SYLLABUS
SEMESTER VIII

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U40B	MECHATRONICS	PCC	2	1	0	3	2020

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

This course provides an insight into the mechanical systems used in Mechatronics and the Integration of mechanical, electronics, control and computer engineering in the design of mechatronics systems.

iii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain the sensors and actuators used in mechatronics	Understand
CO2	Design hydraulic and pneumatic circuits for automation	Apply
CO3	Explain the manufacturing processes used in MEMS	Understand
CO4	Demonstrate the various components of a CNC machine	Apply
CO5	Illustrate PLC programs for mechanical applications	Apply
CO6	Explain the robotic sensors and vision system	Understand

iv) SYLLABUS:

Introduction to Mechatronics: Structure of Mechatronics system. Sensors - Characteristics - Temperature, flow, pressure sensors. Displacement, position and proximity sensing by magnetic, optical, ultrasonic, inductive, capacitive and eddy current methods. Directional control valves, pressure control valves, process control valves. Rotary actuators. Development of simple hydraulic and pneumatic circuits using standard Symbols. Micro Electro Mechanical Systems (MEMS): Mechatronics in Computer Numerical Control (CNC) machines: Design of modern CNC machines - Mechatronics elements - Machine structure: guide ways, drives.. System modeling - Mathematical models and basic building blocks of general mechanical, electrical, fluid and thermal systems. Programmable Logic Controllers (PLC) – Mechatronics in Robotics

v) **a) TEXTBOOKS**

1) Bolton W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Person Education Limited, New Delhi, 2007

2) Ramachandran K. P., G. K. Vijayaraghavan, M. S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Wiley India Pvt. Ltd., New Delhi, 2008.

3) Saeed B. Niku, Introduction to Robotics: Analysis, Systems, Applications, Person Education, Inc., New Delhi, 2006

b) REFERENCES

1) David G. Aldatore, Michael B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw-Hill Inc., USA, 2003.

2) Gordon M. Mair, Industrial Robotics, Prentice Hall International, UK, 1998

3) HMT, Mechatronics, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004

4) Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies, John Wiley & Sons Ltd., England, 2006.

vi) **COURSE PLAN:**

Module	Contents	No. of hours
I	Introduction to Mechatronics: Structure of Mechatronics system. Sensors – Characteristics Temperature, flow, pressure sensors. Displacement, position and proximity sensing by magnetic, optical, ultrasonic, inductive, capacitive and eddy current methods. Encoders: incremental and absolute, gray coded encoder. Resolvers and synchros. Piezoelectric sensors. Acoustic Emission sensors. Principle and types of vibration sensors. Actuators: Mechanical actuators, Electrical actuators, Hydraulic and Pneumatic actuators	**9**
II	Directional control valves, pressure control valves, process control valves. Rotary actuators. Development of simple hydraulic and pneumatic circuits using standard Symbols. Micro Electro Mechanical Systems (MEMS): Fabrication: Deposition, Lithography, Micromachining methods for MEMS, Deep Reactive Ion Etching (DRIE) and LIGA processes Principle, fabrication and working of MEMS based pressure sensor, accelerometer and gyroscope.	**9**

III	Mechatronics in Computer Numerical Control (CNC) machines: Design of modern CNC machines - Mechatronics elements - Machine structure: guide ways, drives. Bearings: anti-friction bearings, hydrostatic bearing and hydrodynamic bearing Re-circulating ball screws, pre-loading methods. Re-circulating roller screws. Measuring system for NC machines - direct and indirect measuring system. System modeling - Mathematical models and basic building blocks of general mechanical & electrical system. Mathematical models and basic building blocks of general fluid and thermal systems	**9**
IV	Typical elements of open and closed loop control systems. Adaptive controllers for machine tools. Programmable Logic Controllers (PLC) – Basic structure, input/ output processing. Programming: Timers, Internal Relays, Counters and Shift registers. Development of simple ladder programs for specific purpose. Case studies of Mechatronics systems: Automatic camera, bar code reader, pick and place robot, automatic car park barrier system, automobile engine management system.	**9**
V	Mechatronics in Robotics-Electrical drives: DC, AC, brushless, servo and stepper motors. Harmonic drive Force and tactile sensors. Range finders: ultrasonic and light-based range finders. Robotic vision system - Image acquisition: Vidicon, charge coupled device (CCD) and charge injection device (CID) cameras. Image processing techniques: histogram processing: sliding, stretching, equalization and thresholding.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U40C	COMPREHENSIVE VIVA VOCE	PCC	1	0	0	1	2020

i) PRE-REQUISITE: Core Mechanical Engineering Courses from S3 to S7.

ii) COURSE OVERVIEW:

The objective of this course viva is to ensure the basic knowledge of each student in the most fundamental core courses in the curriculum. The viva voce shall be conducted based on the core subjects studied from third to eighth semester. This course helps the learner to become competent in placement tests and other competitive examinations.

iii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Apply concepts of engineering design to understand, formulate, solve and analyse engineering problems.	Apply
CO2	Apply concepts of thermal sciences to understand, formulate, solve and analyse engineering problems.	Apply
CO3	Apply concepts of production and manufacturing sciences to understand, formulate, solve and analyse engineering problems.	Apply
CO4	Apply concepts of metallurgy and material sciences to understand, formulate, solve and analyse engineering problems.	Apply
CO5	Apply concepts of industrial engineering to understand industrial systems to formulate, solve and analyse industrial engineering problems	Apply

iv) SYLLABUS:

All core subjects from the third to the eighth semester.

v) a) TEXTBOOKS

Prescribed textbooks for the core courses from the third to the eighth semester

b) REFERENCES

Prescribed reference books for the core courses from the third to the eighth semester

vi) COURSE PLAN

Module	Contents	No. of hours
I	Review of third semester core courses – ME1U20A-Mechanics of solids, ME1U20B-Mechanics of fluids, ME1U20C-Metallurgy and Material Science.	4
II	Review of fourth semester core courses – ME1U20D-Engineering Thermodynamics, ME1U20E-Manufacturing Process, ME1U20-Fluid Machinery	4
III	Review of fifth semester core courses – ME1U30A-Mechanics of Machinery, ME1U30B-Thermal Engineering, ME1U30C-Industrial and Systems Engineering, ME1U30D-Machine Tools and Metrology.	4
IV	Review of sixth semester core courses – ME1U30E-Heat and Mass Transfer, ME1U30F-Dynamics and Design of Machinery, ME1U30G-Advanced Manufacturing Engineering.	2
V	Review of seventh and eighth semester core courses – ME1U40A-Design of Machine Elements, ME1U40B-Mechatronics.	1
	Total hours	**15**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U49C	Project Phase II	PWS	0	0	12	4	2020

i) **Preamble:** The course 'Project Work' is mainly intended to evoke the innovation and invention skills in a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation. The project extends to 2 semesters and will be evaluated in the 7th and 8th semester separately, based on the achieved objectives. One third of the project credits shall be completed in 7th semester and two third in 8thsemester. It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies.

ii) **Course Objectives**

- To apply engineering knowledge in practical problem solving.
- To foster innovation in design of products, processes or systems.
- To develop creative thinking in finding viable solutions to engineering problems.

iii) **COURSE OUTCOMES:**

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Model and solve real world problems by applying knowledge across domains.	Apply
CO2	Develop products, processes or technologies for sustainable and socially relevant applications.	Apply
CO3	Function effectively as an individual and as a leader in diverse teams and to comprehend and execute designated tasks.	Apply
CO4	Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms.	Apply
CO5	Identify technology/research gaps and propose innovative /creative solutions.	Analyse
CO6	Organize and communicate technical and scientific findings effectively in written and oral forms.	Apply

iv) **PROJECT PHASE II**

Phase 2 Targets

- In depth study of the topic assigned in the light of the report prepared under Phase - I;
- Review and finalization of the approach to the problem relating to the assigned topic.

- Preparing a detailed action plan for conducting the investigation, including teamwork.
- Detailed Analysis/ Modeling / Simulation/ Design/ Problem Solving/Experiment as needed.
- Final development of product/ process, testing, results, conclusions and future directions.
- Preparing a paper for Conference Presentation/ Publication in Journals, if possible.
- Presenting projects in Project Expos conducted by the University at the cluster level and/ or state level as well as others conducted in India and abroad.
- Filing Intellectual Property Rights (IPR) if applicable.
- Preparing a report in the standard format for being evaluated by the Department Assessment Board.
- Final project presentation and viva voce by the assessment board including the external expert.

Evaluation Guidelines & Rubrics

Total: 150 marks (Minimum required to pass: 75 marks).

- Project progress evaluation by guide: 30 Marks.
- Two interim evaluations by the Evaluation Committee: 50 Marks (25 marks for each evaluation).
- Final evaluation by the Final Evaluation committee: 40 Marks
- Quality of the report evaluated by the evaluation committee: 30 Marks

(The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project supervisor. The final evaluation committee comprises of Project coordinator,expert from Industry/research/academic Institute and a senior faculty from a sister department).

Evaluation by the Guide

The guide/supervisor must monitor the progress being carried out by the project groups on regular basis. In case it is found that progress is unsatisfactory it should be reported to the Department Evaluation Committee for necessary action. The presence of each student in the group and their involvement in all stages of execution of the project shall be ensured by the guide. Project evaluation by the guide: 30 Marks. This mark shall be awarded to the students in his/her group by considering the following aspects:

Project Scheduling & Distribution of Work among Team members: Detailed and extensive Scheduling with timelines provided for each phase of project. Work breakdown structure well defined. (5)

Literature survey: Outstanding investigation in all aspects. (4)

Student's Diary/ Daily Log: The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily/weekly activity diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily/weekly activity diary shall be signed after every day/week by the guide. (7)

Individual Contribution: The contribution of each student at various stages. (9)

Completion of the project: The students should demonstrate the project to their respective guide. The guide shall verify the results and see that the objectives are met. (5)

EVALUATION RUBRICS for PROJECT Phase II: Interim Evaluation - 1						
No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
2-a	Novelty of idea, and Implementation scope [CO5] [Group Evaluation]	**5**	The project is not addressing any useful requirement. The idea is evolved into a non-implementable one. The work presented so far is lacking any amount of original work by the team.	Some of the aspects of the proposed idea can be implemented. There is still lack of originality in the work done so far by the team. The project is a regularly done theme/topic without any freshness in terms of specifications, features, and/or improvements.	Good evidence of an implementable project. There is some evidence for the originality of the work done by the team . There is fresh specifications/ features/improvements suggested by the team. The team is doing a design from fundamental principles, and there is some independent learning and engineering ingenuity.	The project has evolved into incorporating an outstandingly novel idea. Original work which is not yet reported anywhere else. Evidence for ingenious way of innovation which is also Implementable. Could be a patentable / publishable work.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
2-b	Effectiveness of task distribution among team members. [CO3] [Group Evaluation]	**5**	No task distribution of any kind. Members are still having no clue on what to do.	Task allocation done, but not effectively, some members do not have any idea of the tasks assigned. Some of the tasks were identified but not followed individually well.	Good evidence of task allocation being done, supported by project journal entries, identification of tasks through discussion etc. However, the task distribution seems to be skewed, and depends a few members heavily than others. Mostly the tasks are being followed by the individual members.	Excellent display of task identification and distribution backed by documentary evidence of team brainstorming, and project journal entries. All members are allocated tasks according to their capabilities, and as much as possible in an equal manner. The individual members are following the tasks in an excellent manner.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
2-c	Adherence to project schedule. [CO4] [Group Evaluation]	**5**	Little or no evidence of continued planning or scheduling of the project. The students did not stick to the plan what they were going to build nor plan on what materials / resources to use in the project. The students do not have any idea on the budget required even after the end of phase - I. No project journal kept or the journal.	There is some improvement in the primary plan prepared during phase I. There were some ideas on the materials /resources required, but not really thought out. The students have some idea on the finances required, but they have not formalized a budget plan. Schedules were not prepared. The project journal has no useful details on the project.	Good evidence of planning done and being followed up to a good extent after phase I. Materials were listed and thought out, but the plan wasn't followed completely. Schedules were prepared, but not detailed, and needs improvement. Project journal is presented but it is neither complete nor updated regularly.	Excellent evidence of enterprising and extensive project planning and follow-up since phase I. Continued use of project management/version control tool to track the project. Material procurement if applicable is progressing well. Tasks are updated and incorporated in the schedule. A well-kept project journal showed evidence for all the above, in addition to the interaction with the project guide.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)

