the following 1. Development of Top-Down model for identified energy system 2. Development of Bottom-Up model for identified energy system 3. Development of Hybrid model for identified energy system	4
4 and 5	1. Identify the trade-off parameters 2. Make the necessary changes in the models developed in experiment 2	4

Assignments: At least 2 reports on

1. Local energy system
2. Local energy infrastructure
3. Energy planning for the municipal corporation
4. Cost analysis
5. Possibilities of adding renewable energy resources and its payback

Note: The reports may be prepared by a group of 4 to 5 students

Assessment:

Internal Assessment for 40 marks:

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Modelling and Simulation of Energy Systems by Thomas A. Adams (MDPI)
2. Energy Systems Modelling Principles and Applications by Hooman Farzaneh (Springer)
3. Modelling, Analysis and Optimization of Process and Energy Systems by F. Carl Knopf (Wiley)
4. Modelling, Assessment and Optimization of Energy Systems by Hoseyn Sayyaadi (Academic Press)
5. Modern Power System Analysis by D P Kothari and I J Nagrath (McGraw Hill)

Course Code	Course Name	Credits
ME 415	**Alternate Fuels and Emissions**	**3**

Course Objectives:

1. To provide in depth knowledge of Alternate fuel and energy systems.
2. To address the underlying concepts and methods behind alternate fuel and energy systems.
3. Study the effect of pollution on the environment and human health.
4. Study emission standards, methods of measurement and control techniques.

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

1. Identify different areas of alternate fuels and energy systems.
2. Describe various parameters that are used to characterize fuels.
3. Demonstrate the utilization of alternative fuels for Automotive applications..
4. Understand various sources of emission and harmful effects of pollution
5. Describe the importance of emission measurement and control and summarize pollution norms.
6. Assess need of eco-friendly fuel and vehicle

Module	Detail Content	Hrs.
1.	**Introduction**: Introduction to types of I.C engine, Conventional fuels for I C Engine, Properties of different types of fuels, Fossil fuels, availability and scope, Effect of different types of fuel on engine performance.	05
2.	**Alcohol :** Introduction to Alcohol fuel , Sources of various types and blends of alcohol fuel, Calorific value of different types of fuels, Application of fuel in I C Engine, Multiple fuel system, Improving performance of Engine with types of alcohol fuels. **Biodiesel** : Introduction to biodiesel, sources of biodiesel, Production of biodiesel, various blends of biodiesel, Effect of different types of blends on engine performance like exhaust.	06
3.	**Biogas**: Introduction to biogas, Biogas production methods, Various factors affecting generation of biogas, Application of ion. in Automotive industry. **LPG and CNG :** Introduction, Properties of LPG and CNG, Methods of LPG and CNG Transportation, Safety and regulation in storage and transport, Fuel flow metering system, Combustion, Cost. **Hydrogen and fuel Cell:** Hydrogen as alternative fuel, Sources and methods of hydrogen production, properties of hydrogen, Hydrogen storage and transportation, Application of hydrogen in Automobile, Layout of hydrogen powered Car. **Fuel Cell:** Concept of fuel cell, Types of fuel cell, Power rating and performance, Automobile layout of full cell powered Car.	07
4.	**Solar Energy:** Concept of solar cell, Types of solar cell, Energy production from solar cell, Types of batteries used in harvesting solar energy, Merits and limitations of solar energy, Automobile layout of solar powered car. **Hybrid and electric vehicle :** Introduction and components of electric vehicle	07

	high energy and power density batteries , – Capacity, Discharge rate, State of charge, state of Discharge, Depth of Discharge, Technical characteristics, Motor rating, requirements, Types – series, parallel and series, parallel configuration	
5.	**Introduction**: Air pollution, Sources of air pollution, Engine exhaust and its constituents, Emission from petrol tank & carburetor, crankcase blow-by, Effect of valve timing, ignition timing, Combustion chamber design, Fuel injection, fuel composition, air fuel ratio, Catalytic converters , Effect of automobile exhaust on air quality and human beings. **Pollution Norms:** European pollution norms, Indian pollution norms as per Central Motor Vehicle Rules (C. M.V. R.), The Air (Prevention and Control of Pollution) Act, 1981 **Control Of Engine Emissions:** By injection parameters, Lubricating oil, Compression ratio, Crankcase ventilation, Fuel composition, Injection/ Ignition timing, Charcoal canister.	07
6.	Numerical calculations to determine constituents of exhaust gas by mass basis and by volume basis, EGR mass flow rate estimation, Flame Ionization Detector (FID). Non Dispersive infrared analyzer and NOx Measurement. **Electronic Engine Control Technologies** Electronic throttle control, Closed loop canister purge control system, **Recent Trends in automotive emission technology.**	06

Laboratory Syllabus:

List of Experiments

1. Exhaust gas analysis of 4 stroke diesel engine by using exhaust gas analyser
2. Exhaust gas analysis of 2 stroke petrol engine by using exhaust gas analyser
3. Exhaust gas analysis of 4 stroke petrol engine by using Orsat apparatus
4. Exhaust gas analysis of 4 stroke diesel engine by using Orsat apparatus
5. Exhaust gas analysis of 2 stroke petrol engine by using Orsat apparatus
6. Study of Catalytic converters
7. Study of Emission Norms
8. Study of Exhaust Gas Recirculation (EGR)
9. Study of LPG / CNG Kit

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests - 40 Marks
2. Continuous evaluation- Class Test/ Assignments /Quiz/Case studies/Seminar presentation- 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Internal combustion Engines by Mathur and P. L. Sharma
2. Air pollution By Rao & Rao
3. Electronic Engine Control Technologies by Ronald K. Jurgen
4. Internal combustion Engines & Air pollution by Edward F. Obert
5. Pollution control and conservation by Dr. m. Kovacs

6. Air pollution Volume I to Volume XII by Arthur C. Stern
7. Air pollution by Henry C. Perkins
8. Air pollution by Spedding
9. I.C.Engine fundamentals by J.B. Heywood
10. Alternate Fuels by Dr. S. Thipse, Jaico Publications
11. "Automotive Emission Control" by Crouse, AND Anglin – McGraw Hill.
12. "Alternative Fuels Guidebook" by Bechtold R.
13. "Internal Combustion Engines" by Ganeshan – Tata McGraw Hill

Course Code	Course Name	Credits
ME 416	**Automotive Electronics**	**3**

Course Objectives:

1. To study basic and advanced Automotive Electronics systems and subsystems.
2. To acquaint with working of different Automotive Electronics systems and subsystems.
3. To familiarize basic and advance electronics technologies like Battery, Fuel Cell, ECM etc
4. To familiarize automotive diagnostics and Automotive Communication protocols.

Course Outcomes: Learner will be able to

1. Understand use of energy storage systems for vehicular application
2. Describe the protocols used by microcontrollers to communicate with external sensors and actuators in the real world.
3. Identify different types of starting and electronic ignition systems used in automobiles
4. Explain use of sensors and actuators in vehicle systems
5. Understand lighting and wiring systems of vehicle
6. Describe the diagnostics tools and equipment used for testing of electronic components, sensors, and actuators.

Module	Detail Content	Hrs.
1	**Automotive Energy Storage Systems** Types-Lead Acid, Nickel based batteries, Sodium based batteries and Lithium based batteries, Metal Air batteries Battery characteristics and parameters Fuel Cells Types, Ultra capacitors and Ultra High Speed Flywheels **Automotive Protocols**: The need for Protocol, Automotive Protocols: LIN, CAN, KWP2000 & J1939, FlexRay, Communication Protocol: USART, I2C, SPI, CAN Bus, Use of Protocols, Introduction to Automotive Protocols: CAN, J1939, Introduction to CAN protocol, Use of CAN protocol in Automotive, Basic of CAN Standard and Extended CAN communication, Implementation of CAN drivers, CAN Hardware, comparison I2C, SPI, RS232-drawbacks.	08
2	**Starting and Charging systems** Starting systems-Need, Principle and Construction of Starter motor, Starter motor drives, Starter motor characteristics, design considerations, types of starters and starter switches. Charging systems-Construction and Working of Alternator, Rectification, types of voltage regulators, characteristics of alternator and design considerations Integrated Starter Generator/Motor Generator-Principle and Working	06
3	**Electronic Ignition systems** Battery ignition system, components details and working, Magneto ignition system, Electronic and distributor-less ignition systems, waste-spark and coil-on-plug ignition systems, ignition timing, spark advance, and retarding mechanisms. **Digital Engine Control System**	06

	Open-loop and closed-loop control system, engine cooling and warm-up control, idle speed control, acceleration, and full load enrichment, deceleration fuel cutoff. Fuel control maps, open-loop control of fuel injection, and closed-loop lambda control exhaust emission control, on-board diagnostics, diagnostics, future automotive electronic systems, Electronic dashboard instruments –Onboard diagnosis system.	
4	**Automotive Sensors and Actuators** Systems approach to control and instrumentation, analog, and digital signal processing, sensors - characteristics, response, error, redundancy of sensors in ECUs, avoiding redundancy, sensor modeling, smart nodes. Sensors: accelerometers, wheel speed, brake pressure, seat occupancy, engine speed, steering wheel angle, vehicle speed, throttle position, temperature, mass air flow (MAF) rate, exhaust gas oxygen concentration, throttle plate angular position, crankshaft angular position/rpm, manifold absolute pressure (map), differential exhaust gas pressure and air bag sensors. **Actuators and Controllers** Principles of actuation and control, DC motors, stepper motors, relays and solenoids, hydraulic and pneumatic, components for electronic engine management system, open and closed-loop control strategies, PID control, look-up tables, introduction to modern control strategies like fuzzy logic and adaptive control, parameters to be controlled in SI and CI engines.	07
5	**Lighting ,Wiring systems and accessories** Different Types of lamps in vehicles, Types of auto electric wires (Like AV, AVSS, FLRY-B, etc. or two core, three core, etc.)., Wiring harness design, type of connectors, wiring harness layout in-vehicle, Instrument clusters, Control Area Network (CAN) in-vehicle networking, Vehicle electric earth system, Electromagnetic Interference and Compatibility, Compatibility devices, Centre locking circuit, Immobilizers, Vehicle electrical circuits.	06
6	**Automotive Diagnostics** Testing sensors, Testing actuators, Basic equipment, Basic hand tools Accuracy of test equipment, Multimeters, Logic probe, Oscilloscopes, Waveforms, Scanners/Fault code readers and analyzers, On-board diagnostics introduction, Serial port communications, OBD2 signal protocols, AutoTap OBD scanner, diagnostic equipment, Engine analyzers, Automotive pressure oscilloscope transducer, Breakout boxes, Diagnostic procedures. **Intelligent Vehicle systems**-V2V,V2I,Telematics and application in automobiles, SAE Taxonomy on Autonomous vehicles.	06

Laboratory Syllabus:

List of Experiments

1. Study of Lead Acid Battery.
2. Battery testing :Voltage test,Hydrometer test etc.
3. Dismantling, Inspection & assembly of A. C. Generator/Dynamo.
4. Dismantling, Inspection & assembly of Starter motor.
5. Measurement of Temperature using sensor
6. Measurement of Pressure using sensor.
7. Measurement of Position using sensor.
8. Measurement of Oxygen using sensor.
9. Study of effect of spark advances on Engine Emissions.
10. Study of Electro-magnetic fuel Injector.

11. Engine Diagnostic using Engine Scanner
12. Understanding On Board Diagnostic (OBD) Codes

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/ Assignments / Quiz/ Case studies/ Seminar presentation of 40 Marks

End Semester Examination: 60 marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the syllabus.

Text Books:

1. Tom Denton, Automobile Electrical & Electronic Systems, SAE International.
2. Wiliam B. Ribbens, Understanding Automotive Electronics, SAE International
3. P. L. Kohli, Automotive Electrical Equipments, Tata McGraw Hill Pub. Co. Ltd.

Reference Books:

1. V. A.W. Hillier & David R. Rogers, Fundamentals of Motor Vehicle Technology: Book 3, Chassis & Body Electronics, Nelson Thornes Ltd, Hutchinson Education, London.
2. Barry Hollembeak, Classroom Manual for Automotive Electricity and Electronics, Fifth Edition, Delmar Cengage Learning.
3. Jim Horner, Automotive Electrical Handbook, HP Books.

Course Code	Course Name	Credits
IL 470	**E commerce and E business**	**3**

Course Objectives:

1. To understand the factors needed in order to be a successful in ecommerce
2. Identify advantages and disadvantages of technology choices such as merchant server software and electronic payment options.
3. Analyse features of existing e-commerce businesses, and propose future directions or innovations for specific businesses.

Course Outcomes: Learner will be able to

1. Appreciate the global nature and issues of electronic commerce as well as understand the rapid technological changes taking place.
2. Define and differentiate various types of E-commerce
3. Discuss various E-business Strategies.

Module	Detail Content	Hrs.
1	**E-commerce system:** Introduction- scope of electronics commerce, definition of e-commerce, difference between e-commerce and e-business, business models of e-commerce transactions. E-commerce infrastructure: client server technology, two tier client server architecture for e-commerce, drawbacks, three tier architecture for e-commerce.	8
2	**Business strategies for e-commerce:** Introduction- elements of e-commerce strategy, simplicity, mobile responsiveness, choosing e-commerce store platform, user-based focus, compliance and security measures, e-commerce strategy: strategy overview, strategy task, technology issues. Case study: Flipkart v/s Amazon, competitive edge, marketing strategy, sales strategy	8
3	**Design of E-commerce systems:** e-commerce types- electronic market, electronics data interchange EDI, modeling of e-commerce system, three tier component model of e-commerce system, e-commerce system design- data model, web modeling, database structure design, process model, user friendly design of e-commerce site.	7
4	**Technologies for e-commerce systems:** Introduction- technologies for e-commerce, PHS and Java script, SEO, Social Plugins, payment processes, SSL Encryption, hosting server, Service oriented architecture.	7
5	**Scalability of e-commerce systems:** Web scalability- Vertical scalability , horizontal scalability, Load balancing- working of load balancers, global server load balancers, cloud load balancing- goals of cloud balancing, automated cloud balancing. web caching and buffering	6
6	**E-commerce system implementation:** E-commerce implementation, - website testing, web maintenance, web advertisement, copyright services, SMS alert services, bulk email services, Web personalization- techniques for gathering information, analysis techniques for website personalization, domain name registration and web hosting- different types of web hosting, different components of web hosting, features in web hosting.	6

Assessment:

Internal Assessment: 40 marks

End Semester Examination: 60 Marks

Reference Books:

1. Electronic Business and Electronic Commerce Management, 2nd edition, Dave Chaffey, Prentice Hall, 2006
2. Elias. M. Awad, " Electronic Commerce", Prentice-Hall of India Pvt Ltd.
3. E-Commerce Strategies, Technology and applications (David Whitley) Tata McGrawHill
4. E-business- theory and practise, Brahm Canzer, cengage learning
5. Secure e-commerce systems (Kindle edition), Amazon publishing, P S Lokhande, B B Meshram, first edition

Course Code	Course Name	Credits
IL 471 T	**Business Analytics**	**3**

Will be available Soon.

Course Code	Course Name	Credits
IL 472	**Biomedical Instrumentation**	**3**

Course Objectives:

1. To familiarize students with various aspects of measuring electrical parameters from the living body.
2. To introduce students with the characteristics of medical instruments and related errors.
3. To illustrate various types of amplifiers used in biomedical instruments.
4. To familiarize students with biomedical recording devices.
5. To introduce students with patient monitoring systems & their characteristics.

Course Outcomes: Learner will be able to

1. Safely and effectively use biomechanics instrumentation and equipment to record and assess human and object motion.
2. Describe and characterize the origin of bio-potentials and inspect common biomedical signals by their characteristics features
3. Understand the basic instrumentation system with their limitations & familiarize with pc based medical instrumentation & control of medical devices.
4. Describe and characterize medical instruments as per their specifications, static & dynamic characteristics and understand data acquisition system
5. Describe, analyze, characterize and design bio-potential amplifiers and design various medical recording systems & their components.
6. Understand and describe patient monitoring systems and its necessity in healthcare system.

Module	Detail Content	Hrs
1	**Medical Instrumentation**: Sources of Biomedical Signals, Basic medical Instrumentation system, Performance requirements of medical Instrumentation system, Microprocessors in medical instruments, PC based medical Instruments, General constraints in design of medical Instrumentation system, Regulation of Medical devices.	6
2	**Measurement systems:** Specifications of instruments, Static & Dynamic characteristics of medical instruments, Classification of errors, Statistical analysis, Reliability, Accuracy, Fidelity, Speed of response, Linearization of technique, Data Acquisition System.	6
3	**Bioelectric signals and Bioelectric amplifiers:** Origin of bioelectric signals, Electrodes, Electrode Tissue interface, Galvanic Skin Response, BSR, Motion artifacts, Instrumentation amplifiers, Special features of bioelectric amplifiers, Carrier amplifiers, Chopper amplifiers, Phase sensitive detector. ECG, EEG, EMG, ERG, Lead systems and recording methods.	8
4	**Biomedical recording systems:** Basic Recording systems, General consideration for signal conditioners, Preamplifiers, Differential Amplifier, Isolation Amplifier, Electrocardiograph, Phonocardiograph, Electroencephalograph, Electromyography, Digital stethoscope Other	7

	biomedical recorders, Biofeedback instrumentation, Electrostatic and Electromagnetic coupling to AC signals, Proper grounding, Patient isolation and accident prevention.	
5	**Patient Monitoring Systems:** System concepts, Cardiac monitor, selection of system parameters, Bedside monitors, Central monitors, Heart rate meter, Pulse rate meter, Measurement of respiration rate, Holter monitor and Cardiac stress test, Catheterization Laboratory Instrumentation , Organization and equipments used in ICCU and ITU.	6
6	**Biological sensors:** Sensors / receptors in the human body, basic organization of nervous system-neural mechanism, Chemoreceptor: hot and cold receptors, barro receptors, sensors for smell, sound, vision, Ion exchange membrane electrodes, enzyme electrode, glucose sensors, immunosensors, Basic principles of MOSFET biosensors & BIOMEMS, basic idea about Smart sensors.	6

Assessment:

Internal Assessment: 40 marks

End Semester Examination: 60 Marks

Books/References:

1. Joseph Bronzino, “Biomedical Engineering and Instrumentation”, PWS Engineering, Boston.
2. Cromwell, Weibell & Pfeiffer, “Biomedical Instrumentation & Measurement”, Prentice Hall, India.
3. R. S. Khandpur, “Handbook of Bio-Medical Instrumentation”, 2nd Edition, Tata McGraw Hill.
4. J.Webster, “Bioinstrumentation”, Wiley & Sons.
5. Joseph D.Bronzino, “The Biomedical Engineering handbook”, CRC Press.
6. D. L. Wise, “Applied Bio Sensors”, Butterworth, London.
7. J.J.Carr & J.M.Brown, “Introduction to Biomedical Equipment Technology” Pearson Education, Asia.

Course Code	Course Name	Credits
IL 473	**Design for sustainability**	**3**

Course Objectives:

1. Understand the complex environmental, economic, and social issues related to sustainable engineering
2. Become aware of concepts, analytical methods/models, and resources for evaluating and comparing sustainability implications of engineering activities
3. Critically evaluate existing and new methods
4. Develop sustainable engineering solutions by applying methods and tools to research a specific system design
5. Clearly communicate results related to their research on sustainable engineering

Course Outcomes: Learner will be able to

1. Account for different theoretical and applied design principles and models for sustainable design
2. Account for and critically relate to sustainable design from an ethical, cultural and historical perspective
3. Critically review different design solutions ecological, social and economical consequences, risks, possible uses and functions in the work for a sustainable development
4. Independently apply a specific design theory on a specific challenge within the sustainability field.

Module	Detailed Contents	Hrs
1	Introduction - Need, Evolution of sustainability within Design, environmental - economic sustainability concept, Challenges for sustainable development, Environmental agreement & protocols	6
2	Product Life Cycle Design – Life Cycle Assessment, Methods & Strategies, Software Tools	6
3	Sustainable Product - Service System Design, Definition, Types & Examples ,Transition Path and Challenges, Methods and Tools, Design thinking and design process for sustainable development	8
4	Design for Sustainability – Engineering Design Criteria and Guidelines	6
5	Design for Sustainability – Architecture, Agriculture, Cities & Communities, Carbon Footprint	6
6	Green Building Technologies - Necessity, Principles, low energy materials, effective systems	6

Assessment:

Internal Assessment: 40 marks

End Semester Examination: 60 Marks

Books/References:

1. C. Vezzoli, System Design for sustainability. Theory, methods and tools for a sustainable / satisfaction system/design, Rimini, Maggioli Edition, 2007.
2. C. Vezzoli and E. Manzini, Design for Environmental Sustainability, Springer – Verlag, London, 2008.
3. L. Nin and C. Vezzoli, Designing Sustainable Product-Service Systems for all. Milan: Libreria, CLUP, 2005
4. A. Tukker and U. Tischner (eds.), New Business for Old Europe, Product Services, Sustainability and Competitiveness, Greenleaf Publishing, Shefield, 2008.
5. A. Tukker, M. Charter, C. Vezzoli, E. Sto and M.M. Andersen (eds.), System innovation for Sustainability Perspective on Radical Changes to sustainable consumption and production, Greenleaf Publishing, Shefield, 2008
6. UNEP, Product-Service Systems and Sustainability. Opportunities for sustainable solutions, CEDEX, Paris, 2002, at http://www.uneptie.org/pc/sustain/reports/pss/pss-imp-7.pdf

Course Code	Course Name	Credits
IL 474	**Political Science**	**3**

Course Objectives:

1. Provide a good grounding in the basic concepts of Political Theory.
2. Familiarize learners with fundamental rights and duties.
3. Teach students the structure and process of the electoral system, the features and trends of the party system and create an awareness of the social movements in India.
4. To inculcate the values of renowned thinkers on law, freedom of thought and social justice.
5. To prepare the learners for understanding the importance of Comparative Government and Politics.
6. To train learners in understanding International Relations.

Course Outcomes: Learner will be able to

1. Acquire conceptual and theoretical knowledge in the basic concepts of political theory.
2. Demonstrate understanding of fundamental rights and duties and directive principles.
3. Perform successfully in expressing the process of the electoral system, the features and trends of the party system and the importance of the social movements in India.
4. Illustrate the contribution of renowned thinkers and relate it to the current scenario.
5. Compare and contrast Indian Government and Politics with European countries.
6. Develop an understanding of International Relations with respect to Indian foreign policy.

Module	Detail Content	Hrs.
1	Understanding Political Theory- Evolution of State, Nation, Sovereignty, Types and Linkages between Power and Authority; Interrelationships between Law. Liberty, Equality, Rights; Justice and Freedom, Democracy vs Authoritarianism	4
2	Constitutional Government in India - Evolution of the Indian Constitution, Fundamental Rights and Duties. Directive Principles. Union-State Relations, Union Legislature: Rajya Sabha, Lok Sabha: Organisation, Functions – Law making procedure, Parliamentary procedure, Government in states: Governor, Chief Minister and Council of Ministers: position and functions – State Legislature: composition and functions. Judiciary: Supreme Court and the High Courts: composition and functions – Judicial activism. Constitutional amendment. Major recommendations of National Commission to Review the Working of the Constitution.	6
3	Politics in India: Structures and Processes- Party system: features and trends – major national political parties in India: ideologies and programmes. Coalition politics in India: nature and trends. Electoral process: Election Commission: composition, functions, role. Electoral reforms. Role of business groups, working class, peasants in Indian politics, Role of (a) religion (b) language (c) caste (d) tribe. Regionalism in Indian politics. New Social Movements since the 1970s: (a) environmental movements (b) women's movements (c) human rights movements.	6

4	Indian Political Thought- Ancient Indian Political ideas: overview. Kautilya: Saptanga theory, Dandaniti, Diplomacy. Medieval political thought in India: overview (with reference to Barani and Abul Fazal). Legitimacy of kingship. Principle of Syncretism, Modern Indian thought: Rammohun Roy as pioneer of Indian liberalism – his views on rule of law, freedom of thought and social justice. Bankim Chandra Chattopadhyay, Vivekananda and Rabindranath Tagore: views on nationalism. M.K. Gandhi: views on State, Swaraj, Satyagraha.	7
5	Comparative Government and Politics- Evolution of Comparative Politics. Scope, purposes and methods of comparison. Distinction between Comparative Government and Comparative Politics.	6
6	Perspectives on International Relations- Understanding International Relations: outline of its evolution as academic discipline. Major theories: (a) Classical Realism and Neo-Realism (b) Dependency (c) World Systems theory. Emergent issues: (a) Development (b) Environment (c) Terrorism (d) Migration. Making of foreign policy. Indian foreign policy: major phases: 1947-1962; 1962-1991; 1991-till date. Sino-Indian relations; Indo-US relations.	7

Assessment:

Internal Assessment: 40 marks

End Semester Examination: 60 Marks

Books/References:

1. O.P. Gauba. (2021). *An Introduction to Political Theory*. Mayur books
2. Vibhuti Bhushan Mishra. (1987). *Evolution of the Constitutional History of India (1773-1947 : With Special Reference to the Role of the Indian National Congress and the Minorities).* South Asia Books
3. Chetna Sharma Pushpa Singh. (2019). *Comparative Government and Politics.* SAGE Publications India Pvt Ltd.
4. Henry R. Nau. (1900). *Perspectives on International Relations: Power, Institutions and Ideas*. CQ Press

Course Code	Course Name	Credits
IL 475	**Research Methodology**	**3**

Course Objectives:

1. To understand Research and Research Process
2. To acquaint students with identifying problems for research and develop research strategies
3. To familiarize students with the techniques of data collection, analysis of data and interpretation

Course Outcomes: At the end of the course learner will be able to

1. Prepare a preliminary research design for projects in their subject matter areas.
2. Accurately collect, analyse and report data.
3. Present complex data or situations clearly.
4. Review and analyse research findings.