2-d	Interim Results. [CO6] [Group assessment]	**5**	There are no interim results to show.	The team showed some interim results, but they are not complete / consistent to the current stage, Some corrections are needed.	The interim results showed were good and mostly consistent/correct with respect to the current stage. There is room for improvement.	There were significant interim results presented which clearly shows the progress.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-e	Presentation [Individual assessment]	**5**	Very poor presentation and there is no interim results. The student has no idea about the project proposal.	Presentation is average, and the student has only a feeble idea about the team work.	Good presentation. Student has good idea about the team's project. The overall presentation quality is good.	Exceptionally good presentation. Student has excellent grasp of the project. The quality of presentation is outstanding.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Phase-II Interim Evaluation - 1 Total Marks: 25						

EVALUATION RUBRICS for PROJECT Phase II: Interim Evaluation – 2

No	Parameters	Marks	Poor	Fair	Very Good	Outstanding
2-f	Application of engineering knowledge [CO1] [Individual Assessment]	**10**	The student does not show any evidence of applying engineering knowledge on the design and the methodology adopted. The student's contribution in application of engineering knowledge in the project is poor.	The student appears to apply some basic knowledge, but not able to show the design procedure and the methodologies adopted in a comprehensive manner.	The student is able to show some evidence of application of engineering knowledge in the design and development of the project to good extent.	Excellent knowledge in design procedure and its adaptation. The student is able to apply knowledge from engineering domains to the problem and develop solutions.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
2-g	Involvement of individual members [CO3] [Individual Assessment]	**5**	No evidence of any Individual participation in the project work.	There is evidence for some amount of individual contribution, but is limited to some of the superficial tasks.	The individual contribution is evident. The student has good amount of involvement in core activities of the project.	Evidence available for the student acting as the core technical lead and has excellent contribution to the project.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-h	Results and inferences upon execution [CO5] [Group Assessment]	**5**	None of the expected outcomes are achieved yet. The team is unable to derive any inferences on the failures/ issues observed. Any kind o f observations or studies are not made.	Only a few of the expected outcomes are achieved. A few inferences are made on the observed failures/issues. No further work suggested.	Many of the expected outcomes are achieved. Many observations and inferences are made, and attempts to identify the issues are done. Some suggestions are made for further work.	Most of the stated outcomes are met. Extensive studies are done and inferences drawn. Most of the failures are addressed and solutions suggested. Clear and valid suggestions made for further work.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-i	Documentation and presentation. .[CO6] [Individual assessment]	**5**	The individual student has no idea on the presentation of his/her part. The presentation is of poor quality.	Presentation's overall quality needs to be improved.	The individual’s presentation performance is satisfactory.	The individual's presentation is done professionally and with great clarity. The individual’s performance is excellent.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Phase-II Interim Evaluation - 2 Total Marks: 25						

EVALUATION RUBRICS for PROJECT Phase II: Final Evaluation						
No	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
2-j	Engineering knowledge. [CO1] [Group Assessment]	10	The team does not show any evidenceof applying engineering knowledge on the design and the methodology adopted.	The team is able to show some of the design procedure and the methodologies adopted, but not in a comprehensive manner.	The team is able to show evidence of application of engineering knowledge in the design and development of the project to good extent. There is scope for improvement.	Excellent knowledge in design procedure and its adaptation. The team is able to apply knowledge from engineering domains to the problem and develop an excellent solution.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
2-k	Relevance of the project with respect to societal and/or industrial needs. [Group Assessment] [CO2]	5	The project as a whole do not have any societal / industrial relevance at all.	The project has some relevance with respect to social and/or industrial application. The team has however made not much effort to explore further and make it better.	The project is relevant to the society and/or industry. The team is mostly successful in translating the problem into an engineering specification and managed to solve much of it.	The project is exceptionally relevant to society and/or industry. The team has made outstanding contribution while solving the problem in a professional and/ or ethical manner.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-i	Innovation / novelty / Creativity [CO5] [Group Assessment]	5	The project is not addressing any useful requirement. The idea is evolved into a non-implementable one. The work presented so far is lacking any amount of original work by the team.	Some of the aspects of the proposed idea appears to be practical. There is still lack of originality in the work done. The project is a regularly done theme/topic without any freshness in terms of specifications, features, and/ or improvements.	Good evidence of an implementable project. There is some evidence for the originality of the work done by the team. There is fresh specifications/ features/improvements suggested by the team. The team is doing a design from fundamental principles, and there is some independent learning and engineering ingenuity. Could be translated into a product / process if more work is done.	The project has evolved into incorporating an outstandingly novel idea. Original work which is not yet reported anywhere else. Evidence for ingenious way of innovation which is also Implementable. Could be a patentable publishable work.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-m	Quality of results / conclusions / solutions. [CO1] [Group Assessment]	10	None of the expected outcomes are achieved. The team is unable to derive any inferences on the failures/issues observed. Any kind of observations or studies is not made.	Only a few of the expected outcomes are achieved. A few inferences are made on the observed failures/issues. No further work suggested.	Many of the expected outcomes are achieved. Many observations and inferences are made, and attempts to identify the issues are done. Some suggestions are made for further work.	Most of the stated outcomes are met. Extensive studies are done and inferences drawn. Most of the failures are addressed and solutions suggested. Clear and valid suggestions made for further work.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)

2-n	Presentation - Part I Preparation of slides. [CO6] [Group Assessment].	5	The presentation slides are shallow and in a clumsy format. It does not follow proper organization.	Presentation slides follow professional style formats to some extent. However, its organization is not very good. Language needs to be improved. All references are not cited properly, or acknowledged. Presentation slides needs to be more professional.	Presentation slides follow a good style format and there are only a few issues. Organization of the slides is good. Most of references are cited properly. The flow is good and team presentation is neatly organized. Some of the results are not clearly shown. There is room for improvement.	The presentation slides are exceptionally good. Neatly organized. All references cited properly. Diagrams/Figures, Tables and equations are properly numbered, and l i s ted. Results/ inferences clearly highlighted and readable.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
	Presentation - Part II: Individual Communication [CO6] [Individual Assessment].	5	The student is not communicating properly. Poor response to questions.	The student is able to explain some of the content. The student requires a lot of prompts to get to the idea. There are language issues.	Good presentation/ communication by the student. The student is able to explain most of the content very well. There are however, a few areas where the student shows lack of preparation. Language is better.	Clear and concise communication exhibited by the student. The presentation is outstanding. Very confident and tackles all the questions without hesitation. Exceptional traits of communicator.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Phase-II Final Evaluation, Marks: 40						

EVALUATION RUBRICS for PROJECT Phase II: Report Evaluation						
Sl. No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
2-o	Report [CO6]	30	The prepared report is shallow and not as per standard format. It does not follow proper organization. Contains mostly unacknowledged content. Lack of effort in preparation is evident. References are not cited. Unprofessional and inconsistent formatting.	Project report follows the standard format to some extent. However, its organization is not very good. Language needs to be improved. All references are not cited properly in the report. There is lack of formatting consistency.	Project report shows evidence o systematic documentation. Report i mostly following the standard styl format and there are only a few issues Organization of the report is good Mostly consistently formatted. Most o references/sources are cited acknowledged properly.	The report is exceptionally good. Neatly organized. All references cited properly. Diagrams/Figures, Tables and equations are properly numbered, and listed and clearly shown. Language is excellent and follows professional styles. Consistent formatting and exceptional readability.
			(0 - 11 Marks)	(12 - 18 Marks)	(19 - 28 Marks)	(29 - 30 Marks)
Phase - II Project Report Marks: 30						

PROGRAMME ELECTIVE III

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U42A	QUALITY MANAGEMENT	PEC	2	1	0	3	2020

i) **PRE-REQUISITE:** NIL

ii) **COURSE OVERVIEW:**

Objective of the course is to to facilitate the students to understand the concept and culture of total quality management

iii) **COURSE OUTCOMES:**

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain the important terms for quality management in organisations..	Understand
CO2	Explain the complete theoretical and practical contributions of Quality Gurus	Understand
CO3	Explain the knowledge of the underlying principles of strategic quality management	Understand
CO4	Explain the various human dimensions of TQM	Understand
CO5	Apply different tools and techniques in TQM	Apply
CO6	Explain the core and extended modules of ISO 9000 family of standards	Understand

iv) **SYLLABUS:**

Quality Engineering - Quality, quality planning, quality control, quality assurance, quality management, Total Quality Management (TQM) - Barriers to TQM Deming approach to TQM – Juran's quality trilogy- Crosby's fourteen steps for quality improvement

Strategic Quality Management: Cost of Quality- Customer satisfaction- Quality Function Deployment (QFD)- Concepts of 5S, Six Sigma, Kaizen

Human dimensions of TQM – Top management commitment- Leadership for TQM- Employee involvement, role of the quality director- Quality System: ISO 9000 family of

standards

Quality control and Inspection- Destructive and non-destructive testing methods- process capability- Statistical quality control –Acceptance sampling- Reliability-types and causes of failures- Bath tub curve.-System reliability- life testing

Supporting Tools, Activities And Techniques in TQM Projects : Affinity diagram - brainstorming - cause and effect analysis - process flow chart – check sheets- Scatter diagram - Pareto chart- Histogram and fundamentals of statistics - Taguchi's robust design- Total Productive maintenance- Failure Mode and Effect Analysis - Quality auditing- types and benefits.

v a) TEXTBOOKS

1) Besterfield Dale H. , Besterfield Carol, Besterfield Glen H., Besterfield Mary, Urdhwareshe Hemant, Urdhwareshe Rashmi, "Total Quality Management (TQM) 5e", Pearson Education, 2018.

2) Juran J M and Gryna, F M, "Quality Planning and Analysis - From Product Development through Use", Tata McGraw Hill Publishing Limited, New Delhi, Third Edition, 2004.

b) REFERENCES

1) Subburaj Ramasamy, "Total Quality Management", McGraw Hill Education,, 2017.

2) Dr. K.C. Arora, "Total Quality Management", S K Kataria and Sons, 2013.