Module	Detail Content	Hrs.
1	**Introduction and Basic Research Concepts** 1.1 Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Philosophy and validity of research 1.2 Objectives of Research 1.3 Characteristics of Research: Systematic, Valid, Verifiable, Empirical and Critical 1.4 Need of Research in Business and Social Sciences 1.5 Issues and Problems in Research	8
2	**Types of Research** 2.1. Pure and Applied Research 2.2. Descriptive and Explanatory Research 2.3. Analytical Research 2.4 Qualitative and Quantitative Approaches 2.5 Literature review 2.6 Developing the objectives.	8
3	**Research Design and Sample Design** 3.1 Research Design – Meaning, Types and Significance 3.2 Sample Design – Meaning and Significance Essentials of a good sampling Stages in Sample Design Sampling methods/techniques Sampling Errors	7
4	**Research Methodology** 4.1 Meaning of Research Methodology 4.2. Stages in Scientific Research Process: a. Identification and Selection of Research Problem b. Formulation of Research Problem c. Review of Literature d. Formulation of Hypothesis e. Formulation of research Design f. Sample Design g. Data Collection h. Data Analysis i. Hypothesis testing and Interpretation of Data	8

	j. Preparation of Research Report	
5	**Formulating Research Problem** 5.1 Considerations: Relevance, Interest, Data Availability, Choice of data, Analysis of data, Generalization and Interpretation of analysis.	4
6	**Outcome of Research** 6.1 Preparation of the report on conclusion reached. 6.2 Validity Testing & Ethical Issues 6.3 Suggestions and Recommendation 6.4 Identification of future scope	4

Assessment:

Internal Assessment: 40 marks

End Semester Examination: 60 Marks

Reference Books:

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers Distributors.
2. Kothari, C.R.,1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nded), Singapore, Pearson Education

Course Code	Course Name	Credits
IL 476	**Maintenance of Mechanical Equipment**	**3**

Will be available Soon.

Course Code	Course Name	Credits
IL 477	**Cooking and Nutrition**	**3**

Course Objectives: The course is aimed to

1. To understand nutrition and of health problems related to diet and various factors affect diet
2. To various statistical tools required to analyze the experimental data in nutrition and community research
3. Gain information about various food constituents, and changes that occur in them during food processing.
4. To gain food-related knowledge and skills so that they can organise and manage family resources effectively according to the needs and lifestyles of family members
5. To be able to make informed judgements and choices about the use of food available.
6. To create interest in the creative side and enjoyment of food and the skills necessary for food preparation and food preservation. And to be aware of relevant mandatory and other necessary safety and hygiene requirements

Course Outcomes: On successful completion of course learner/student will be able to

1. To understand the importance and mechanisms of the food components taking place during food processing,
2. To understand nutrition and of health problems related to diet and various factors affect diet
3. To aware how eating patterns and dietary needs depend on age and social group
4. Ability to assess the effectiveness and validity of claims made by advertisers
5. To enhance aesthetic and social sensitivity to dietary patterns and to develop an interest in the creative aspect and enjoyment of food
6. To develop skills necessary for food preparation and food preservation and knowledge of safety and hygiene requirements

Module	Detail Content	Hrs.
1	**Nutritional terms**: proteins (high biological and low biological value), carbohydrates (monosaccharide, disaccharide and polysaccharide), fats, vitamins (A, C, D, E, K, B group – thiamin, riboflavin, nicotinic acid and cobalamin), mineral elements (calcium, iron, phosphorous, potassium, sodium, iodide) water Sources and uses of food energy. Sources and functions of dietary fibre.	3
2	**Kitchen equipment & Kitchen planning:** Selection, Use and care of: modern cookers, thermostatic control and automatic time-controlled ovens, microwave ovens, slow electric cook pots, refrigerators and freezers, small kitchen equipment, e.g. knives, pans, small electrical kitchen equipment, e.g. food processors, electric kettles, Advantages and disadvantages of microwave ovens, Organisation of cooking area and equipment for efficient work., Selection, Use and care of: work surfaces, flooring, walls and wall coverings, lighting, ventilation	4
3	**Meal planning and guidelines:** Factors affecting food requirements, Planning and serving of family meals, Meals for different ages, occupations, cultures and religions, Special needs of: people with food allergies and intolerances, people with medical conditions linked to diet, such as diabetes, convalescents, vegetarians, including vegans and lacto-vegetarians, Meals for special occasions, festivals, packed meals,	6

	snacks, beverages, Use of herbs, spices and garnishes, Attractive presentation of food, Terminology describing recommended dietary intakes, e.g. Dietary Reference Value (DRV) and Reference Daily Intake (RDI).	
4	**Strategic cooking**: Transfer of heat by conduction, convection and radiation. Principles involved in the different methods of cooking, baking, boiling, braising, cooking in a microwave oven, frying, grilling, poaching, pressure cooking, roasting, simmering, steaming, stewing, use of a slow cooker. Reasons for cooking food, Sensory properties of food (flavour, taste, texture), Effect of dry and moist heat on proteins, fats and oils, sugars and starches, and vitamins to include: caramelisation, coagulation dextrinization, enzymic and non-enzymic browning, gelatinisation, rancidity, smoking point, Preparation and cooking of food to preserve nutritive value, Economical use of food, equipment, fuel and labour.	6
5	**Convenience foods and Basic proportions:** Foods partly or totally prepared by a food manufacturer – dehydrated, tinned, frozen, ready-to-eat, Intelligent use of these foods, Advantages and disadvantages, Food additives – types and function, Packaging – types, materials used, Labelling – information found on labels, Importance of maintaining proportions, maintaining proportions for : Bakery products, melting, rubbing-in and whisking methods, Pastries – shortcrust, flaky and rough puff, Sauces – pouring and coating, roux and blended methods, Batters – thin (pouring) and coating, Sweet and savoury yeast products	5
6	**Food preservation & Kitchen safety and first aid**: Food preservation & Kitchen safety and first aid: Reasons for preserving food, Methods of preservation and an understanding of the principles involved: heating – canning, bottling; removal of moisture – dehydrating; reduction in temperature – freezing; chemical preservation – sugar, salt, vinegar; modified atmosphere packaging; irradiation; Awareness of potential danger areas in the kitchen. Safety precautions. First aid for burns and scalds, cuts, electric shock, fainting, shock.	5

Assessment:

Internal Assessment: 40 marks

End Semester Examination: 60 Marks

Books/References:

1. Fundamentals of Food and Nutrition by Tejmeet Rekhi, Heena Yadav
2. Food Process Engineering And Technology by Akash Pare, B L Mandhyan

Course Code	Course Name	Credits
ME 491	**Major Project II**	**4**

Course Objectives:

1. To acquaint with the process of undertaking literature survey or market survey or feasibility study /industrial visit and identifying the problem
2. To familiarize the process of problem solving in a group
3. To acquaint with the process of applying basic engineering fundamental in the domain of practical applications
4. To inculcate the process of research

Course Outcomes: Learner will be able to

1. Do literature survey based on market or feasibility study/industrial visit and identify the problem.
2. Apply basic engineering fundamentals in the domain of practical applications
3. Cultivate the habit of working in a team
4. Attempt a problem solution in a right approach.
5. Correlate the theoretical and experimental/simulations results and draw the proper inferences
6. Prepare project report as per guidelines and with proper references/citations.
7. Exhibit and explain project ideas/models at various platforms

Guidelines for Project

- Students should do literature survey/Market survey/ feasibility study/visit industry/analyze current trends and identify the problem for Project and finalize the project title in consultation with Guide/Supervisor.
- Students should use multiple literatures and understand the problem.
- Students should attempt a solution to the problem by experimental/simulation methods.
- The solution to be validated with proper justification and report to be compiled in standard format.

Assessment:

Project II should be assessed based on following points

1. Quality of problem selected
2. Clarity of Problem definition and Feasibility of problem solution
3. Relevance to the specialization / Industrial trends
4. Clarity of objectives and scope
5. Quality of work attempted
6. Validation of results using numerical/experimental & simulation techniques
7. Quality of Written, Oral Presentation & Question answer session.

Project Report has to be prepared strictly as per report writing guidelines.

Project II should be assessed through a presentation by the student project group to a panel of Internal and External Examiner approved by the BoS of the Department.

Course Code	Course Name	Credits
ME 417	**Personal Financial Management**	**2**

C**ourse Objectives**: The course is aimed

1. To introduce the basic concepts of finance and their practical application.
2. To demonstrate the process of drafting a financial budget.
3. To explain investment avenues and planning of personal finance.
4. To develop portfolio strategies for individual and institutional investor
5. To discuss various components of insurance and tax management.
6. To introduce financial frauds, measures to avoid frauds and resources of frauds.

Course Outcomes: On successful completion of course learner/student will be able:

1. To know the basic concepts of finance and interpret current business positions by reading books of accounts.
2. To analyze investment avenues and plan personal finance to develop portfolio strategies for individuals.
3. To Develop skills to interpret current market position.
4. To Create analytical approach for financial decisions.
5. To learn and understand Tax and Insurance management.
6. To identify financial frauds and understand the level of financial aspects.

Detailed Theory Syllabus:

Module No	Module	Detailed Contents of Module	Hrs.
1	Introduction to Personal Financial Planning	Financial Planning Process: Goal, Vision and mission , Components of Personal Financial Plan, Advantages and developing personal financial plan	3
2	Financial Budget	Meaning and Process of Drafting Financial Budget,Components of Financial Budget,Drafting Financial Budget	3
3	Investment Management	Meaning of Investment,Concept of Risk and Return and Time Value of Money,Investment Avenues,Portfolio Creation and Management	6
4	Insurance and Spending Management	Components of Insurance: Life Insurance, Health Insurance, Property Insurance, Spending Management	3
5	Tax Management	Introduction to Tax Regime and Tax Returns,Introduction to Income Tax and its impact on Incomes ,Tax on property: Revenue and Capital Incomes,Tax Management, Tax Saving, Tax Avoidance	3

6	Financial Frauds	Meaning and Types of Fraud,Investment Frauds, Online Payment Frauds, Identity Theft, Mass Marketing Fraud ,Measures to avoid frauds,Recourse from frauds,Cases of Frauds	6

Theory Assessment:
Internal Assessment: 20 marks
Consisting of Two compulsory internal assessments 20 Marks each. The final marks will be the average score of both the assessments.
End Semester Examination: 40 Marks
Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books and References:

1. Financial Management: I M Pandey, Vikas Publishing House.
2. Financial Management: M.Y. Khan, P.K. Jain, Tata McGraw Hill.
3. Financial Management: Prassana Chandra, Prentice Hall.
4. Investment Analysis & Portfolio Management- Prasanna Chandra, Tata McGrawHill
5. Wealth Management- Dun & Bradstreet, Tata McGrawHill
6. Wealth Management- S. K. Bagachi, Jaico publishing house

Course Code	Course Name	Credits
ME 418	**Instrumentation in Thermal Systems**	**3**

Course Objectives:

1. To learn different techniques of instrumentation involved in thermal systems
2. To learn static and dynamic characteristics of instruments.
3. To learn different control systems.
4. To learn different kind of errors involved in experimentation and their analysis

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

1. Apply different instrumentation techniques to different thermal systems.
2. Understand the basic concept of engineering experimentation
3. Understand different control systems.
4. Understands different types of errors in instruments.

Theory syllabus:

Module	Detail Content	Hrs.
1.	**Introduction** Fundamental elements of a measuring instrument, static and dynamic characteristics of instruments, experimental error analysis, systematic and random errors, statistical analysis, uncertainty, reliability of instruments, Variable resistance transducers, capacitive transducers, piezoelectric transducers, photoconductive transducers, photovoltaic cells, ionization transducers, Hall effect transducers.	6
2.	**Dynamic Measurement** Dynamic response considerations, Bridgman gauge, McLeod gauge, Pirani thermal conductivity gauge, Knudsen gauge, Alphatron.	6
3.	**Flow And Temperature Measurement** Flow measurement by drag effects; hot-wire anemometers, magnetic flow meters, flow visualization methods, interferometer, Laser Doppler anemometer. Temperature measurement by mechanical effect, temperature measurement by radiation, transient response of thermal systems, thermocouple compensation, temperature measurements in high- speed flow.	7
4.	**Thermal Conductivity Measurement** Thermal conductivity measurement of solids, liquids, and gases, measurement of gas diffusion, convection heat transfer measurements, humidity measurements, heat-flux meters. Detection of thermal radiation, measurement of emissivity, reflectivity and transmissivity, solar radiation measurement	7
5.	**Control Systems** Review of open and closed loop control systems and servo mechanisms, Transfer functions of Mechanical Systems, input and output systems. Basics of P, PI, PID controllers, pneumatic and hydraulic controllers, electronic controllers, Laser Doppler Anemometer, Hot wire Anemometer	6
6.	**Errors In Instrumentation** Analysis of experimental data and determination of overall uncertainties in experimental investigation, uncertainties in measurement of	6

	measurable parameters like pressure, temperature, flow etc. under various conditions	

Laboratory Syllabus:

List of Experiments:

1. To carry out Calibration of thermocouple for temperature measurement.
2. To carry out calibration of pressure measuring devices: U-tube manometer, pressure gauge.
3. To carry out calibration of flow measuring devices: orifice meter and rotameter.
4. To study various electronics controllers used in thermal measurements.
5. Study and calibration of a rotameter for flow measurement
6. Study and calibration of LVDT transducer for displacement measurement.

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/ Assignments / Quiz/ Case studies/ Seminar presentation of 40 Marks

End Semester Examination: 60 marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the syllabus.

Books/References:-

1. Holman, J.P., “Experimental methods for engineers”, Tata McGraw-Hill, 7th Edition, 2007.
2. Prebrashensky V., “Measurement and Instrumentation in Heat Engineering”, Vol.1, MIR Publishers, 1980.
3. Raman, C.S. Sharma, G.R., Mani, V.S.V., “Instrumentation Devices and Systems”, 2nd Edition, Tata McGraw-Hill., 2001.
4. Morris. A.S, “Principles of Measurements and Instrumentation”, 3rd Edition, Butterworth-Heinemann, 2001
5. Prebrashensky V, Volume I &II “Measurements and Instrumentation in Heat Engineering”, MIR Publishers
6. Buck & Beckwith, “Mechanical Measurements”, Pearson Education Asia
7. E R G Eckert and Goldsteen, “Measurement Techniques in Heat Transfer”, Technovision
8. R K Jain, “Mechanical and Industrial Measurements”, Khanna Publishers

Course Code	Course Name	Credits
ME 419	**Synthesis of Mechanisms**	**3**

Prerequisites:

1. Mechanics
2. Vector theory
3. Linear Algebra
4. Kinematics of Machinery
5. Basic computer programming and graphing using any language/software.
6. 3D Modeling and Kinematic Analysis using software such as SolidWorks etc.
7. Additive Manufacturing / 3D Printing (Rapid Prototyping) fundamentals and practice.

Course Objectives:

1. Revise the basic fundamentals of kinematics of mechanisms.
2. Understand graphical and analytical techniques commonly used in the synthesis of mechanisms.
3. Simulate synthesis of mechanisms (analytical techniques) using computer programs.
4. Create a scaled/full-sized rapid prototype model (3D printing) to physically realize one of the synthesized mechanisms.

Course Outcomes: Upon successful completion of this course, learner will be able to

1. Understand the basics of kinematics and mechanisms.
2. Understand the three general phases of kinematic synthesis.
3. Apply the graphical and analytical techniques commonly used in the synthesis of mechanisms.
4. Formulate and solve problems of analysis and synthesis of mechanisms using modern IT tools.
5. Synthesize mechanisms with 3 and 4 accuracy points using geometric and algebraic methods.

Theory Syllabus:

Module	Detail Content	Hrs.
1.	**Basics of Mechanisms:** Rigid body, Kinematic pairs, Lower pairs connections, Higher pair connections, Kinematic chain, Mechanism, Four bar mechanism, Slider crank mechanism, Transmission, deviation and pressure angles, Equivalent mechanisms, review of analytical and graphical methods of velocity and acceleration analysis of the links of mechanisms.	4
2.	**Type Synthesis, Number Synthesis, Dimensional Synthesis**: Type synthesis, Number synthesis, Dimensional synthesis, Accuracy points, Spacing of accuracy points, Chebyshev polynomials.	6
3.	**Synthesis of Mechanisms**: Introduction, Synthesis, Function, Path and Motion Generation, Limiting Conditions, Graphical and Analytical Synthesis of Four bar and Slider Crank Mechanisms.	6
4.	**Linkage Synthesis with Three Accuracy Points (Geometric Methods):** Concept of poles, relative poles, pole triangle of four-bar and slider crank mechanism. Application in position generation, function generation problems.	7

5.	**Linkage Synthesis with Four Accuracy Points (Geometric Methods):** Concept of opposite pole quadrilateral, center point curve, circle point curve, Application in position generation problems.	6
6.	**Linkage Synthesis with Three Accuracy Points:** (Algebraic Method). Freudenstein displacement equation of four bar linkage for three accuracy points, Crank-follower linkage synthesis, angular velocities and acceleration. **Linkage Synthesis with Three Accuracy Points:** Complex Number Method.	10

Laboratory Syllabus:

Sr. No.	Details	Hrs.
1.	1 Problem on Graphical and Analytical Synthesis of Four bar Mechanism	2
2.	1 Problem on Graphical and Analytical Synthesis of Slider Crank Mechanism	2
3.	1 Problem on Linkage Synthesis with 3 Accuracy Points (Geometric Method)	2
4.	1 Problem on Linkage Synthesis with 4 Accuracy Points (Geometric Method)	2
5.	1 Problem on Linkage Synthesis with 3 Accuracy Points (Analytical Method - Freudenstein Displacement Equation)	2
6.	1 Problem on Linkage Synthesis with 3 Accuracy Points (Analytical Method - Complex Number Method)	2
7.	Write computer programs using any programming software of your choice, on at least 4 of the above (Sr. No. 1-6), and generate the output, and validate the results obtained. The validated program can hence be used for further simulation of synthesis of mechanisms, to generate required types of output link motions.	8
8.	3D modeling and kinematic simulation of any one of the synthesized mechanisms.	2
9.	Rapid prototyping (3D printing) of the mechanism synthesized (as in Sr.No. 8 above) in scaled/full size.	4

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/ Assignments / Quiz/ Case studies/ Seminar presentation of 40 Marks

End Semester Examination: 60 marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the syllabus.

Books/References:

1. Theory of Mechanisms & Machines by Amitabha Ghosh, Asok Kumar Mallik, Affiliated East-West Press Pvt Ltd.
2. Mechanism and Machine Theory by J.S.Rao and R.V.Dukkipati, New Age International.
3. Theory of Machines and Mechanisms (India Edition) by John J. Uicker Jr., Gordon R. Pennock and Joseph E. Shigley, Oxford University Press.
4. R.L. Norton, Kinematics and Dynamics of Machinery, First Edition in SI, Tata McGraw Hill Publishing Company Ltd, New Delhi.

5. Kinematics and Dynamics of plane mechanisms, Jeremy Hirschhorn, McGraw-Hill, 1962.
6. Design of machinery, Robert L Norton third edition, McGraw-Hill, 2004.
7. Kinematic Linkage Design, Allen S.Hall Jr., Prentice-Hall of India, 1964.
8. Kinematics and Dynamics of Machinery, Charles E Wilson, Pearson, 3rd Edition.
9. 3D Printing: Top 5 Methods + Secrets From The Trade, by Ben Franta.
10. Additive Manufacturing: 3D Printing For Prototyping and Manufacturing, by Andreas Gebhardt & Jan-Steffen Heotter, Hanser Gardner Publications.
11. 3D Printing for Model Engineers: A Practical Guide, by Neil M. Wyatt, The Crowood Press.

Course Code	Course Name	Credits
ME 420	**Microprocessor and Controllers**	**3**

Course Objectives:

1. To understand the basic concepts of microcomputer systems.
2. To understand the architecture of 16-bit Microprocessor 8086.
3. To understand the architecture of 8-bit Microcontroller 8051.
4. To write programs for 8051 Microcontroller.
5. To understand peripheral devices and their interfacing to microcontrollers.

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

1. Understand the basic concepts of microcomputer systems.
2. Understand the detailed architecture of 8086 microprocessor and 8051 microcontroller.
3. Study the in-depth working of the 8051 microcontroller and their Instruction set.
4. Interface various peripheral devices to 8051 microcontroller.
5. Write programs for 8051 microcontroller.

Module	Detail Content		Hrs.
1.	**Introduction to Microcomputer System**		06
	1.1	Block diagram of microprocessor based system: CPU, I/O Devices, Clock, Memory, Concept of Address, Data and Control Bus and Tristate logic.	
	1.2	Concepts of Program counter register, Reset, Stack and stack pointer , Subroutine and Interrupts.	
	1.3	Concept of RISC & CISC Architecture	
	1.4	Concept of Harvard & Von Neumann Architecture	
2.	**Architecture of 8086 Microprocessor**		08
	2.1	Major features of 8086 processor,	
	2.2	8086 CPU Architecture and the pipelined operation,	
	2.3	Programmer's Model & Memory Segmentation.	
	2.4	8086 pin description in detail.	
3.	**8051 Microcontroller Architecture**		06
	3.1	Comparison between Microprocessor and Microcontroller	
	3.2	Features, architecture and pin configurations	
	3.3	Memory organization	
4.	**8051 Microcontroller assembly language programming**		08
	4.1	Addressing modes of 8051.	
	4.1	Assembler directives of 8051.	
	4.2	Instruction Set: Data transfer, Arithmetic, Logical, Branching.	
	4.4	Programs related to: arithmetic, logical, delay, input, output, timer, counters, port, serial communication, and interrupts.	
5.	**8051 Internal Hardware & Programming**		10
	5.1	I/O port structure and programming.	
	5.2	Interrupts and programming.	
	5.3	Timer/Counter and programming.	
	5.4	Serial port and programming.	

6.	**8051 Interfacing & Applications**		08
	6.1	Display interfacing: 7-segment LED display, 16x2 generic alphanumeric LCD display.	
	6.2	Analog devices interfacing: 8-bit ADC/DAC	
	6.3	Motor interfacing: Relay, dc motor, stepper motor and servo motor.	

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/ Assignments / Quiz/ Case studies/ Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Text Books:

1. Microprocessor and Interfacing: By Douglas Hall (TMH Publication)
2. M. A. Mazidi, J. G. Mazidi and R. D. Mckinlay, "The 8051 Microcontroller & Embedded systems", Pearson Publications, Second Edition 2006.
3. C. Kenneth J. Ayala and D. V. Gadre, "The 8051 Microcontroller & Embedded system using assembly & 'C' ", Cengage Learning, Edition 2010.