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	**Quality Engineering** - Quality planning, quality control, quality assurance, quality management, Total Quality Management (TQM)- overview on TQM - the TQM axioms - consequences of total quality- Barriers to TQM Deming approach to TQM – Juran's quality trilogy- Crosby's fourteen steps for quality improvement	8

II	**Strategic Quality Management**: Cost of Quality- Customer satisfaction- Quality Function Deployment (QFD)- Integrating quality into strategic management - obstacles to achieving successful strategic quality management- Concepts of 5S, Six Sigma, Kaizen.	**9**
III	**Human dimensions of TQM** – Top management commitment- Leadership for TQM- Change management- resources for quality activities - training for quality –Employee involvement, motivation empowerment- teamwork- self managing teams - role of the quality director- Quality System: ISO 9000 family of standards.	**10**
IV	**Quality control and Inspection**- Destructive and non-destructive testing methods- process capability- Statistical quality control – Acceptance sampling- causes of variation in quality control charts for X and R, Problems- Reliability-types and causes of failures- Bath tub curve.-System reliability- life testing.	**9**
V	**Activities And Techniques in TQM Projects** : Affinity diagram - brainstorming - cause and effect analysis - process flow chart – check sheets- Scatter diagram - Pareto chart- Histogram and fundamentals of statistics - Taguchi's robust design- Total Productive maintenance- Failure Mode and Effect Analysis - Quality auditing.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U42B	INDUSTRIAL HYDRAULICS	PEC	2	1	0	3	2020

i) PRE-REQUISITE:

ii) COURSE OVERVIEW:

This course covers the fundamentals of operating principles, configuration features, functionalities, and applications of various elements in typical hydraulic systems

iii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain the basic elements of a fluid power system	Understand
CO2	Explain the operation and features of various hydraulic actuators	Understand
CO3	Outline the purpose, construction and operation of various control valves	Understand
CO4	Develop a hydraulic circuit to perform a desired function	Apply

iv) SYLLABUS:

Introduction to fluid power: - Classification of fluid power systems- Basic components, Symbols & circuits of a hydraulic and pneumatic system, - Fluid for hydraulic systems- Hydraulic fluids reservoirs- Hydraulic seals- Filters and Strainer

Hydraulic pumps: - - Principle of working and constructional details of vane pump, gear pumps, radial and axial plunger pumps- Pump performance, Hydraulic pressure intensifiers, Power storage devices –Accumulators

Hydraulic actuators: - Linear Hydraulic Actuators-Types, Cylinder cushions, Rotary actuators – Classification, construction and working of gear, vane, axial and radial piston motors Limited rotation hydraulic actuators- Hydraulic motor performance.

Hydraulic control valves: Directional control valves Pressure control valves- Flow control valves- Servo Valves Hydraulic conductors

Hydraulic circuits:- Control of single and double acting hydraulic cylinder, Regenerative circuit- Pump-unloading circuit, Double pump hydraulic system, Pressure intensifier circuit, Counter balance valve application, Hydraulic cylinder sequencing circuits, Automatic cylinder reciprocating system, Locked cylinder using pilot check valves, Cylinder synchronizing circuits- Speed control of a hydraulic cylinder, Bleed off flow control circuit Fail-safe circuits- Hydraulic motor breaking system, Hydraulic circuit examples with accumulator

v a) TEXTBOOKS

1) Anthony Esposito, Fluid Power with Applications, Pearson Education India, 2013 NIL

b) REFERENCES

1) J. J. Pipenger, Tyler Gregory Hicks, Industrial Hydraulics, McGraw Hill,1979
2) Herbert E. Merritt, Hydraulic Control Systems, John Wiley & Sons, 1967
3) S R Majumdar, Oil hydraulic systems: Principles and Maintenance, McGraw Hill Education, 2017
4) Qin Zhang, Basics of hydraulic systems, CRC Press, 2018.

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Introduction to fluid power – Classification of fluid power systems, Hydraulics and pneumatics systems, Hydrostatic and hydrodynamic Systems, Advantages, disadvantages and applications of fluid power Basic components, symbols & circuits of a hydraulic and pneumatic system, Comparison between hydraulic and pneumatic systems, Comparison of different power systems Properties of fluids- Density, Specific weight, Specific volume and Specific gravity- Pressure, head and force- Pascal's law and its applications-Bulk modulus-Viscosity and viscosity index Hydraulic fluids and fluid-handling components:- Fluid for hydraulic systems-Functions of hydraulic fluid	9
II	Hydraulic pumps: Classification and pumping theory, Gear pump Construction and working of external gear pump, Advantages and disadvantages, Theoretical flow rate Construction and working of the Internal gear pump, Lobe pump, Gerotor pumps and Screw pump Construction and working of Vane pump, Advantages and disadvantages, Theoretical flow rate, Variable displacement vane pump- Balanced vane pump, Advantages and disadvantages Piston pump- Axial and radial design, Axial piston pump (Bent axis design, Swash-plate-type piston pump, and Radial piston pump, Pump performance-Volumetric efficiency,Mechanical efficiency and Overall efficiency, Pump performance curve, Pump noise and Pump selection Hydraulic pressure intensifier:-axial-piston style single and double-acting hydraulic pressure intensifiers Power storage devices - Accumulators: Types- Weight loaded or gravity type, Spring loaded type and Gas loaded (Non-separator and separator) type.	9

III	Linear hydraulic actuators-Types-Single acting and double acting cylinders, Ram cylinders, Telescopic cylinders and Tandem cylinders Cylinder cushions, Cushioning pressure, Cylinder force, Velocity and Power, Acceleration and deceleration of cylinder loads Cylinder mountings, Mechanics of hydraulic cylinder loadings First class, Second class and Third class lever systems Rotary actuators – Classification, Construction and working of gear, vane, balanced vane, axial (Swash plate and Bent-axis design) and radial piston motors, Limited rotation hydraulic actuators Theoretical torque, power, flow rate, hydraulic motor performance- volumetric efficiency, mechanical efficiency and overall efficiency, Performance characteristics of hydraulic motor, Comparison of gear, vane and piston motor, Simple numerical problems	**9**
IV	Hydraulic control valves-Classification of control valves, Directional control valves-symbolic representation, constructional features of poppet, sliding spool, rotary spool valves, Manual, mechanical, solenoid and pilot operated DCV, shuttle valve, and check valves-Two way, Three way, and Four way valves Applications Pressure control valves – types, Simple pressure-relief valve, Compound pressure-relief valve, Pressure-reducing valve, Unloading valve, Counterbalance valve and Pressure sequence valve- Applications Flow control valves – Functions of flow control valves, Factors that determine the flow rate across an orifice or a restrictor, compensated and non-compensated FCV, needle valve, temperature compensated, pressure compensated, pressure and temperature compensated FCV, symbolic representation. Servo valves-Mechanical-hydraulic servo valve, Electrohydraulic servo valve, Proportional control valves Hydraulic conductors-Conductor sizing, Pressure rating of conductors, Steel pipes, Steel tubing, Plastic conductors and Flexible hoses, Pressure losses in hydraulic conduits	**9**
V	Control of single and Double -acting hydraulic cylinder, Regenerative circuit- Expression for the cylinder extending speed Pump-Unloading Circuit, Double-pump hydraulic system, Pressure intensifier circuit, Counter balance valve application Hydraulic cylinder sequencing circuits, Automatic cylinder reciprocating system Locked cylinder using pilot check valves, Cylinder synchronizing circuits- Parallel and series Speed control of a hydraulic cylinder-meter-in and meter-out circuit, Meter-in and meter-out flow control of both strokes, Bleed-off flow control circuit Fail-Safe circuits- Protection from inadvertent cylinder extension and fail-safe overload protection Hydraulic motor breaking system, Hydraulic circuit examples with accumulator-Accumulator as an auxiliary power source, Accumulator as a leakage compensator, Accumulator as an emergency power source, Accumulator as a shock absorber	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U42C	Pressure Vessel and Piping Design	PEC	2	1	0	3	2020

i) **PRE-REQUISITE:** ME1U20A Mechanics of Solids

ii) **COURSE OVERVIEW:**

Objective of the course is to develop knowledge of pressure vessel design, designing of piping and piping systems, and familiarize with the codes and practices in design.

iii) **COURSE OUTCOMES:**

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain the design considerations of pressure vessels.	Understand
CO2	Explain the design considerations of thick cylinders under various kinds of loadings.	Understand
CO3	Apply design concepts in the design of shell and supports of vertical and horizontal pressure vessels	Apply
CO4	Solve problems involving the thickness and stiffener support requirements of cylinders under buckling loads	Apply
CO5	Solve problems involving pipe stress and flexibility analysis and also understand the fracture based design concepts of pressure vessels	Apply

iv) **SYLLABUS:**

Design of thin pressure vessels: Membrane stresses in general axisymmetric shell under internal Pressure. Stresses and dilation in various kinds of components. Bending plates

Design of thick pressure vessels: Stresses in thick walled cylinders – Lame's equation - Shrink fit Stresses in built up cylinders in Built up cylinders. Autofrettage in cylinders. Thermal stresses and significance

Vertical and horizontal vessel design: Design of tall vertical shell structure and its supports, Design of shell and supports for horizontal vessels, Familiarization with standards and codes

Buckling Analysis: Derivation of critical buckling pressure under external pressure, Pipe sizing and stiffener support design, Combined circumferential and axial buckling design.

Flexibility analysis and fracture design: Pipe stress and flexibility analysis, Fracture fundamentals, SIFs, leak before break and failure assessment diagram

v **a) TEXTBOOKS**

1) John F. Harvey, "Theory and Design of Pressure Vessels" CBS Publisher and Distributors

2) Brownell, L. E., and Young, E. H., "Process Equipment Design", John Wiley and Sons
3) Somnath Chathopadhyay, "Pressure Vessels Design and practice", C. R. C Press
4) Prashant Kumar, "Elements of fracture mechanics", McGraw Hill Education India

b) REFERENCES

1) Henry H. Bender, "Pressure Vessels Design hand book"
2) ASME Pressure Vessel Codes Section VIII, 2006
3) Dennis Moss,"Pressure Vessel Design Manual" Gulf publishing, 2003
4) "American standard code for pressure piping, B 31.1", ASME
5) ASME Pressure Vessel and Boiler code, Section VIII Div. 1, 2, and 3", ASME
6) Smith P, "Fundamentals of Piping Design", Elsevier
7) T. L Anderson "Fracture Mechanics: Fundamentals and applications" Taylor &Francis
8) J. Phillip Ellenberger, "Pressure Vessels: ASME Code Simplified", ASME
9) D. Broek, "Elementary Engineering Fracture Mechanics", Kluwer Academic Publications

vi) COURSE PLAN:

Module	Contents	No. of hours
I	**Pressure vessel** – Terminology – Types of loads – Types of pressure- Stresses in pressure vessels – Dilation of pressure vessels – Membrane stress analysis of vessel shell components Cylindrical shells, spherical shells, torus, conical head, elliptical head Bending of circular plates under uniform pressure load with simply supported and clamped edges (no derivation)	8
II	**Stresses in thick walled cylinders –** Lame's equation for internal and external pressure Shrink-fit stresses in Built up cylinders, autofrettage of thick cylinders, Thermal stresses and their significance	9
III	**Design of pressure vessels-** shell and support design of tall vessel under wind and seismic load. Shell and support design of horizontal vessels. Familiarization with relevant ASME codes and standard practices in pressure vessel design	10

IV	**Buckling** -Elastic buckling of cylinders or pipes under external pressure- Pipe sizing under external pressure- Design of Stiffeners Buckling under combined compressive pressure and axial load	**9**
V	**Pipe stress Analysis** -allowable displacement stress range for expected cyclic life-stress intensification factor and flexibility factor-Flexibility Analysis (Analysis as per clause 119.7.1 in Code ASME B31.1/clause 319.4.1 in ASME B31.3 only) Fracture based design of pressure vessels- modes of fracture-stress intensity factor –through thickness and surface cracks in pressure vessels (mode-I only)-fracture toughness-leak before break-failure assessment diagram	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U42D	DATA ANALYTICS FOR ENGINEERS	PEC	2	1	0	3	2020

i) **PRE-REQUISITE:** MA0U20D Probability, Statistics and Numerical Methods

ii) **COURSE OVERVIEW:**

Objective of the course to impart knowledge of the techniques to analyze different types of data,characterize it and can apply them to make decision modelling process more intelligent

iii) **COURSE OUTCOMES:**

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain different data analysis techniques	Understand
CO2	Discuss the concepts behind the descriptive analytics and predictive analytics of data.	Understand
CO3	Describe with Big Data and its sources	Apply
CO4	Illustrate different visualization techniques in data analysis material handling.	Apply

iv) **SYLLABUS:**

Introduction to Data Analysis - Evolution of Analytic scalability, analytic processes and tools, Statistical concepts: Sampling distributions, prediction error.