Reference Books:

1. 8086 Microprocessor Programming and Interfacing the PC: By Kenneth Ayala (West Publication)
2. Microcomputer Systems: 8086/8088 family Architecture, Programming and Design: By Liu & Gibson (PHI Publication).
3. Satish Shah, "The 8051 Microcontrollers", Oxford publication first edition 2010.
4. "MCS@51 Microcontroller, Family users Manual" Intel

Course Code	Course Name	Credits
ME 421	**Characterization Techniques**	**3**

Prerequisites:

1. Knowledge of Engineering Materials, Metallurgy and basic science skills

Course Objectives:

1. To introduce the students to the principles of optical and electron microscopy
2. To familiarize students with material characterization techniques and its importance.
3. To get exposure with various techniques of characterization and interpretation of results including standards etc

Course Outcomes: Upon successful completion of this course, learner will be able to:

1. Explain importance & Classification of Characterization Techniques.
2. Describe use of Vacuum systems in Material Characterization techniques.
3. Explain working of Thermal Analysis techniques.
4. Describe the principal and methods of different optical microscopy techniques for observation of Microstructure.
5. Describe the principal and methods of different electron and atom microscopy techniques.
6. Explain Chemical & Elemental Analysis for a given engineering application.
7. Explain identification techniques of crystal structure, lattice parameter & crystallite size of different materials using X-ray diffraction.
8. Demonstrate the ability to use the core concepts of engineering application for Material characterization techniques

Module	Detail Content	Hrs.
1.	Importance and need of Material characterization, Classification of techniques for characterization and available techniques	2
2.	**Electron microscopy:** Electron beam. Principle, Construction and Working of TEM, SEM, STEM, with their merits, limitations and applications.	3
3.	**Atomic Microscopy and Surface Analysis**- Field Ion Microscope, Working of AFM and STM with their merits, limitations and applications.	3
4.	**Spectroscopic Techniques for chemical analysis:**, UV-Visual(UV-VIS), IR, FTIR, EDS & WDS, X-ray Fluoroscopy (XRF), Atomic absorption spectrometer(AAS), Atomic Emission spectroscopy (AES). Secondary Ion mass spectrometry (SIMS), Rutherford backscattering spectroscopy (RBS)	6
5.	**Diffraction method**: Fundamental crystallography, Bragg's Law, X-ray diffraction methods,Electron diffraction, determination of crystal structure, lattice parameter, crystallite size, merits and demerits Generation and detection of X-rays	5
6.	**Thermal Analysis**- Techniques, Principle, Working and application of DTA, TGA, TMA and DSC.	5

Laboratory Syllabus:

Module	Details	Hrs.
1.	To Study Differential scanning calorimetry technique.	1
2.	To study Thermogravimetric Analysis for oxidation rate measurement.	1
3.	To analyze the microstructure and measure the grain size using an image analyzer.	1
4.	To study the diffraction pattern using powder diffraction pattern and to predict the lattice parameter and structure of crystal.	1
5.	Analyzing AFM SEM and STM data	1
6.	Collection and Study of various samples of coated & surface treated-materials, new alloys etc.	1

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Li, Lin, Ashok Kumar Materials Characterization Techniques Sam Zhang; CRC Press, (2008).
2. Cullity, B.D., and Stock, R.S., "Elements of X-Ray Diffraction", Prentice-Hall, (2001)
3. Tyagi, A.K., Roy, Mainak, Kulshreshtha, S.K., and Banerjee, S., Advanced Techniques for Materials Characterization, Materials Science Foundations (monograph series), Volumes 49 – 51, (2009).
4. Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films. Editors C. Richard Brundle, Charles A. Evans, Jr., Shaun Wilson, Butterworth-Heinemann, Boston, USA
5. An Introduction to Materials Characterization by P. R. Khangaonkar, Penram International Publishing (India) Pvt. Ltd.
6. D. A. Skoog, F. James Leary and T. A. Nieman, Principles of Instrumental Analysis, Fifth Edition, Saunders Publishing Co., 1998
7. Y. Leng, "Materials Characterization: Introduction to Microscopic and Spectroscopic Methods", Second Edition, Wiely-VCH, 2013
8. K.P. Menard, "Dynamic Mechanical Analysis; A Practical Introduction", CRC Press, Boca Raton, 1999. 4. S. Zhang, L. Li and A. Kumar, "Materials Characterization Techniques", CRC Press, Boca Raton, 2008
9. Whan R E (Ed), ASM Handbook, Volume 10, Materials Characterisation, Ninth Edition, ASM international, USA, 1986.

Course Code	Course Name	Credits
ME 422	**Processing and Testing of Materials**	**3**

Prerequisites:

1. Engg Chemistry
2. Materials and Metallurgy

Course Objectives:

1. To make students aware of the shaping technologies for different classes of materials
2. To understand the mechanical testing requirements of materials
3. To make the students know the importance of various tests and interpretation of the results

Course Outcomes: Upon successful completion of this course, learner will be able to

1. To distinguish between the deforming abilities of metals, ceramics,composites and polymers
2. Differentiate between processing techniques and make good use of them
3. Test materials as per the specified standards having understanding of the requirements
4. Understand new techniques for testing of materials
5. Develop objects by processing of polymers/composites/ceramics
6. Synthesis nanomaterials and do their testing

Theory Syllabus:

Module	Detail Content	Hrs.
1.	Conventional Metal Forming Processes-Hot and Cold working operations-Forging,Casting, Rolling, Extrusion	4
2.	Processing of Polymers -Compression moulding, Injection moulding,rotational moulding,blow moulding,Recycling of polymer-recent trends	5
3.	Processing of Ceramics and Composites-powder metallurgy route, tape casting, slurry casting, layup method,Resin transfer moulding, Vacuum bagging ,pultrusion, tube rolling,Vacuum assisted Resin transfer moulding	7
4.	Nanoindentation technique to test and measure material properties,thickness measurements using interference,contact angles measurements from high resolution images	4
5.	Testing of Metals-ASTM standards for Tension, Compression, shear, Flexure testing.Hardness tests, impact tests, torsional, fatigue test,Testing procedures for ceramics and composites - ASTMD standard	7
6.	Nanomaterials synthesis and testing-sol gel process, inert gas condensation,plasma vapor deposition and chemical vapor deposition	6

Lab Syllabus:

Module	Details	Hrs.
1.	Processing of Polymers -Compression moulding/ Injection moulding/casting	2
2.	Processing of Ceramics and its testing	2
3.	Processing of Composites and its testing	2
4.	Non Destructive Testing of materials	2
5.	Solgel synthesis of nanomaterial	4
6.	Laser texturing of metals	2

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Advanced Materials -Processing and Testing Technology (https://main.scientific.net/book/advanced-materials-processing-and-testing-technology/978-3-0357-3623-6/ebook)
2. Composite Materials Design and Testing, Stephen W. Tsai, Jose Daniel D. Melo
3. Advanced Materials Processing and Manufacturing,Yogesh Jaluria Springer)|2018|
4. Materials: Engineering, Science, Processing and Design, MF Ashby
5. Testing of Materials, John Vernon,Springer

Course Code	Course Name	Credits
ME 423	**Tool Engineering**	**3**

Course Objectives:

1. To familiarize with the sheet metal working techniques for design of press tools.
2. To acquaint with the various press working operations for mass production of sheet metal components
3. To develop capability to design jigs and fixtures.
4. To familiarize with the capabilities of designing a simple productive and cost effective jigs and fixtures
5. To understand the design aspects of moulding dies and cutting tools.

Course Outcome: Learner will be able to.

1. Understand the basic concepts and principles of press tools.
2. Design the press tools for the various sheet metal operations
3. Design and develop simple productive and cost effective jigs and fixtures
4. Understand the moulding process and be able to design injection moulds for plastic components.
5. Design single and multipoint cutting tools

Module	Detail Content	Hrs.
1	**Sheet Metal Processing:** Basic Types of Press Working Operations and Equipment: General classification and components of Press Tools. Dies and Punches: Elements of Dies and Punch set. Types of dies – simple, compound, combination and progressive dies and punches of various press working operations such as punching, blanking, drawing, bending, forming, coining, Fine Blanking Burr free blanking etc. Design of Blanking die, Progressive die, Calculations of clearances, center of pressure, different forces, press tonnage, strip layout, sheet utilization ratio, methods of reducing forces.	08
2	**Drawing and Bending dies:** Design of Shallow & Deep drawing die, Calculation of blank size, number of draws, drawing force, press capacity, ironing & ironing force, Types of Bending dies, various methods used to overcome spring back, Calculation of total bend length and calculation of various forces.	06
3	**Design of Jigs and Fixtures**: Need for jigs and fixtures, elements of Jigs and fixtures, principles of location, design of locating elements, locating pins support pins spring back, vee blocks, etc. principles of clamping simple hand operated clamps, like screw clamp, lever clamps and other types of clamps. Drill bushes-their types and applications indexing devices, auxiliary elements. Design of drill jigs like plate, leaf solid and box types for drilling combined with reaming, spot facing etc. Design of milling fixtures such as plain, string, gang and indexing types. Design of turning fixtures.	10
4	**Plastics Injection Mold Design:** Introduction of compression and transfer moulding process, Study of Injection and blow moulding process; - machine specifications, moulding cycle. Mould Design – Design of simple two plate injection moulds. Design of simple blow moulds for articles like bottles, cans, etc. Study of types of ejectors, gates, runner's, Study of cooling systems and heat transfer	08

	consideration. Calculation of no. of cavities, Mould opening force, ejection force etc. Basic concepts of mold standardization and innovative mold components.	
5	**Design of single point cutting tools:** Different systems of tool nomenclature like MRS, ORS and NRS. Interrelationship among different systems of nomenclature for tool angles. Constructional features of solid tool, tipped tools, mechanically held regrind able insert type tools and throw away tip type tools. Design of shanks, cutting tip and chip breakers for HSS and Carbide tools. ISO coding system for tipped tools and tool holders.	06
6	**Design of Multi point cutting tools:** Various types such as flat form tool, tangential form tool, circular form tool, constructional details and fields of application. Profile design of flat and circular form tools. Broach nomenclature, design steps for circular pull type, key way and spline broaches. Design of face and peripheral milling cutters.	06

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/ Assignments / Quiz/ Case studies/ Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Reference Books:

1. Cyrll Donaldson, George H.LeCain, V.C. Goold, “Tool Design”, Tata McGraw Hill Publishing Company Ltd., 2000, 3rdEdition.
2. *Jigs and Fixtures,* P H Joshi, McGraw Hill.
3. *Production Technology,* R C Patel & C G Gupte.
4. *Production Technology*, HMT, Tata Mc Graw Hill.
5. Vukota Boljanovic, “Sheet Metal Forming Processes And Die Design”, Industrial Press, New York, 2004.
6. *Introduction to Jigs and Tool design*, HA Kempster, Butterworth Heinemann Ltd.
7. *Manufacturing Process*, R A Lindberg, PHI India.
8. *Fundamentals of modern Manufacturing*, Fourth Edition, Mikell P Groover, John Wiley & Sons.
9. *Metals handbook*, Forming and Forging, Vol. 14, ASM.

Course Code	Course Name	Credits
ME 424	**Additive Manufacturing**	**3**

Course Objectives:

1. To acquaint students with the fundamentals of Additive Manufacturing Technologies for various applications
2. To understand the process of conversion of part file into STL format.
3. To acquaint students with various Additive manufacturing processes of liquid based, powder based and solid based techniques.
4. To familiarize with the manufacturing procedure of a prototype using FDM technique.
5. To introduce the students to the mathematical models for AM

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

1. Illustrate the fundamentals of Additive Manufacturing Technologies for various applications.
2. Apply the methodology to produce the parts using SLA and SGC technologies
3. Select the appropriate material for AM processes
4. Understand the methodology to manufacture the products using LOM and FDM technologies and study their applications, advantages and case studies
5. Understand the methodology to manufacture the products using SLS and 3D Printing technologies and study their applications, advantages and case studies
6. Understand the modelling of AM processes

Module	Detail Content	Hrs.
1.	Introduction to prototyping fundamentals, historical development, advantages of AMT, AM process chain, 3D modelling, Data Conversion, and transmission, Checking and preparing, Building, Post processing, RP data formats, classification of AMT process, applications in various fields	06
2.	Materials used in AM, use of multiple materials, multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, structure property relationship, Grain structure and microstructure	06
3.	Liquid based systems: Stereo lithography apparatus (SLA): Models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. Solid ground curing (SGC): Models and specifications, process, working, principle, applications, advantages and disadvantages, case studies.	08
4.	Solid based systems: Laminated object manufacturing(LOM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies. Fused Deposition Modeling (FDM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies, practical demonstration	08
5.	Powder Based Systems: Selective laser sintering (SLS): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Three dimensional printing (3DP): Models and specification, process, working principle, applications, advantages and disadvantages, case studies.	08

6.	Mathematical models for AM, Selection of AM technologies using decision methods, AM process plan, Monitoring and control of defects, transformation.	06

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/ Assignments / Quiz/ Case studies/ Seminar presentation of 40 Marks

End Semester Examination: 60 marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the syllabus.