Predictive Analytics – Regression, Decision Tree, Neural Networks. Dimensionality Reduction - Principal component analysis

Descriptive Analytics - Mining Frequent item sets - Market based model – Association and Sequential Rule Mining - Clustering Techniques – Hierarchical – K- Means.

Introduction to Big data framework - Fundamental concepts of Big Data management and analytics - Current challenges and trends in Big Data Acquisition

Popular Big Data Techniques and tools- Map Reduce paradigm and the Hadoop system Applications Social Media Analytics, Recommender Systems- Fraud D

a) TEXTBOOKS

1) EMC Education Services, *Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data*. John Wiley & Sons, 2015.

2) Jaiwei Han, Micheline Kamber, "*Data Mining Concepts and Techniques*", Elsevier, 2006.

3) Michael Berthold, David J. Hand, *Intelligent Data Analysis*, Springer, 2007.2..

b) REFERENCES

1) Bart Baesens," Analytics in a Big Data World: The Essential Guide to Data Science and its Business Intelligence and Analytic Trends", John Wiley & Sons, 2013 Challenges and Future Prospects, Springer, 2014.

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Introduction to Data Analysis - Evolution of Analytic scalability, analytic processes and tools, Analysis vs reporting - Modern data analytic tools. DATA Mining - DATA warehousing - Statistical concepts: Sampling distributions, re-sampling, statistical inference, prediction error.	9
II	Predictive Analytics – Regression, Decision Tree, Neural Networks. Dimensionality Reduction - Principal component analysis	9
III	Descriptive Analytics - Mining Frequent item sets - Market based model – Association and Sequential Rule Mining - Clustering Techniques – Hierarchical – K- Means	9
IV	Introduction to Big data framework - Fundamental concepts of Big Data management and analytics - Current challenges and trends in Big Data Acquisition	9

V	Popular Big Data Techniques and tools- Map Reduce paradigm and the Hadoop system Applications Social Media Analytics, Recommender Systems- Fraud Detection	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U42E	Industrial Tribology	PEC	2	1	0	3	2020

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

The need for structural integrity of the surfaces of components is an essential requirement from the point of view of reliability of industrial components. Surfaces need to possess special properties so to prevent material loss, and to perform with minimal energy losses by way of friction. Surface treatment methods and prudent lubrication strategies coupled with testing-equipment/probes for conducting the tribological investigations form the basic aspects of tribological management in an industry. This course is meant to introduce the basic aspects of tribology, which a practicing engineer or an engineer-analyst working in this area would require.

iii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Apply Surface characterisation techniques for tribological investigations	Apply
CO2	Explain theories of friction.	Understand
CO3	Apply theories of wear for industrial problems.	Apply
CO4	Explain Lubrication methods employed in Industrial scenarios.	Understand
CO5	Explain Surface Coating techniques for industrial applications.	Understand

iv) SYLLABUS:

Tribology as Surface Science- considerations in design of machine elements, and industrial maintenance - surface failure of machine components-Physical and chemical characterization of surfaces-Surface roughness–– The Scanning Electron Microscope- b- X-ray dispersive analysis-. X-ray photoelectron spectroscopy and chemical characterization.

Friction-coefficient of friction- Stribeck Curve-Lubrication regimes- Film thickness parameter- Fundamentals of hydrodynamic lubrication

Measurement of film thickness in well lubricated contacts. Boundary lubrication-plowing and adhesion components-Pin-on-plate arrangement to measure friction. Theories of friction

Wear – wear of metals-wear of polymers- Types of wear: - quantification of wear- wear debris analysis. Pin-on-disk machine and the Four Ball Tester. Friction and wear in the context of internal combustion engines, Bearings, Gears, cams and tappets, and in metal machining.

Lubricants: Terminology - Classification, Grades and applications-Engine oil viscosity classification. Selection of industrial Lubricating oils. Metal working lubricants. Types of additives in lubricants for improved tribological performance. Environmental aspects and sustainability aspects, recycling.

Surface Engineering: Thermal Diffusion Method –Methodical Methods for coating development- PVD Methods-CVD Methods-Electrochemical Deposition-Thermal spraying.

Bearings-Classification, materials, maintenance, diagnostic maintenance of Tribological components and considerations in IC engines and automobile parts, roller chains and wire ropes.

v

a) TEXTBOOKS

1. Prasanta Sahoo, "Engineering Tribology", PHI, New Delhi, 2005.
2. John Williams, "Engineering Tribology", Illustrated edition, Cambridge University Press, 2005.
MECHANICAL ENGINEERING
3. R.D. Arnell, P. B. Davies, J. Halling, T. L. Whomes, "Tribology: Principles and Design Applications ", 1991.

b) REFERENCES

1. Theo Mang, Kirsten Bobzin, and Thorsten Bartels, "Industrial Tribology- Tribosystems, Friction, Wear and Surface Engineering, Lubrication", Wiley-VCH; First edition, 2011.
2. B. Bhushan," Principles and Application of Tribology", Wiley, Second Edition, 2013.
3. G. W. Stachowiak and A. W. Batchelor, "Engineering Tribology", Butterworth-Heinemann, Second revised edition, 2000.

vi) COURSE PLAN:

Module	Contents	No. of hours
I	Tribology as a Surface Science- Tribological considerations in design of machine elements, and industrial maintenance - surface failure of machine components-Physical and chemical characterization of surfaces-Surface roughness- tools for roughness characterization Industrial norms in roughness quantification/characterization-surface finish symbols Characterization of surface morphology – The Scanning Electron Microscope- backscattered and secondary imaging- X-ray dispersive analysis-. X-ray photoelectron spectroscopy and chemical characterization of surface films.	**9**
II	Friction-coefficient of friction- Stribeck curve-Lubrication regimes- Film thickness parameter- Fundamentals of hydrodynamic lubrication - Hydrodynamic pressure profile Visualization and Measurement of film thickness in well lubricated contacts. Boundary lubrication-plowing and adhesion components-Pin-on-plate arrangement to measure friction. Theories of friction	**9**
III	Wear – wear of metals-wear of polymers- Types of wear: adhesive wear-abrasive wear corrosive wear-fretting wear- quantification of wear- wear debris analysis. Pin-on-disk machine and the Four Ball Tester. Friction and wear in the context of internal combustion engines, Bearings, Gears, cams and tappets, and in metal machining.	**9**
IV	Lubricants: Classification according to Carbon Distribution-Viscosity Index-Viscosity Grades and their choice for various applications-Engine oil viscosity classification. Selection of industrial Lubricating oils. Metal working lubricants. Types of additives in lubricants for improved tribological performance. Environmental aspects and sustainability aspects related to use and disposal of lubricating oils, recycling.	**9**
V	Surface Engineering: Thermal Diffusion Methods(carburizing, Nitriding, Nitro-carburizing, boriding, chromizing) –Methodical Methods for coating development-PVD Methods-CVD Methods-Electrochemical deposition-Thermal spraying. Bearings-Classification of Bearings-Bearing materials-Bearing maintenance, diagnostic maintenance of Tribological components and considerations in IC engines and automobile parts, roller chains and wire ropes.	**9**
	Total hours	**45**

PROGRAMME ELECTIVE IV

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U43A	COMPOSITE MATERIALS	PEC	2	1	0	3	2020

i) **PRE-REQUISITE:** ME1U20C Metallurgy and Material Science

ii) **COURSE OVERVIEW:**

This course helps the students to understand the concept of various matrices and reinforcements used in composites. The course also covers about types of fibers, polymer matrix composites, metal matrix composites, ceramic matrix composites and its manufacturing and applications, micromechanics of composites

iii) **COURSE OUTCOMES:**

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain about composites, various matrices and reinforcements used in composites	Understand
CO2	Explain the types of fibers/ whiskers used in composites, structure, properties and applications, manufacturing process	Understand
CO3	Explain polymer matrix composites, classification, properties, characteristics and applications, manufacturing methods.	Understand
CO4	Elaborate about metal matrix composites, classification, properties, characteristics and applications, manufacturing methods, alloys and their potential role as matrices in composites.	Understand
CO5	Elaborate ceramic matrix composites, classification, properties, characteristics and applications, manufacturing methods, micromechanics of composites	Understand

iv) **SYLLABUS:**

Composite: Introduction, definition, characteristics, functions, classification of composites

Fibers: Introduction, types of fibers, natural fibers, glass fiber fabrication, structure, properties and applications, boron fiber fabrication, structure, properties and applications, carbon fiber, Ex-Pan carbon fiber, ex cellulose carbon fiber, Ex-Pitch carbon, carbon fiber structure, properties

Polymer matrix composites (PMC), Metal matrix composites (MMC) : classification of metals, intermetallic, Ceramic matrix composites (CMC) : classification of ceramics and their potential role as matrices, properties, characteristics and applications of ceramics as matrix materials, conventional techniques.

v) a) TEXTBOOKS

1) K. K. Chawla, Composite Materials : Science and Engineering, Springer, 3e, 2013.

2) P.K.Mallicak, Fiber-reinforced composites , Monal Deklar Inc., New York, 1988.

3) Reddy J N (Ed.), Mechanics of Composite Materials; Selected Works of Nicholas J. Pagano, Springer, 1994

4) Robert M. Jones, Mechanics of Composite Materials, CRC Press, 1998

b) REFERENCES

1) F.L.Matthews & R.D.Rawlings, Composite Materials, Engineering and Sciences, Chapman & hall, London, 1994

2) Hand Book of Composites, George Lubin. Van Nostrand, Reinhold Co. 1982

3) Micael hyer, Stress Analysis of Fiber - Reinforced Composite Materials , Tata McGraw Hill, 1998.

vi) COURSE PLAN:

Module	Contents	No. of hours
I	Composite : Introduction, definition, characteristics, functions. Classification of composites based on structure and matrix: History, industrial scene and applications. Smart composites, advantages and limitations. Interfaces: wettability and bonding interface in composites. Types of bonding at interface.	**9**
II	Introduction, types of fibers, natural fibers. Fiberization, stabilization, carbonization, graphitization, glass fiber Fabrication, structure, properties and applications. Boron fiber fabrication, structure, properties and applications. Carbon fiber, Ex-Pan carbon fiber, Ex-Pitch carbon, Ex cellulose carbon fiber Aramid fiber fabrication, structure, properties and applications. Whiskers: characteristics, properties and applications.	**9**
III	Polymer matrix composites (PMC) : thermoset, thermoplastic and Elastomeric polymers. Properties, characteristics and applications asmatrix materials. Processing of polymer matrix composites: hand methods, Lay up method, spray up method. Moulding methods, pressure bagging and bag moulding methods, Autoclave-based processing with prepregs. Pultrusion and filament winding process.	**9**
IV	Classification of metals, intermetallic, alloys and their potential role as matrices in composites. Properties, characteristics and applications of metals as matrix material. Production techniques: powder metallurgy, diffusion bonding, melt stirring. Squeeze Casting, liquid infiltration under pressure, insitu process.	**9**

V	Classification of ceramics and their potential role as matrices. Properties, characteristics and applications of ceramics as matrix materials. Conventional techniques : cold pressing and sintering, hot pressing, Reaction bonding, liquid infiltration, pultrusion. Lanxide process, insitu chemical technique, sol-gel technique Micromechanics of composites: maximum stress and strain criterion (derivations only), Tsai-Hill and Tsai-Wu failure criterion (derivations only), Mechanics of load transfer from matrix to fiber (description only)	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U43B	**ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING**	PEC	2	1	0	3	2020

i) **PRE-REQUISITE:** NIL

ii) **COURSE OVERVIEW:**

This course is specifically designed for Mechanical Engineers to get acquainted with essential mathematical concepts, brush up on their statistics and the fundamentals of ML and AI

iii) **COURSE OUTCOMES:**

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Illustrate the basic mathematics of artificial intelligence and Machine learning	Understand
CO2	Explain the concepts of artificial intelligence	Understand
CO3	Explain machine learning techniques and computing environment that are suitable for the applications under consideration	Understand
CO4	Develop scaling up machine learning techniques and associated computing techniques and technologies for various applications	Apply
CO5	Explain data analytics and Machine learning Applications	Understand

iv) **SYLLABUS:**

Fundamentals of probability and statistics – Probability theory- sample and population – statistical interference – random process – logical relations: Introduction to artificial intelligence - Typical Applications, Keras API, Artificial Neural Networks- (ANNs): Concept, Activation Functions, Feed Forward Neural Networks and Back Propagation-Working of CNN, Machine learning: Introduction, Types of Machine Learning: Supervised, Unsupervised and Reinforcement learning, Applications, Classification vs Prediction Problems, Linear Regression Algorithm, Python Basics: Introduction to KNN (K Nearest Neighbor), Working of KNN, Decide the value of K, Confusion Matrix, Accuracy Score, Introduction to Data Science, Flow of Data Science, Numpy, Pandas, Matplot lib. Machine Learning Applications across Industries.

v **a) TEXTBOOKS**

1) T.K.V. Iyengar “Probability & Statistics”, S.Chand (G/L) & Company Ltd, 2008

2) Schalkoff, R.J., "Artificial Intelligence: An Engineering Approach", McGraw-Hill,1990

3) Stuart Russell and Peter Norvig, "Artificial Intelligence: A modern approach". PrenticeHall, New Jersey, 1995

4) Ethem Alpaydin, Introduction to Machine Learning, 2nd edition, MIT Press 2010

5) Tom Mitchell, Machine Learning, McGraw-Hill, 1997

b) REFERENCES

1 Nilson, N. J., "Principles of Artificial Intelligence", Springer Verlag, Berlin, 1980

2 Eugene Charniak and Drew McDermot, "Introduction to Artificial Intelligence",Addison Wesley Longman Inc., 1998

3 Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements Of Statistical Learning, Second edition Springer 2007

4 Shai Shalev-Shwartz and Shai Ben-David., Understanding Machine Learning ,Cambridge University Press. 2017

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Probability theory- sample and population – statistical interference, random process – logical relations, conditional probability – density function – distributions, Parametric estimation – non parametric – statistical test.	9
II	Introduction to artificial intelligence - Typical Applications, Keras, API, Artificial Neural Networks (ANNs): Concept, Activation Functions, Feed Forward Neural Networks and Back Propagation- Working of CNN, Convolutional Layer, Pooling, Flatten, Image recognition techniques	**9**
III	Machine learning: Introduction, Supervised, Unsupervised and Reinforcement learning, Classification vs Prediction Problems, Linear Regression Algorithm, Python Basics, simple programming exercises using python	9

IV	Introduction to KNN (K Nearest Neighbor), Working of KNN, Confusion Matrix, Accuracy Score, Web Scraping Basics- Need of Web Scraping, Natural Language Processing: Introduction, Stages in natural language Processing	**9**
V	Introduction to Data Science, Flow of Data Science, Numpy, Pandas, Matplotlib, Machine Learning Applications across Mechanical Industries	**9**
	Total Hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U43C	ACOUSTICS AND NOISE CONTROL	PEC	2	1	0	3	2020

i) PRE-REQUISITE: NIL

ii) COURSE OVERVIEW:

To understand the principles of acoustics, give awareness about different acoustic measurement instruments and analysis equipment, introduce the importance of noise control and to give awareness about regulations and standards related to noise exposure.

iii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain various acoustic terminologies and understand the physics behind acoustic wave propagation	Understand
CO2	Evaluate reflection and transmission coefficients in sound transmission through different media and understand the concept ofstanding waves	Apply
CO3	Explain the mechanism of hearing, concept of noise, various noise criteria and standards	Understand
CO4	Explain various noise measures and various noise measurement devices	Understand
CO5	Apply noise control measures to different machines and devices	Apply

iv) SYLLABUS:

Basic acoustic principles, sound pressure, acoustic velocity, particle velocity, acoustic wave equation, Plane acoustic wave, harmonic solution. Spherical waves, Beam width and directivity index. Transmission through one, two and three media Transmission loss- reflection at plane surface, standing waves, standing wave apparatus. Ear its structure and function, Hearing Thresholds, Human reaction to sound. Noise criteria and standards – noise and number index guide lines for designing quieter equipment Noise measurement- microphones, sound level meters, sound intensity probes, dosimeters, noise analyzer and graphic level recorder, spectrum Analysis, Measurement in anechoic and reverberation chambers Principles of noise control, control at

source, during transmission and at receiver- protection of receiver, Acoustic insulation – acoustic materials – acoustic filter and mufflers – plenum chamber, advanced acoustic absorbers.

v a) TEXTBOOKS

1) Kinsler and frey – Fundamentals of Acoustics
2) I. L. Ver, L. L. Beranek– Noise and Vibration Control Engineering
3) Grad – Industrial noise and vibration

b) REFERENCES

1) Malcom J Crocker , Handbook of noise and vibration control, John Wiley & Sons, Inc.
2) Heinrich Kuttruff, Acoustics an introduction, Taylor & Francis
3) David-A Bies. Collin H Hansen, Engineering Noise control- Theory and Practice, Fourth edition, Spon press, London
4) Michael Moser, Engineering Acoustics, Springer

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Introduction – Basic acoustic principles, sound pressure, acoustic velocity, particle velocity Acoustic wave equation, Plane acoustic wave, harmonic solution Frequency, wavelength, acoustic impedance, sound power, sound intensity, Energy density, Decibel scale – relationship between pressure, intensity and power	9
II	Spherical waves – radiation – simple source – hemispherical source- radiating piston – pressure intensity distribution – Beam width and directivity index Transmission through one, two and three media Transmission through pipes – branched and unbranched, resonators – Transmission loss- reflection at plane surface, standing waves, standing wave apparatus.	9
III	Ear its structure and function, Hearing Thresholds, Loudness of Sound, and Sound Adaptation Human reaction to sound – definitions of speech interference level, perceived noise level, phon and sone, hearing loss Noise criteria and standards – noise and number index guide lines for designing quieter equipments	9
IV	Noise measurement- microphones, sound level meters, sound intensity probes, dosimeters, noise analyzer and graphic level recorder, spectrum Analysis Measurement in anechoic and reverberation chambers	9

V	Principles of noise control, control at source, during transmission and at receiver- protection of receiver, Acoustic insulation – acoustic materials – acoustic filter and mufflers – plenum chamber, advanced acoustic absorbers Principles of noise control in machinery such as pumps, rotating machines, reciprocating machines etc	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U43D	HEAT TRANSFER EQUIPMENT DESIGN	PEC	2	1	0	3	2020

i) PRE-REQUISITE: ME1U30E Heat and Mass Transfer

ii) COURSE OVERVIEW:

The course is designed to provide a complete design knowledge of various heat transfer equipment's which are invariably used in most of the chemical process industries.

iii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Analyse the thermal performance of double pipe heat exchangers.	Apply
CO2	Apply the principles of heat transfer in the design of a shell and tube heat exchanger.	Apply
CO3	Analyse the performance of a cooling tower.	Apply
CO4	Illustrate the mechanism of heat transfer in a heat pipe.	Understand
CO5	Apply the operational and design principles of a heat pipe.	Apply

iv) SYLLABUS:

Thermal performance analysis of heat exchangers – Type of heat exchangers, double pipe heat exchangers, Design calculation of double pipe heat exchanger. Shell and tube heat exchangers – classification, Design of shell and tube heat exchangers, performance analysis of 1-2 heat exchanger Direct contact heat transfer –Classification of cooling towers, heat balance, heat transfer by simultaneous diffusion and convection; Design and analysis of cooling towers. Heat pipes –types and applications, operating principles, effective thermal conductivity of wick structures, limitations on heat transport capability . Heat pipe design –fluid selection, wick selection, material selection, heat pipe design procedure, wick design. Non-conventional heat pipes – Applications

v a) TEXTBOOKS

1) Kern, D. Q., Process Heat Transfer, Tata McGraw-Hill, 2000

2) Chi, S. W., Heat Pipe Theory and Practice- A Source Book, McGraw-Hill, 1976

3) Fraas, A. P., Heat Exchanger Design, Second Edition, John Wiley & Sons, 1989

4) Hewitt G.F, Shires G.L. and Bott T.R. Process Heat Transfer, Behel House, 2000.

b) REFERENCES

1) R K Shah, Fundamentals of Heat Exchanger Design, John Wiley & Sons

2) Dunn, P. D. and Reay, D. A., Heat Pipes, Fourth Edition, Pergamon Press, 1994.

3) Das, S.K., Process heat transfer, Narosa publishing house.2005.

4) Robert W. S and Thomas L, Process Heat Transfer Principles Applications and Rules of thumb, Elsevier Science, 2014.