Books/References:-

1. Ian Gibson, David W. Rosen and Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing, Springer, 2010.
2. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: Principles and applications, 3rd Edition, World Scientific, 2010.
3. D.T. Pham and S.S. Dimov, “Rapid Manufacturing”, Springer, 2001
4. Terry Wohlers, “ Wholers Report 2000”, Wohlers Associates, 2000
5. Paul F. Jacobs, “ Rapid Prototyping and Manufacturing”–, ASME Press, 1996
6. Ian Gibson, Davin Rosen, Brent Stucker “Additive Manufacturing Technologies, Springer, 2nd Ed, 2014.
7. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.
8. J.D. Majumdar and I. Manna, Laser-assisted fabrication of materials, Springer Series in Material Science, e-ISBN: 978-3-642- 28359-8.
9. L. Lu, J. Fuh and Y.-S. Wong, Laser-induced materials and processes for rapid prototyping, Kluwer Academic Press, 2001.
10. Zhiqiang Fan and Frank Liou, Numerical modeling of the additive manufacturing (AM)
processes of titanium alloy, lnTech, 2012.

Course Code	Course Name	Credits
ME 425	**Energy Audit and Management**	**3**

Course Objectives:

1. To impart basic knowledge to the students about current energy scenario, energy conservation, audit and management.
2. To inculcate among the students systematic knowledge and skill about assessing the energy efficiency, energy auditing and energy management.
3. To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management
4. To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

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

1. To identify and describe the present state of energy security and its importance.
2. To identify and describe the basic principles and methodologies adopted in energy audit of an utility
3. To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.
4. To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities.
5. To analyze the data collected during performance evaluation and recommend energy saving measures

Module	Detail Content	Hrs.
1.	**Energy Scenario**: Energy needs of growing economy, Long term energy scenario, Energy pricing, Energy sector reforms, Energy and environment: Air pollution, Climate change, Energy security, Energy conservation and its importance, Energy strategy for the future, Energy conservation Act-2001 and its features.	04
2.	**Energy Management and Audit:** Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments. **Material and Energy balance:** Facility as an energy system, Methods for preparing process flow, Material and energy balance diagrams. **Financial Management:** Investment-need, Appraisal and criteria, Financial analysis techniques- Simple payback period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis, Financing options, Energy performance contracts and role of ESCOs.	10
3.	**Energy Management and Energy Conservation in Electrical System:** Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipments and appliances, star ratings. Energy efficiency measures in lighting system, Lighting control: Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.	10

4.	**Energy Management and Energy Conservation in Thermal Systems:** Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.	10
5.	**Energy Performance Assessment:** On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis.	3
6.	**Energy conservation in Buildings**: Energy Conservation Building Codes (ECBC): Green Build Building, LEED rating, Application of Non-Conventional and Renewable Energy Sources	3

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/ Assignments / Quiz/ Case studies/ Seminar presentation of 40 Marks

End Semester Examination: 60 marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the syllabus

Books/References:

1. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy Research Institute (TERI).
5. Energy Management Principles, C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press

Course Code	Course Name	Credits
ME 426	**Solar Energy Engineering**	**3**

Course Objectives:

1. To learn the basics of the solar energy spectrum.
2. To learn about types of Solar cells and their ratings.
3. To learn the solar thermal system; an energy efficient approach.
4. To learn about solar power plants.

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

1. Get knowledge of the competing demands and requirements of the various solar operated electrical power networks.
2. Understand how renewable generation and distributed storage interacts with and is integrated into the power network.
3. Solar energy measurement techniques.
4. Need of solar cooling system to reduce dependency on mains grid.

Theory Syllabus:

Module	Detail Content	Hrs.
1.	Introduction to solar energy , World and Indian energy scenario, Types of energy resources and its importance, need of energy conservation, Solar spectrum, Solar constant , Solar Energy & Environment , green house effect, Physics of the Sun - Energy balance of the earth, Energy scenario and sustainable development through solar energy.	06
2.	Solar energy measurement:- Estimation of solar energy on earth's surface, characteristics of solar radiation, Sun –earth geometry and its effect on solar energy reaching on earth's surface, Depletion of solar radiation - Absorption, scattering, Solar day length – Sun path diagram – Shadow determination. Estimation of Sunshine hours, Calculation of total solar radiation on horizontal and tilted surfaces.	08
3.	**Solar Photovoltaic system :** Solar Cell, PV Module and Solar arrays:- 1. Introduction and types of solar cell 1.1. Parameters of solar cell 2. Factors affecting electricity generation by solar cell 2.1. Effect of conversion efficiency 2.2. Change in amount of input light 2.3. Change in solar cell area 2.4. Change in angle of light falling on PV Panel 2.5. Change in solar cell operating temperature 2.6. I-V characteristics of solar cell 3. PV Module and its ratings 3.1. PV Module parameters 3.2. Measuring PV Module parameters 4. Types of PV Module connections 4.1. Series connection of PV Modules 4.2. Parallel connection of PV Modules 4.3. Mixed Combination of connections	08
4.	**Solar thermal system:** Flat Plate Collector, Hot Air Collector, Evacuated Tube Collector, Parabolic , Compound Parabolic and Fresnel Solar Concentrators, Central Receiver System, Thermal Analysis of Solar Collectors Performance of Solar Collectors, Solar Water Heating	08

	Systems(Active & Passive), Solar Space Heating & Cooling Systems, Solar Industrial Process Heating Systems, Solar Dryers & Desalination Systems, Solar Thermal Power Systems.	
5.	**Electrical energy conversion from solar energy:** Solar Power plant, Estimating power and energy demand, site selection, land requirements, choice of modules, economic comparison, balance of systems, off grid systems, grid interface, Supporting structures, mounting and installation, junction boxes, battery storage, power condition unit, selection of cables and balance of systems, economic analysis.	08
6.	**Solar Cooling:** Potential and scope of solar cooling. Types of solar cooling systems, solar collectors and storage systems for solar refrigeration and air conditioning. Solar operation of vapour absorption and compression refrigeration cycles and their assessment. Solar dessicant cooling system. Open cycle absorption/desorption solar cooling alternatives. Advanced solar cooling systems. Refrigerant storage for solar absorption cooling systems. Solar thermoelectric refrigeration and air conditioning. Economics of solar cooling	10

Laboratory Syllabus

Sr. No.	Details	Hrs.
1	Investigating the thermal performance of solar collector.	1
2	Study of solar hot water systems (FPC and ETC)	1
3	Characteristics of SPV system.	1
4	Determination of efficiency of DC/AC inverter.	1
5	Study of Lead Acid Battery as a energy storage.	1
6	Solar PV Simulator.	1
7	Developing Solar PV Grid-tied Training kit.	1
8	Developing Solar Thermal Training kit.	1
9	Developing Solar Concentrator Training kit.	1
10	Determination of I-V& P-V Characteristics of a Solar PV Panel.	1
11	Power Flow calculation of Stand-Alone PV System of DC Load with Battery.	1
12	To study Charging and Discharging Characteristics of Battery	1
13	Industrial Visit	1

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Foster .R, Ghassemi M., Cota A., “Solar Energy”, CRC Press, 2010.
2. Duffie .J.A, Beckman W.A. “Solar Engineering of Thermal Processes”, 3rd ed., Wiley, 2006.
3. De Vos .A, “Thermodynamics of Solar Energy Conversion”, Wiley-VCH, 2008.

4. Garg .H.P, Prakash .J, “Solar Energy Fundamentals and Applications”, Tata McGraw-Hill, 2005.
5. Kalogirou .S, “Solar Energy Engineering”, Processes and Systems, Elsevier, 2009.
6. Petela .R, “Engineering Thermodynamics of Thermal Radiation for Solar Power”, McGraw-Hill Co., 2010.
7. Yogi Goswami .D, Frank Kreith, Jan F. Kreider, “Principles of Solar Engineering”, Second Edition, Taylor & Francis, 2003.
8. Andrews .J, Jelley .N, “Energy Science”, Oxford University Press, 2010.
9. Renewable Energy: Power for a Sustainable Future, Edited by Godfrey Boyle, 3rd Edition, Oxford University Press
10. Solar Energy: Principles of Thermal Collection and Storage by SP Sukhatme and J K Nayak, TMH
11. Solar Energy: Fundamentals and Applications by H.P. Garg& Jai Prakash, Tata McGraw Hill.
12. Solar Photovoltaic’s: Fundamentals, Technologies and Applications, C S Solanki, 2ndEdition, PHI Learning
13. Renewable Energy Technologies: A Practical Guide For Beginners, PHI Learning
14. Solar Energy: The Physics and Engineering of Photovoltaic Conversion, Technologies by Arno Smets, Klaus Jäger Olindo Isabella René van Swaaij , UIT Cambridge LTD
15. Solar Photovoltaic Technology And Systems - A Manual For Technicians,Trainers And Engineers, PHI Learning

Course Code	Course Name	Credits
ME 427	**Hybrid & Electric Vehicles**	**3**

Course Objectives:

1. To appreciate the need of Sustainable transportation options available.
2. To familiarize with basic Concepts of Hybrid, Electric and Fuel Cell vehicles.
3. To acquaint with various aspects of hybrid and electric drive train and Battery Management Systems.
4. To study various challenges involved with Fuel cell technology.

Course Outcomes: Learner will be able to

1. Identify and describe the history and evolution of electric & hybrid electric vehicles.
2. Identify and describe the working principle of different EV/HEV's configurations.
3. Compare various energy sources and storages for EV and HEV's
4. Design drivetrain parameters for HEV's
5. Elaborate use of fuel cells in vehicular applications
6. Appreciate the need of BMS and chargers in EV's and perform sizing calculations for Batteries and Electric Motors.

Module	Detail Content	Hrs.
1	**Introduction** Environmental Impact: Air pollution, Global Warming, Petroleum Resources, Importance of Different transportation development, History of Electric Vehicles, History of Hybrid Vehicles and History of Fuel Cell Vehicles, Well to Wheel Analysis, GoI Initiatives, Conventional Drivetrain. State of the art and Indian and global scenario in EV/HEV	05
2	**Electric Vehicles** 1. Configurations 2. Traction Motor characteristics, Tractive effort , transmission requirement and Vehicle Performance 3. EV Parameters-Weight,Size,Force,Energy and Performance	07
3	**Hybrid Electric Vehicles** 1. Configurations-Series,Parallel,Series-Parallel and Complex 2. Torque Coupling, Speed coupling and combined Torque and speed coupling Hybrid electric drivetrain. 3. Power flow control for above configurations Design of Series and Parallel Hybrid drivetrain 1. Control strategies for Series and Parallel hybrid drivetrain 2. Sizing of drivetrain parameters	07
4	**Energy Storages and Drives and Regeneration** 1. Specific Energy ,Specific power, Energy Efficiency, Electrochemical reactions and voltages 2. Batteries for EV's and HEV's-Lead Acid, Nickel Based and Lithium Ion Battery Chemistries 3. Ultra capacitors 4. Ultra High speed flywheels 5. Hybridization of Energy storages 6. Motors for Electric Vehicles-DC Motors, Induction Motors and Switched Reluctance Motors(SRM) 7. Energy consumption in braking, Brake systems for EV's and HEV's	07

5	**Fuel Cell Electric Vehicles** 1. Operating Principles of fuel cell 2. Electrode potential and current voltage curve 3. Fuel Cell Technologies-PEMFC,AFC,PAFC,MCFC,SOFC,DMFC 4. Hydrogen storage and Production 5. Fuel cell hybrid electric drive train-Configuration, control strategy	07
6	**BMS,Chargers for EV'S and Case Study** 1. Need of Battery management systems(BMS) for Electric Vehicles 2. Basics of Electric Vehicles Chargers-AC and DC Chargers 3. V2G and G2V concept. 4. Calculation for Battery Sizing, Motor Sizing for any 2Wheeler/4 Wheeler	06

Laboratory Syllabus:

List of Experiments (any 6 of the following)

1. Battery Sizing calculations for 2W/3W/4W Electric Vehicles.
2. Motor Selection and Sizing Calculations for 2W/3W/4W Electric Vehicles.
3. Vehicle Performance Calculations for HEV and EV's.
4. Simulating Vehicle Performance Calculations in Matlab/Scilab.
5. Modeling Li-Ion Battery in Matlab/Simulink.
6. Modeling BMS in Matlab/Simulink.
7. Case Study on Hybrid Electric Vehicle Model.
8. Case Study on Electric Vehicle Model.