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Thermal performance analysis of heat exchangers - compact, cross flow, liquid to gas, and double pipe heat exchangers, film coefficients for tubes and annuli, equivalent diameter of annuli, fouling factors, caloric or average fluid temperature, true temperature difference; Design calculation of double pipe heat exchanger, double pipe exchangers in series-parallel arrangements	8
II	Shell and tube heat exchangers - tube layouts, baffle spacing, classification of shell and tube exchangers, Design calculation of shell and tube heat exchangers, shell-side film coefficients, shell-side equivalent diameter, true temperature difference in a 1-2 heat exchanger, performance analysis of 1-2 heat exchangers, flow arrangements for increased heat recovery	10
III	Direct contact heat transfer - Classification of cooling towers, wet-bulb and dew point temperatures, Lewis number, cooling-tower internals, heat balance, heat transfer by simultaneous diffusion and convection; Design and analysis of cooling towers, determination of the number of diffusion units, performance evaluation of cooling towers, influence of process conditions and operating variables on their design.	9
IV	Heat pipes - types and applications, operating principles, working fluids, wick structures, control techniques, pressure balance, maximum capillary pressure, liquid and vapour pressure drops, effective thermal conductivity of wick structures, capillary limitation on heat transport capability, sonic, entrainment, and boiling limitations, determination of operating conditions	8

V	Heat pipe design – fluid selection, wick selection, material selection, preliminary design considerations, heat pipe design procedure, determination of heat pipe diameter, design of heat pipe containers, wick design, entertainment and boiling limitations, design problems; Non-conventional heat pipes – flat, rotating, reciprocating and disc shaped heat pipes, heat pipes in cooling microelectronics – micro and mini heat pipes.	**10**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U43E	ROBOTICS AND AUTOMATION	PEC	2	1	0	3	2020

i) PRE-REQUISITE: NIL

ii) COURSE OVERVIEW:

The objective of this course is to know the wide applications of Robotic technology in various domains, familiarize various robot sensors and their perception principles that enable a robot and to get a basic understanding about the kinematics and dynamics of robot

iii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain the concept, development and key components of robotics	Understand
CO2	Apply the mathematics used to describe positions and orientations inspace.	Apply
CO3	Apply the mathematics used to describe positions and orientations inspace.	Apply
CO4	Explain various robot sensors and their perception principles.	Understand

iv) SYLLABUS:

History and evolution of Robotics, Industrial Robots, Field and Service Robots, Wheeled Mobile Robots, Underwater Robots, remotely operated vehicles, Autonomous Underwater Vehicle, Robotics for Healthcare, Rehabilitation Robotics, Aerial Robotics, Domestic Robots. Components of a Robot. Robot drive systems: Pneumatic Drives. Spatial description and Transformations. Robot Manipulator: Manipulator joints Robot Kinematics: Robot Coordinates- global and tool coordinates. Link and joint parameters Denavit and Hartenberg convention, DH algorithm. Robot statics, Robot Dynamics. Sensors and machine vision: Requirements of a sensor, Principles and Applications of the following types of sensors – Position of sensors (Piezo Electric Sensor, LVDT, Resolvers, Optical Encoders), Range Sensors (Triangulation Principle, Structured, Lighting Approach, Laser Range Meters). Proximity Sensors (Inductive, Capacitive and Ultrasonic), Touch Sensors, (Binary Sensors,

Analog Sensors), Wrist Sensors, Compliance Sensors, Slip Sensors. Camera, Frame Grabber, Sensing and Digitizing Image Data – Signal Conversion, Image Storage, Lighting Techniques.

v a) TEXTBOOKS

1) Craig, J.J., Introduction to Robotics: Mechanics and Control, Pearson Education India; 3rd edition ,2008.
2) M.P.Groover, Industrial Robotics – Technology, Programming and Applications, McGraw-Hill, 2001.
3) Fu.K.S., Gonzalz.R.C. and Lee C.S.G., Robotics Control, Sensing, Vision and Intelligence, McGraw-Hill Book Co., 1987
4) Janakiraman.P.A., Robotics and Image Processing, Tata McGraw-Hill, 1995.

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Introduction to robotics: History and evolution of Robotics, Industrial Robots, Field and Service Robots. Wheeled Mobile Robots, Underwater Robots, remotely operated vehicles, Autonomous Underwater Vehicle Robotics for Healthcare, Rehabilitation Robotics Aerial Robotics, Domestic Robots. Components of a Robot: Mechanical systems, Electrical systems. Pneumatic Drives – Hydraulic Drives –Mechanical Drives – Electrical Drives ; D.C. Servo Motors, Stepper Motor ,A.C. Servo Motors	9
II	Robot Manipulator Spatial description and Transformations: Description of Position and Orientation, Rotation matrix, Euler angles. Frames and Displacement mappings, Homogeneous transforms. Transformation of free vectors. Robot Manipulator: Manipulator joints- linear and rotary, Types. link description, link-connection description. Robot architecture, convention for affixing frames to links, reference frames, degree of freedom. Common body and arm configurations in industrial robots- cartesian, polar, cylindrical, jointed arm, SCARA. Wrist assembly-end effector, Mechanical gripper.	9
III	Robot Kinematics :Global and tool coordinates. Link and join parameters. Denavit and Hartenberg convention. DH algorithm. Examples of forward Kinematics of planar robots. Inverse manipulator kinematics. Solvability. Algebraic vs Geometric Solutions. Inverse Kinematics of RR and RP planar manipulators General considerations in trajectory description and generation: joint-space schemes, cartesian-space schemes.	9

IV	Robot Statics and Dynamics Motion of the links of a robot, velocity propagation from link to link, Geometric Jacobian, Jacobian computation Kinematic singularities Static forces in manipulators, Jacobians in the force domain. Cartesian transformation of velocities and static forces. Lagrangian formulation of manipulator dynamics. Dynamical model of 2 DOF planar manipulators	**9**
V	Requirements of a sensor, Piezo Electric Sensor, LVDT, Resolvers, Optical Encoders. Range Sensors, Triangulation Principle, Structured, Lighting Approach, Laser Range Meters. Proximity Sensors-Inductive, Capacitive and Ultrasonic. Touch Sensors, (Binary Sensors, Analog Sensors), Wrist Sensors, Compliance Sensors, Slip Sensors. Camera, Frame Grabber.Sensing and Digitizing Image Data – Signal Conversion.Sensors and machine vision system. Image Storage, Lighting Techniques.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U43F	TECHNOLOGY MANAGEMENT	PEC	2	1	0	3	2020

i) **PRE-REQUISITE: HS0U30B** Management For Engineers

ii) **COURSE OVERVIEW:**

Objective of the course to facilitate the students to understand the concept of technology management, Key issues in managing technology. This course will also help the students to gain a fair understanding on contemporary topics in technology and innovation management.

iii) **COURSE OUTCOMES:**

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain important terms for technology management in organization anddescribe technology management strategy	Understand
CO2	Explain the need of technology forecasting	Understand
CO3	Explain the essence of technology acquisition	Understand
CO4	Outline the basics of innovation	Understand
CO5	Identify human factors in technology management	Apply

iv) **SYLLABUS:**

Technology and Technology Management - Technology- evolution and growth of technology, technology management: concepts and definitions, role and significance of technology management, impact of technology on society and business. Technology and competition, - process technology, product technology

Technology Acquisition and Technology Forecasting - Technology acquisition, new technology, alternatives for acquiring new technologies, - technology forecast methods, principles of technology forecasting. Technology generation and development, technology generation, importance of technology generation and development.

Technology strategy and management - Need for technology strategy, role of technology absorption, benefits of technology absorption, constraints in technology absorption, technology package and technological dependence, Indian experience in technology absorption efforts,

Management of R&D and innovation - Importance of Research and Development (R&D), corporate research and product lifecycle, production costs and R&D, translation of R&D efforts to technology, innovation, types of innovation, difference between innovation and invention, framework for

management of innovation - case studies about management of R&D and innovation..

Human Aspects in Technology Management - Integration of people and technology, human factors to be considered in technology management - human resource management issues in R&D and innovation, technology assessment and environmental impact analysis

a) TEXTBOOKS

1) P N Rastogi, Management of Technology and Innovation: *Competing Through Technological Excellence*, SAGE Publications, 2009

2) Tushman, M.L. and Anderson ,P., *Managing Strategic Innovation & Change*, Oxford University Press, New York, 2004

3) Khurana, V. K., *Management of Technology and Innovation*, Ane Books New Delhi, 2012

4) Narayanan, V. K, *Managing Technology and Innovation for Competitive Advantage*, Pearson Education, 2002

b) REFERENCES

1) Afuah, A, *Innovation Management, Strategies, Implementation and Profits*, Oxford University Press, 2009

2) Paul Trott, *Innovation Management and New Product Development*, Pearson Education, 2004

3) Robert A Burgelman, Clayton.M.Christensen, Steven.C.Wheelright, Strategic *Management of Technology and Innovation (Fifth Edition*), McGraw-Hill Education, 2009

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Technology and Technology Management - Technology- evolution and growth of technology, technology management: concepts and definitions, role and significance of technology management, impact of technology on society and business. Technology and competition, organizing technology at the enterprise level, key issues in managing technological innovation and forms of technology- process technology, product technology.	8
II	Technology Acquisition and Technology Forecasting - Technology acquisition, new technology, alternatives for acquiring new technologies, management of acquired technology, technology forecasting, characteristics of technology forecasting, technology forecast methods, principles of technology forecasting, technology forecasting process, need and role of technology forecasting, forecasting methods and techniques, planning and forecasting. Technology generation and development, technology generation, process, technology development, importance of technology generation and development.	9

III	Technology strategy and management - Need for technology strategy, technology adoption, diffusion, absorption and competitiveness, elements of technology strategy, role of technology absorption, benefits of technology absorption, constraints in technology absorption, technology package and technological dependence, Indian experience in technology absorption efforts, issues involved in the management of technology absorption and government initiatives, technology policies, science and technology policy in India.	**9**
IV	Management of R&D and innovation - Importance of Research and Development (R&D), corporate research and product lifecycle, production costs and R&D, translation of R&D efforts to technology, innovation, types of innovation, difference between innovation and invention, framework for management of innovation, organizational characteristics that facilitate innovation, trademarks, copyrights, patents and their use in innovation management, remedy against infringement, the role of technology transfer in innovation and new product development, role of government in innovation, globalization and innovations, technology and innovation management -case studies about management of R&D and innovation.	**10**
V	Human Aspects in Technology Management - Integration of people and technology, human factors to be considered in technology management - organisational factors and psychological factors, organisational structure and technology, implications of technological change, implementation of rationalization and automation in India, impact of technological change, human resource management issues in R&D and innovation, technology assessment and environmental impact analysis	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U43G	CRYOGENIC ENGINEERING	PEC	2	1	0	3	2020

i) **PRE-REQUISITE:**ME1U20D Engineering Thermodynamics;

ii) **COURSE OVERVIEW:**

This course provides fundamental knowledge of types of cryogenic fluids, behavior of materialsand properties at temperatures, liquefaction systems, cryogenic refrigeration, gas separation, purification, insulators, cryogenic storage, transfer and measuring instruments

iii) **COURSE OUTCOMES:**

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain the properties of cryogenic liquids and properties of material at cryogenic temperatures	Understand
CO2	Analyze cryogenic liquefaction systems	Apply
CO3	Analyze cryogenics refrigeration systems	Apply
CO4	Explain gas separation and purification methods	Understand
CO5	Describe insulation system for cryogenic application and explain cryogenic storage	Understand
CO6	Explain instrumentation for various measurements in cryogenic engineering.	Understand

iv) **SYLLABUS:**

Introduction to cryogenic engineering- Historical background - Major events in the development of cryogenic engineering, Low Temperature properties of Engineering Materials Cryogenic fluids and their properties. Applications of cryogenics

Liquefaction systems – System performance parameters, ideal liquefaction system, Joule-Thomson expansion, Adiabatic expansion, Liquefaction systems for gases other than Neon. Hydrogen and Helium. Liquefaction systems for Neon, Hydrogen and Helium

Cryogenic Refrigeration systems: Ideal isothermal and isobaric refrigeration systems-Refrigeration using liquids as refrigerant, Refrigeration using gases as refrigerant. Refrigerators using solids as working media-Magnetic refrigerators–dilution

refrigerators.

Gas separation and purification: Thermodynamic ideal separation system, mixture characteristics, principle of gas separation, separation of air, hydrogen and helium, gas purification methods

Cryogenic fluid storage and transfer systems: Cryogenic fluid storage vessel, Thermal insulation and their performance at cryogenic temperatures, Super Insulations, Vacuum insulation, Powder insulation, Cryogenic fluid transfer systems, Cryo pumping.

Cryogenic instrumentation, Pressure measurement, Flow measurement, Liquid level gauges, Temperature measurements, Types of heat exchangers used in cryogenic systems, Safety in cryogenic fluid handling, storage and use.

v a) TEXTBOOKS

1) Randal F. Barron, Cryogenic systems, McGraw Hill, 1986
2) M Mukhopadhyay, Fundamentals of Cryogenic Engineering, PHI Learning , 2010
3) K. D. Timmerhaus and T. M. Flynn, Cryogenic Process Engineering, Springer, 2013
4) S.S Thipse, Cryogenics, Narrosa, 2012

b) REFERENCES

1) A. R. Jha, Cryogenic Technology and applications, Elsevier Science, 2011
2) R. B. Scott, Cryogenic Engineering, Van Nostrand Co., 1989
3) M. D. Atrey (Ed.) Cryocoolers: Theory and Applications, 1st ed., International Cryogenics

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Introduction to cryogenic engineering- Historical background - Major events in the development of cryogenic engineering, Low Temperature properties of Engineering Materials - Mechanical properties- Thermal properties- Electric and magnetic properties, Cryogenic fluids and their properties. Applications of cryogenics: Applications in space, food processing, super conductivity, electrical power, biology, medicine, electronics and cutting tool industry.	9

II	Liquefaction systems – System performance parameters, ideal liquefaction system, Joule-Thomson expansion, Adiabatic expansion, Liquefaction systems for gases other than Neon. Hydrogen and Helium. Simple Linde - Hampson system, Claude & Cascaded System. Liquefaction systems for Neon. Hydrogen and Helium – LN2 precooled Linde Hampson and Claude systems, Ortho to Para conversion arrangement in hydrogen liquefaction system, Simon Helium liquefaction system, Collins Helium liquefaction system. Critical components of Liquefaction systems – critical components and their effect on system performance.	**9**
III	Cryogenic Refrigeration systems: Ideal isothermal and isobaric refrigeration systems- Refrigeration using liquids as refrigerant- Linde-Hampson refrigerator, Claude refrigerator. Refrigeration using gases as refrigerant- Stirling cycle, cryo coolers, Philips refrigerator, Effect of regenerator effectiveness on performance of Philips refrigerator, Gifford McMahon refrigerators. Refrigerators using solids as working media-Magnetic refrigerators– Thermodynamics of magnetic refrigerators, dilution refrigerators.	**9**
IV	Gas separation and purification: Thermodynamic ideal separation system, mixture characteristics, principle of gas separation, separation of air, hydrogen and helium, gas purification methods Cryogenic fluid storage and transfer systems: Cryogenic fluid storage vessel, Thermal insulation and their performance at cryogenic temperatures, Super Insulations, Vacuum insulation, Powder insulation, Cryogenic fluid transfer systems, Cryo pumping.	**9**
V	Cryogenic instrumentation, Pressure measurement – McLeod gauge, Pirani gauge and Penning gauge, Flow measurement – Orifice meter, Venturimeter and Turbine flow meter. Liquid level gauges-hydrostatic, resistance gauge, capacitance gauge and thermodynamic gauge, Temperature measurements- ITS-90, Thermocouple, RTD, magnetic thermometers and vapor pressure thermometers, Types of heat exchangers used in cryogenic systems, Safety in cryogenic fluid handling, storage and use.	**9**
	Total hours	**45**

PROGRAMME ELECTIVE V

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U44A	RELIABILITY ENGINEERING	PEC	2	1	0	3	2020

i) **PRE-REQUISITE:** MA0U20D Probability, Statistics and Numerical methods

ii) **COURSE OVERVIEW:**

Objective of the course is to generate in students an awareness of the importance of statistical concepts, and to make them realize that engineering is also largely statistics based.

iii) **COURSE OUTCOMES:**

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain the basic concepts of reliability, various models of reliability and failure concepts.	Understand
CO2	Analyze mathematical models of reliability and failure modes.	Apply
CO3	Interpret the design process of reliability.	Understand
CO4	Explain the relation between reliability, availability and maintainability.	Understand
CO5	Explain economic aspects of reliability and perform reliability management effectively.	Understand

iv) **SYLLABUS:**

Reliability concepts: Definition of reliability, Reliability vs. Quality, Reliability function, MTTF, hazard rate function, bathtub curve, derivation of the reliability function, Failure and Failure modes, Causes of Failures and Unreliability. Reliability Models, constant failure rate.

Redundancy Techniques in System design: Component vs Unit redundancy, Weakest-link Technique, Mixed redundancy, Standby redundancy, Redundancy optimization, double failures and Redundancy. Markov analysis**,** availability, Repairable systems, Markovian models. Reliability Allocation: for series system. Economics of Reliability: Economic issues, Manufacturers cost, Customers cost, reliability achievement cost models, reliability utility cost models, depreciation cost models, availability cost model for parallel systems. Reliability management, Reliability management by objectives

v) **a) TEXTBOOKS**

1) Balagurusamy E., Reliability Engineering, Tata McGraw Hill.

2) Srinath L. S., Reliability Engineering, East West Press

3) Charles E. Ebeling, Reliability and Maintainability Engineering, Tata McGraw Hill.

4) Patrick D. T. O'Connor, Practical Reliability Engineering, John

b) REFERENCES

1) E.E. Lewis, Introduction to Reliability Engineering, JW.

2) NVR Naidu, et al, Total Quality Management, New Age International Publishers.

3) J.M. Juran and Frank M. Gryna, Quality Planning and Analysis, Tata McGraw Hill.

vi) **COURSE PLAN:**

Module	Contents	No. of hours
I	Definition of reliability, Reliability vs. Quality, Reliability function, MTTF,hazard rate function, bathtub curve, derivation of the reliability function, Failure and Failure modes, Causes of Failures and Unreliability Reliability Models: constant failure rate model, time dependent failure models, Weibull distribution, Normal distribution, lognormal distribution.	**9**
II	Serial configuration, parallel configuration, combined series parallel systems, K-out-of-m systems Redundancy Techniques in System design: Component vs Unit redundancy, Weakest-link Technique, Mixed redundancy, Standby redundancy, Redundancy optimization Double failures and Redundancy. Markov analysis, load sharing systems, standby system	**9**
III	Reliability design process, system effectiveness, economic analysis and life cycle cost, Reliability allocation, optimal allocations, ARINC, AGREE methods System safety and Fault Tree Analysis, Tie-set and Cut-set methods Use of Boolean Algebra in reliability analysis.	**9**
IV	Maintainability and Availability: Definitions and basic concepts, Relationship between reliability, availability and maintainability Inherent availability, Achieved availability, Operational availability Operational availability, Repairable systems, Markovian models Reliability Allocation: for series system.	**9**

V	Economics of Reliability: Economic issues, Manufacturers cost, Customers cost, reliability achievement cost models reliability utility cost models, depreciation cost models, availability cost model for parallel systems Reliability management, Reliability management by objectives	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U44B	PROJECT PLANNING AND MANAGEMENT	PEC	2	1	0	3	2020

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

Objective of the course is to involve the application of principles studied in Project planning, Analysis, Selection Implementation of different project which has social cost, multiple projects, project review, financial analysis.

iii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain about the Capital investment, Strategy, Generation & Screening of Project Idea, Demand analysis.	Understand
CO2	Explain the Technical Analysis, Product Mix, Plant Capacity, Cost of project and means finance. Cash flow, Projected Balance sheet, Trial balance, Profit and Loss account, Time value of money	Understand
CO3	Explain about the investment analysis, Cash flow of the project, Cost of capital, Project Risk, Multiple projects, Social Cost Benefit Analysis, Capital Budgeting.	Understand
CO4	Explain about the Rate return of projects, Project financing, Financing infrastructure projects, Financial Institutions, Working capital management. Term loan appraisal.	Understand
CO5	Explain the principles of Project Management, PERT, CPM, Project overview, Post audit, Critical path.	Understand

iv) SYLLABUS:

Capital Investment – Phases of Capital Budgeting, Decision making, Project analysis- Risks, Discounted cash flow (DCF), Financing, Earning per share (EPS), Diversification-risk reduction

Manufacturing process/ technology, Raw materials, product mix, plant capacity, location and site, plant and machinery, project chart and layout, project implementation

Net present value (NPV), Benefit cost ratio (BCR), internal rate of return (IRR), pay back period, accounting rate of return, project cash flow, NPV-IRR comparison, multiple project and constrains.

Project financing, Financial closure, financial institutions, information and documents for term loan appraisal, project appraisal, credit risk rating, inventory management, purchase, optimum level of inventory, economic order quantity, just in time (JIT). Cash Management, Inventory Management, Receivable Management, Cash Management.

Project management, principle-Project planning, project control, cash forecasting, network techniques in project management, development of project network, Network Technologies, PERT model, CPM model, network cost system, project review, post audit, Project review.

v a) TEXTBOOKS

1) Weist, J.D,and F,K. Levy, A management Guide to PERT/CPM, Prectice-Hall of India, New Delhi

2) Pouliquen.L.Y, Risk analysis in Project aAprisal, Johns Hopkins Press, Baltimore, California

b) REFERENCES

1) Dr.Prasanna Chandra. Project Planning, Implementation and Review. Tata McGraw Hill , NewDelhi.