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests - 40 Marks
2. Continuous evaluation- Class Test/Assignments /Quiz/Case studies/Seminar presentation- 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Text Books:

1. Robin Hardy, Iqbal. Hussein, Electric and Hybrid Vehicles, CRC Press,ISBN-0-8493-1466-6.
2. J. Larminie and J. Lowry, Electric Vehicle Technology Explained, Wiley, 2003
3. C. MI, M. Abul and D. W. Gao, Hybrid Electrical Vehicle Principles and Application with Practical Perspectives, Wiley 2011

.

Books/References:

1. Sandeep Dhameja,"Electric Vehicle Battery Systems",Newnes,Massachusetts,2002
2. C.C.Chan and K.T.Chau,"Modern Electric Vehicle Technology", Oxford University Press, 2001
3. I. Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003

Course Code	Course Name	Credits
ME 428	**Vehicle Dynamics and Control**	**3**

Course Objectives:

1. To familiarize with basic concepts of vehicle dynamics.
2. To analyze the vehicle in context of ride, handling and longitudinal dynamics of the vehicle.
3. To get acquainted with simulation processes using software in the domain of vehicle dynamics.

Course Outcomes: After completion of this course, Learner will be able to

1. Analyze the vehicle directional stability.
2. Enumerate the suspension systems, tire dynamics & directional stability of the vehicle.
3. Develop physical and mathematical models to predict the dynamic response of vehicles
4. Demonstrate the ride characteristic of the vehicle.
5. Analyze the vehicle roll behaviour
6. Comprehend the various trends in Vehicle Dynamics.

Theory Syllabus:

Module	Detail Content	Hrs.
1	**Introduction** History of Road and Off-Road Vehicle dynamics, Road Load, Aerodynamics-Drag, Side force, Lift force, Rolling Resistance Total Road Loads, Introduction about Longitudinal vehicle Dynamics, Introduction about control theory applied to Longitudinal dynamics	4
2	**Tyres** SAE Tyre axis system, Tyre forces, Moments, Lateral force V/S Slip Angle, Aligning Torque V/S Slip Angle, Tyre Construction, Tractive Properties, Cornering Properties, Camber Thrust, Aligning Moment, Combined braking and Cornering, Conicity and Ply Steer, Tire Vibration, Tyre Properties affecting Vehicle Roll over, Introduction to Magic Tyre Formula , Tyre testing on various road surfaces	6
3	**Suspension** Solid Axles, Independent suspensions, Variable Rate Leaf Spring., Anti Squat and Anti Pitch Suspension Geometry, Anti Dive Suspension Geometry, Equalizing Suspension, Roll Centre Analysis, Motion Analysis of Wheel Suspension, semi active and Active Suspensions, Introduction about control theory applied to Suspension systems	8
4	**Vertical Dynamics** Lumped mass, Equation of Simple Spring Mass System with to degrees of freedom system, pitch and bounce motion frequencies, Conjugate Points, Elastic, Dynamic, doubly Conjugate Points, Calculation of Conjugate Points Sources for vehicle vibration, vibration isolation, Effects of damping the vibration, vibration absorbers.	10

5	**Lateral Dynamics** Steering geometry, Front wheel geometry, Steering system forces and moments, Steering system effects, Influence of front wheel drive, four wheel steering, Suspension effect of cornering, High speed cornering, understeer, oversteer, Jack Knifing of articulated vehicles , Introduction about control theory applied to Lateral dynamics	6
6	**Recent Trends in Vehicle dynamics** Vehicle dynamic Control (ESP and active steering), Actuators, Sensors for Automobile Control, Sensors for Detecting Vehicle Environment, Central Tyre Inflation system.	4

Laboratory Syllabus:

List of Experiments :

1. To plot characteristic curves for shock absorbers.
2. Simulation of Quarter car model for pitch and bounce.
3. Simulation of Quarter car model for different road profiles
4. Simulation of Half car model for pitch and bounce.
5. Simulation of Half car model for different road profiles.
6. Experimental studies of measurements of drag and lift coefficient for different geometry vehicle using wind tunnel apparatus.
7. To perform test on chassis dynamometer

Term work :

Term work shall consist of minimum 5 exercises, from the list, 6 assignments covering maximum portion of the syllabus (one on each module) or case study or mini project based on topics related to vehicle Dynamics. The case study or mini project is assigned for a group of students and the number of students in a group should not be more than two. The introduction of vehicle dynamics systems using any of the Dynamics software (like CARSIM etc) can be given to the students as a part of term work.

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/ Assignments / Quiz/ Case studies/ Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Text Books:

1. Gillespie T.D, ―Fundamentals of Vehicle Dynamics‖, SAE USA 1992
2. Giri N.K – Automotive Mechanics, Khanna Publishers, 2007.
3. Colin Campbell - Automobile Suspension and Handling
4. William F Milliken and Douglas L Milliken - Race Car Vehicle Dynamics
5. Konrad Reif Ed. – Automotive Mechatronics Bosch Professional Automotive Information , Springer

Reference Books:

1. J. Y. Wong, “Theory of Ground Vehicles”, 3rd ed., John Willey & Sons, New York, 1997.
2. Hans B, Pacejka - Tyre and Vehicle Dynamics - SAE Publication – 2002

3. Vehicle Dynamics Theory and application – Reza Jazar, Springer
4. Heinz Heisler, “Advanced Vehicle Technology “, 2nd Edition, Butterworth-Heinemann, 2002
5. Rajesh Rajamani “ Vehicle Dynamics and Control “
6. Road and Off Road Vehicle system Dynamics. Hand Book
7. Mechanics of Road Vehicle, Steeds
8. Car Suspension : Bastow

Course Code	Course Name	Credits
IL 480	**Digital Business Management and Digital Marketing**	**3**

Will be available Soon.

Course Code	Course Name	Credits
IL 481	**Medical Image Processing**	**3**

Course Objectives:

1. To introduce the learners to the basic theory of digital image processing.
2. To expose learners to various available techniques and possibilities of this field.
3. To prepare learners to formulate solutions to general image processing problems.

Course Outcomes: Learner will be able to

1. Record, extract and analyse key information about teeth, muscles, bones etc
2. Acquire the fundamental concepts of a digital image processing
3. Analyze images in the spatial and frequency domain.

Module	Detail Content	Hrs.
1	**Medical Imaging Systems:** Properties, advantages and disadvantages of X-rays based imaging systems, Magnetic Resonance Imaging (MRI) imaging, Gamma-rays based imaging systems, Positron emission tomography (PET), Single-photon emission computerized tomography (SPECT) scan, Computed Tomography (CT) scan, Ultrasound (sonography), Endoscopy, and Thermography based imaging systems. Difference between different medical imaging systems. Nature of Biomedical images, Objectives of biomedical image analysis, Difficulties in biomedical image acquisition and analysis.	7
2	**Medical Imaging Toolkits:** ImageJ (and/or FIJI), ITK-Snap, SimpleITK, MITK, FreeSurfer, SLICER, OsiriX. Image Formats: dicom (.dcm), Nifti (.nii), Minc (.mnc), Analyze (img/hdr), Raw (.raw), MHD (.mhd) and MHA (.mha)	5
3	**Medical Image Detection and Recognition:** Medical image parsing, Deep Learning for Medical Image Recognition, Automatic Interpretation of Carotid Intima–Media Using Convolutional Neural Networks, Deep Cascaded Networks for Sparsely Distributed Object Detection, Deep Voting and Structured Regression for Microscopy Image Analysis.	6
4	**Medical Image Registration:** Intensity-based methods, Cost functions - correlation, least squares, mutual information, robust estimators. Optimization techniques - fixed-point iteration, gradient descent, Nelder-Mead simplex method. MRI motion compensation, Convolutional Neural Network for Robust and Real-Time 2-D Registration.	6
5	**Medical Image Segmentation Networks:** Comparative study and analysis of U-Net family of segmentation: U-Net, V-Net, 3D U-Net, H-DenseUNet, GP-Unet, UNet++, MDU-Net, DUNet, RA-UNet, nnU-Net, SUNet, IVD-Net, LADDERNET, Attention U-Net, R2U-Net, MultiResUNet, U-NetPlus, CE-Net, CIA-Net, U2-Net, ScleraSegNet, AHCNet, MFP-Unet, ResUNet-a, RAUNet, 3D U2-Net, SegNAS3D, U^2-Net, UNET 3+.	9
6	**Deep Learning for Healthcare:** Deep learning for different healthcare applications: Diabetic Retinopathy, Knee Osteoarthritis, Histological and Microscopic Elements Detection, Gastrointestinal Diseases Detection,	6

	Cardiac Imaging. Lesion detection: Brain tumor detection, prostate lesion detection, Lung nodule detection.	

Assessment:

Internal Assessment: 40 marks

End Semester Examination: 60 Marks

Reference Books:

1. W. Birkfellner, Applied Medical Image Processing: A Basic Course, CRC Press , Second Edition, 2014
2. I. Bankman, Handbook of Medical Image Processing and Analysis, Academic Press , Second Edition, 2008
3. Rangaraj M. Rangayyan, “Biomedical Image Analysis”, CRC Press, 2000.
4. Zhou et al “Deep learning for Medical image analysis” Elsevier 2018.
5. R. C. Gonzalez, Digital Image Processing, Pearson Education India , Third Edition, 2013
6. S. Jayaraman, T. Veerakumar, S. Esakkirajan, Digital Image Processing, McGraw Hill Education , 2017
7. A K Jain, “Fundamental of Digital Image Processing”, Prentice Hall, 2002.

Course Code	Course Name	Credits
IL 482	**Technologies for Rural Development**	**3**

Course Objectives:

1. To understand the nature and characteristics of rural resources and its importance in Rural Development.
2. To understand various technologies required for Rural Development

Course Outcomes: Learner will be able to

1. Understand various natural resources and their importance in rural development.
2. Get exposure to various challenges and problems with regard to availability and use of natural resources.
3. Develop and implement various technologies for rural development
4. Explore various schemes for rural development

Module	Detail Content	Hrs.
1	**Nature and Characteristics of Rural Resources: Land Resources. water Resources, Living Resources, Human Resources** Definition and meaning of Resources, Types of Rural Resources, Natural and Man-made, Characteristics of Resources, Importance of different resources in Rural Development.	8
2	**Concept of Information and Communication Technologies (ICT's)** Evolution of ICT's, Communication Functions of ICT's, Nature and Scope of ICT's, Information Haves and Information Have Nots in the Rural Areas, Strengths and Weaknesses of ICT's in Rural India, Application of ICT's for Rural Development in India, Management Information System for Rural Development in India, Success Stories relating to ICT's for Rural Development (Andhra Pradesh, Tamil Nadu, Kerala and Karnataka Experiments), Satellite Communication support for Rural Development, Telecommunication support for Rural Development, Computer Communication support for Rural Development	10
3	**Crop production technology /Processing Plants** for major cereal crops viz., paddy, wheat, maize, pearl millet, sorghum, etc.; Major varieties, sowing time, method of sowing, spacing, inter culturing, fertilizer and water requirement, time of harvest, maturity index, yield potential, cost of cultivation, income from production, etc. Rural Energy system Technologies for Water treatment	8
4	**The Role of Rural Technology** – Need & importance of rural Technology, appropriate rural Technology, Technology for Rural Women, difficulties in adoption of rural technology.	6
5	**Globalisation of Rural Economy-** Globalisation and aims and objectives; Impact of Globalisation on rural economy, Contract farming, corporate farming, SEZ's and Agriculture. Agricultural value chain	6
6	Government Schemes, initiatives and participation of various Stake holders for development and Protection of Rural resources	4

Assessment:

Internal Assessment: 40 marks

End Semester Examination: 60 Marks

Books/References:

1. Rural Development: Principles, Policies and Management, Katar Singh, Sage Publications India Pvt. Ltd., 2009
2. Development of Land Resources – E-book on Activities Department of Land Resources, Ministry of Rural Development, Government of India, Dec. 2014,
3. Http://dolr.nic.in/downloads/PDFs/DoLR%20Activities.pdf
4. S.S. Singh., Principles and Practices of Agronomy. 1985. Kalyani Publishers, Ludhiana
5. Indian Economy by Datt, Rudra & Sundharam, New Delhi: S. Chand, 2008.
6. W.T.O and Indian Economy by Deogirikar, A. B. Jaipur: Shri Niwas Publications, 2004

Course Code	Course Name	Credits
IL 483	**Economics**	**3**

Course Objectives:

1. Provide a good grounding in the basic concepts of Micro and Macroeconomics.
2. Familiarize learners with concept of demand, supply, price, income and equilibrium.
3. Teach students to represent Indifference curve in regular as well as in exceptional cases with respect to consumer behaviour, consumer preferences and Risk Aversion.
4. To inculcate the skills required to understand the concept of Production function with single and two variable inputs.
5. To create an awareness of the different market structures and its impact on the price and output of a product.
6. To prepare the learners in understanding the Keynesian System of Money, Interest and Income and its impact in society with respect to Inflation.

Course Outcomes: Learner will be able to

1. Acquire conceptual and theoretical knowledge of Micro and Macroeconomics and learn to think critically about issues and topics of the subject.
2. Demonstrate the understanding of the concepts of demand, supply, price, income and equilibrium and relate it to the existing scenario in the society.
3. Perform successfully in representing the Indifference curve in relation to the prevalent consumer behaviour and consumer preferences.
4. Illustrate the skills required for maximising output and minimising cost for effective production.
5. Determine the importance of the existence of different market structures and its impact in society.
6. Develop an understanding of the Keynesian System of Money, Interest and Income and formulate anti- inflationary policies.

Module	Detail Content	Hrs.
1	Introduction to Micro and Macro Economics	5
2	Demand & Supply: Concept of demand & supply functions, Price, Income & Cross elasticities of demand, Elasticity of Supply, Market demand functions, Concept of equilibrium, Impact of changes in demand & supply on equilibrium	7
3	Theory of Consumer Behaviour: Concept of cardinal and ordinal utility, consumer's equilibrium, Consumer's preferences, Risk Aversion and Indifference Curve Analysis, & its properties, Shapes of Indifference Curves in exceptional cases	7
4	The Theory of Production: Concept of Production function, Production with a single variable input, Production with two variable inputs, Optimal input combination, Constrained output maximization, Cost minimization, Elasticity of substitution	6
5	Theory of Cost: Different concept of cost, Short-run and Long- run cost analysis, modern concept. Market Structures a. Perfect Competition Short-run and long-run equilibrium of the firm and Industry, Stability of equilibrium, Concept of imperfect competition; short run and long run price and output decisions of a monopoly firm; concept of a supply curve under monopoly; comparison of perfect competition and monopoly,	4

6	The Keynesian System: Money, Interest and Income Money in the Keynesian theory, Interest Rate Determination (Liquidity Preference Theory), Money Market, Bond market and Commodity Market, Monetary policies and fiscal policies, Inflation and Unemployment Inflation, Role and Effects of inflation, Anti- inflationary policies	7

Assessment:

Internal Assessment: 40 marks

End Semester Examination: 60 Marks

Reference Books:

1. Dr. Samwel Nyagucha Ores. (2019). *Micro and Macro Economics: Understanding the Basics of Economics*. New Generation Publishing.
2. Daron Acemoglu and James A. Robinson. (2013). *Why Nations Fail: The Origins of Power, Prosperity and Poverty*. Profile Books

Course Code	Course Name	Credits
IL 484	**GIS and Remote Sensing**	**3**

Prerequisites: Knowledge of Python or other software programming language

Course Objectives:

1. To gain basic understanding of GIS and remote sensing techniques
2. To understand basic software such as QGIS used for GIS analysis
3. To understand various GIS data sources, their processing and interpretation

Course Outcomes: Learner will be able to

1. Know and apply GIS and remote sensing concepts to real world problems
2. Learner will become proficient in using Python and QGIS to conduct geospatial analysis

Module	Detail Content	Hrs.
1	Introduction to GIS Mapping. GIS Data models and modelling, Maps and Databases, GIS data types (vector, raster etc), Geographic coordinate systems,	10
2	Introduction to QGIS software, GIS data sources, Digitizing data, Georeferencing.	10
3	Spatial Analysis techniques vector and raster analysis and tools.	20
4	Satellite images, electromagnetic energy and remote sensing, satellites and sensors, arial cameras, surveys using drones, multispectral scanners, LIDAR.	10
5	Applications of GIS in industry, governments, NGOs etc	10

Assessment:

Internal Assessment: 40 marks

End Semester Examination: 60 Marks

Reference Books:

1. Principals of Remote Sensing: An Introductory Textbook (https://webapps.itc.utwente.nl/librarywww/papers_2009/general/principlesremotesensing.pdf)
2. Principals of GIS (https://webapps.itc.utwente.nl/librarywww/papers_2009/general/principlesgis.pdf)

Course Code	Course Name	Credits
IL 485	**Physical Education**	**3**

Course Objectives:

1. To understand the components of Physical Fitness.
2. To understand the modern development and social aspects of physical education
3. To understand general troop games, recreational games and the importance of playing to achieve health & wellness.
4. To acquaint students with principles of nutrition and the application of human energy.
5. To understand the role of food in physical performance.
6. To understand the need for wellness & weight management.
7. To understand common sports injuries, first aid & their treatment.
8. To understand the application of Yoga in physical education & sports.
9. To enable the student to understand the basic structure & function of the human body and the effect of exercise on the body as a whole.

Course Outcomes: Learner will be able to

1. Maintain a health-enhancing level of fitness throughout the program as well as be able to collect and analyse personal fitness data.
2. Gain knowledge regarding the application of yoga to Physical Education and Sports
3. Understand the anatomy and Physiology of Asanas and Pranayamas.
4. Acquire the knowledge regarding the effect of exercise on the body as a whole
5. Develop an understanding of the concept of personality, factors affecting personality development
6. To understand proportional body weights and their management
7. To understand nutrition and balance diet

Module	Detail Content	Hrs.
1	**Physical Fitness** 1.1 Concept, definition and meaning of Physical fitness, activity and exercise 1.2 Component of Physical fitness, Benefit of Physical fitness & exercise. 1.3 Principles of physical fitness 1.4 Definition and concept of wellness and factors affecting Physical fitness & wellness 1.5 Concept and importance of physical conditioning, warming up and cooling down of all age groups	8
2	**Nutrition and Dietary Requirement** 2.1 Nutrition components and balanced diet 2.2 Meaning and definition of doping and ergogenic aids 2.3 Prevention and first-aid of common injuries during Physical training 2.4 Need of Energy, Carbohydrate and Protein 2.5 Concept training nutrition and competition nutrition	6
3	**Wellness, Weight management and Holistic health** 3.1 Meaning, concept and components of Wellness 3.2 Manipulation of energy balance to induce weight loss and weight gain 3.3 Methods of weight management 3.4 Concept, types and cause of obesity and its management. 3.5 Waist hip ratio, larger heart, BMI, calculation of Training Heart Rate	6

4	**Human body system, function and effect of exercise** 4.1 Meaning and Importance of the study of Human anatomy in physical education & sports 4.2 Classification and functions of bones and joints 4.3 Movements of various joints 4.4 Structural classification of muscle, types of muscle and effect of exercise on the musculoskeletal system. 4.5 Structure and Effect of exercise on the cardiorespiratory system 4.6 Digestion and effect of exercise on the digestive system 4.7 Nervous system and effect of exercise on the nervous system.	6
5	**Yoga and meditation** 5.1 Concept of Yoga and misconception about Yoga 5.2 Comparison of Physical Education exercise and Yogic exercise. 5.3 Meaning, Types and principles of Meditation 5.4 Principles governing various exercises in Yoga(Asana, Pranayam, Bandha, Mudra, Kriya) 5.5 Yoga for stress management and emotional stability 5.6 Application of Yoga in sports & physical education and effect of Yogic exercise on different systems of the human body.	8
6	**General & recreational troop games and its method of skill training** 6.1 The game soccer and its rules and regulation 6.2 The game Volleyball, Basketball and its rules and regulations 6.3 The Indoor games and their rules and regulations 6.4 Method of sports skill developing training 6.5Recreational games and their importance in day to day life	6

Assessment:

Internal Assessment: 40 marks

End Semester Examination: 60 Marks

1. Term Papers:

Two theory papers will be conducted for 40 marks each with average marks of both papers as the final score. One hour theory paper as per the pattern of the semester-end examination will be conducted.

2. Projects/Assignments:

Project on Nutrition (10 Marks): The learner will be given one project on the calculation of Basel metabolic rate. He /she will submit the report of the same in a prescribed format based on which the learner will be evaluated for 10 marks by the concerned teacher/s

Projects/Assignment on Yoga education (10 Marks): The learner will be given an assignment on yoga education such as gathering/compiling the information about the various aspects of asanas and asking to prepare and submit the report of the same based on which the concerned subject teacher will give marks out of 10.

Assignments on Sports Injuries (10 Marks): The learner will be given two assignments on the specific sports injuries and their remedial aspects based on the report submitted in the prescribed format by him/her as well as observations, the concerned teacher/s will give marks out of 10.

3. Physical Activities:

a. To perform 8 Asanas in a group (10)
b. To perform one Pranayama and one Kriyas(5)
c. To perform any five exercises of Motor Fitness. (5)
d. To perform any five exercises of HRPF(5)

4. Trekking/ Hiking - The learner should be provided experience of participating in the organization and the actual conduct of the co-curricular activities viz. Hiking/Trekking and the assessment of 05 marks should be done based on learners actual participation and involvement in the same.

Reference Books:

1. Padmakshan Padmanabhan 'Handbook of Health & Fitness', Indus Source; First edition, Indus Source Books, Wadala Mumbai. 2014.
2. Adams, William.C. 'Foundation of Physical Education Exercises and Sports Sciences', Lea and Febigor, Philadelphia, 1991.
3. Dr. Kamlesh M.L. 'Principles and History of Physical Education and Sports', Friends Publication (India) New Delhi, 2004
4. Bates M.'Health Fitness Management (2nd Ed.) USA : Human Kinetics.2008
5. Fink, H.H., Burgoon,L.A., & Mikesky. Practical Applications in Sports Nutrition. Canada : Jones and Bartlett Publishers. 2006.
6. Worthington, Vivian. History of Yoga. London : Routledge and Kegan Paul Ltd. 1982.
7. Rajan, M. Yoga Stretching and Relaxation for Sportsman. Delhi : Allied publishers. 1985.
8. Crouch James E. – Essential Human Anatomy A Text – Lea & Febriger , Philladalphia
9. Murgesh N. – Anatomy, Physiology and Health Education, Sathya, Chinnalapatti, 1990
10. Giam, C.K. Sport Medicine Exercise and Fitness. Singapore : P.G. Medical Book. 1994.

Course Code	Course Name	Credits
IL 486	**Environmental Management**	**3**

Will be available Soon.

Course Code	Course Name	Credits
ME 492	**Major Project III**	**2**

Course Objectives:

1. To acquaint with the process of undertaking literature survey or market survey or feasibility study /industrial visit and identifying the problem
2. To familiarize the process of problem solving in a group
3. To acquaint with the process of applying basic engineering fundamental in the domain of practical applications
4. To inculcate the process of research

Course Outcomes: Learner will be able to

1. Do literature survey based on market or feasibility study/industrial visit and identify the problem.
2. Apply basic engineering fundamentals in the domain of practical applications
3. Cultivate the habit of working in a team
4. Attempt a problem solution in a right approach.
5. Correlate the theoretical and experimental/simulations results and draw the proper inferences
6. Prepare project report as per guidelines and with proper references/citations.
7. Exhibit and explain project ideas/models at various platforms

Guidelines for Project

Students are expected to have one of the following outcome of the project work done

1. Filing of patent on the innovating work done
2. Presentation of the work done in National/International Conference
3. Publishing the work done in National/International Journal
4. Participation in Project competition at State/National level

Assessment:

Project III should be assessed based on following points

1. Continuous assessment on the progress
2. Quality of platform used to present the project work done