2) Rajiv Srivastava and Anil Misra, Financial Management, Oxford University Press, New Delhi

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	**Capital Investment** – importance and differences, Phases of Capital Budgeting, Decision making, Project analysis- Risks, Discounted cash flow-(DCF), Financing, Earning per share (EPS), weakness in capital budgeting, Formulation of strategies, grand strategy, Diversification- risk reduction-value creation, portfolio strategy, business level strategies, screening of project idea, tools for identifying investment analysis, preliminary screening, positive net present value, demand forecasting,marketing plan, marketing survey. Demandanalysis.	8
II	**Manufacturing process/ technology**, raw materials, product mix, plant capacity, location and site, plant and machinery, project chart and layout, project implementation, need for alternatives, project inter linkage, cost of project, means of finance, profitability projection, basic acceptation and principles of cash flow statement, projected balance sheet, trial balance, profit and loss account, time value of money.	9
III	**Net present value (NPV)**, benefit cost ratio (BCR), internal rate of return (IRR), pay back period, accounting rate of return, project cash flow – basic principle, biases in cash flow estimation, difference between company cost of capital and project cost of capital, project risk analysis, sources,-measures and perspective risk, break even analysis, scenario analysis, managing risk, social cost benefit analysis, UNIDO - approach,features of capital budgeting,NPV-IRR comparison, multipleproject and constrains.	10
IV	**Project financing**, capital structure, key factors in determining the Debt-Equity ratio, sources of finances, equity capital, preference capital, term loan, working capital, project financing structure, financial closure, financial institutions, information and documents for term loan appraisal, project appraisal, credit risk rating, private public partnership (PPP)managing risk in private infrastructure project, working capital management, working capital policy, estimation of working capital, inventory management, purchase, optimum level of inventory, economic order quantity, just in time (JIT). Cash Management, Cash flow process. Term loan appraisal, PPP, Inventory Management, Receivable Management, Cash Management	9

V	**Project management**, principle-forms of project organisation, project planning, project control, authority, orientation , motivation, group function, pre-requisite for successful project implementation, accounts receivable, impact of credit policy, components of credit policy, cash management, motives for holding cash, cash flow process and its relevance, principles of cash management, collection and disbursement management, cash forecasting, network techniques in project management, development of project network, rules for network construction, time estimation, determination of critical path, schedule when resources are limited, Network Technologies, PERT- CPM model, network cost system, project review, post audit, Project review.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U44C	Fracture Mechanics	PEC	2	1	0	3	2020

i) **PRE-REQUISITE:** ME1U20A Mechanics of Solids.

ii) **COURSE OVERVIEW:**

Fracture mechanics is a relatively new engineering discipline concerned with the study of the propagation of cracks, fracture failure and methods to arrest the crack in materials. This subject is based on the implicit assumption that there exists a crack in a material. There are many machine components, plants and equipment that fail through fatigue and fracture. Knowledge of fracture mechanics can assist the machine designer to safeguard structures against catastrophic fracture. Fracture mechanics is applied extensively to many engineering fields like nuclear power plant, aircraft, spaceship, etc. This undergraduate course offers an introduction to the basic concepts of fracture mechanics.

iii) **COURSE OUTCOMES:**

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain the basic concepts of conventional design methodologies, failure mechanics	Understand
CO2	Apply the conservation of energy law for the mathematical formulation of energy	Apply
CO3	Solve the problems related to stresses and displacement fields of linear elastic materials	Apply
CO4	Apply the principal stresses, various theory of yield criteria and failure theories to find the plastic zone shape, size and effective crack length	Apply
CO5	Analyze the elastic-plastic behaviour near crack tip by solving path independent integral	Apply
CO6	Explain the environmentally assisted cracking and corrosion fatigue	Understand

iv) **SYLLABUS:**

Introduction to fracture mechanics, Linear Elastic Fracture Mechanics, An elastic Plastic Zone Shape and Size, J – Integral.

v **a) TEXTBOOKS**

1) Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw Hill, New Delhi, India, 2009

2. Kare Hellan, "Introduction of Fracture Mechanics", McGraw-Hill Book Company,1985

b) REFERENCES

1. T.L. Anderson, Fracture Mechanics – Fundamentals and Applications, 3rd Edition, Taylor and Francis Group, 2005
2. K. R.Y. Simha, Fracture Mechanics for Modern Engineering Design, Universities Press (India) Limited, 2001
3. David Broek," Elementary Engineering Fracture Mechanics ", Fifth off and Noerdhoff International Publisher, 1978

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Introduction to fracture mechanics: - Review on conventional design methodologies, Brittle and ductile fracture, Modes of fracture failure, Damage tolerance, Spectacular failures, Lessons from spectacular failures, fracture mechanics approach to design, damage tolerance approach to design (review)	9
II	Griffith's Dilemma – surface energy- Griffith analysis – Energy Release Rate – Double cantilever beam (DCB) with constant load, DCB with fixed grip, Energy release rate of DCB specimen. An elastic deformation at crack-tip, Crack resistance, stable and unstable crack growth, Rcurve, Critical energy release rate (concepts only).	9
III	Linear Elastic Fracture Mechanics (LEFM): - stress and displacement fields in isotropic elastic materials - Stress intensity factor - Field equations - Airy's Stress Function – Bi harmonic Equation, Westergaard's Approach (concepts only, no derivations, final result)	9
IV	An elastic Plastic Zone Shape and Size: - plastic zone shape for plane stress - plastic zone shape for plane strain. Effective Crack Length: - approximate approach - Irwin's correction – Dug dale approach	9
V	J - Integral: Path independence of J - integral (concepts only), stress strain relation, Engineer approach to J – integral, Ramberg - Osgood relation (simple problem only). Fatigue Crack Propagation: - Paris Law – crack closure. Environmentally Assisted Cracking: - types of corrosion – cracking mechanism. Corrosion Fatigue (concepts only).	9
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U44D	GAS TURBINES AND JET PROPULSION	PEC	2	1	0	3	2020

i) PRE-REQUISITE: ME1U20B Mechanics of Fluids, ME1U30E Heat and Mass Transfer

ii) COURSE OVERVIEW:

Objective of the course is to develop a platform where the students can enhance their engineering knowledge in the fluid mechanics domain

iii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain the basic fundamentals of the various gas turbine cycles	Understand
CO2	Discuss various laws pertaining to gas turbines and jet propulsion	Understand
CO3	Identify, formulate, and solve problems related to gas turbines and jet propulsion	Apply
CO4	Illustrate different techniques used in rocket propulsion	Understand

iv) SYLLABUS:

Compressible Flow: Wave propagation and sound velocity; Mach number and compressible flow regimes; basic equations for one-dimensional compressible flow, isentropic flow relations; area-velocity relation. Gas Turbine Systems and Cycles: System of operation of gas turbines-constant volume and constant pressure gas turbines; thermodynamics of Brayton cycle; regeneration- inter-cooling, reheating and their combinations; closed cycle and semi-closed cycle gas turbines; Compare Gas turbines, I.C engines and steam turbines.

Compressors: Classification-positive displacement and dynamic compressors, Operation of single stage reciprocating compressors; isothermal efficiency; volumetric efficiency; multi-stage compression. Centrifugal compressors; principle of operation; work done and pressure rise; diffuser; compressibility effects; non dimensional quantities for plotting compressor characteristics; compressor characteristics. Axial flow compressors; basic operation; elementary theory; factors effecting stage pressure ratio; degree of reaction; calculation of stage performance; Axial flow characteristics.

Combustion Systems: Types, operational requirements; combustion process; factors affecting combustor design; combustion chamber performance; Gas turbine emissions. Air-breathing Propulsion Systems: Principle of jet propulsion; analysis and performance characteristics of turbojet, turboprop, ramjet and pulsejet; thrust power and propulsion efficiency. Rocket Propulsion: Operating principle; solid and liquid propellants, performance

analysis-calculations for specific impulse and propulsive efficiency.

v **a) TEXTBOOKS**

1) Gas Turbine Theory – Saravanamuttoo, Cohen and Rogers, Pearson Education Asia
2) Gas Turbines – V. Ganesan, Tata McGraw Hill

b) REFERENCES

1) Elements of Gas Turbine Propulsion- James Mattingly, Tata McGraw Hill
2) Gas Turbine Engine Technology – Irwin E Treager, McGraw Hill Education, 2013

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Compressible Flow: Wave propagation and sound velocity; Mach number and compressible flow regimes; basic equations for one-dimensional compressible flow, isentropic flow relations; area-velocity relation; normal shock waves, relation between upstream and downstream flow parameters.	7
II	Gas Turbine Systems and Cycles: System of operation of gas turbines-constant volume and constant pressure gas turbines; thermodynamics of Brayton cycle; regeneration- inter-cooling, reheating and their combinations; closed cycle and semi-closed cycle gas turbines; gas turbine v/s I.C engines and steam turbines	7
III	Compressors: Classification-positive displacement and dynamic compressors, Operation of single stage reciprocating compressors; isothermal efficiency; volumetric efficiency; multi-stage compression. Centrifugal compressors; principle of operation; work done and pressure rise; diffuser; compressibility effects; non dimensional quantities for plotting compressor characteristics; compressor characteristics. Axial flow compressors; basic operation; elementary theory; factors effecting stage pressure ratio; degree of reaction; calculation of stage performance; Axial flow characteristics.	12
IV	Combustion Systems: Types, operational requirements; combustion process; factors affecting combustor design; combustion chamber performance; Gas turbine emissions	7
V	Air-breathing Propulsion Systems: Principle of jet propulsion; analysis and performance characteristics of turbojet, turboprop, ramjet and pulsejet; thrust power and propulsion efficiency Rocket Propulsion: Operating principle; solid and liquid propellants, performance analysis-calculations for specific impulse and propulsive efficiency.	12
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U44E	ADVANCED ENERGY ENGINEERING	PEC	2	1	0	3	2020

i) PRE-REQUISITE: NIL

ii) COURSE OVERVIEW:

Objective of the course is to provide basic ideas about various energy sources and its environmental impacts.

iii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Interpret the energy scenario and explain the concept of various types of power generation	Understand
CO2	Explain solar and wind power generation and its economics.	Understand
CO3	Explain biomass energy sources and its economics.	Understand
CO4	Identify the concepts and feasibility of various renewable energy sources.	Apply
CO5	Explain the environmental impacts of various energy generation and the importance of sustainable energy.	Understand

iv) SYLLABUS:

Introduction, global and indian energy resources, energy audit and power plants. Solar and wind energy – Principle of energy conversion, energy systems and classifications, photovoltaic systems, economics of solar power and wind power, solar–wind hybrid energy. Biomass energy – Biomass as a fuel, conversion types of biomass, economics of biomass power generation. Other renewable energy sources – Brief account of Geothermal, Tidal, Wave, MHD power generation, Fuel cells and Hydrogen energy conversion systems, hybrid systems, economics and technical feasibility of such systems. Environmental impact of energy conversion and sustainability.

v a) TEXTBOOKS

1) P K Nag, Power Plant Engineering, TMH, 2002.

2) Dr. G.K Vijayaraghavan, Dr. R. Rajappan, Dr. S. Sundaravalli, Advanced Energy Engineering, Laxmi Publications.

3) S.S.Thipse, Non Conventional and Renewable Energy Sources.

4) Jefferson W Tester, Sustainable Energy Choosing among options, PHI, 2006.

5) Tiwari G N, Ghosal M K, Fundamentals of renewable energy sources, Alpha Science International Ltd., 2007.

b) REFERENCES

1) David Merick, Richard Marshall, Energy, Present and Future Options, Vol.I & II, John Wiley & Sons, 2001.

2) Godfrey Boyle, Renewable Energy: Power for a Sustainable Future, Oxford University Press, 2012.

3) Roland Wengenmayr, Thomas Buhrke, 'Renewable Energy: Sustainable energy concepts for the future, Wiley – VCH, 2012.

4) Twidell J W and Weir A D, Renewable Energy Resources, UK, E&F.N. Spon Ltd., 2006.

vi) COURSE PLAN:

Module	Contents	No. of hours
I	Introduction to the course, Global and Indian energy resources. Energy demand and supply components, layout and working principles of steam, hydro, nuclear, gas turbine and diesel power plants.	9
II	Solar Energy - passive and active solar thermal energy, solar collectors, solar thermal electric systems, solar photovoltaic systems, economics of solar power. Wind Energy - Principle of wind energy conversion system, wind turbines, aerodynamics of wind turbines, wind power economics. Introduction to solar-wind hybrid energy.	10
III	Biomass Energy – Biomass as a fuel, thermo-chemical, bio-chemical and agro-chemical conversion of biomass - pyrolysis, gasification, combustion and fermentation, transesterification, economics of biomass power generation, future prospects.	8
IV	Other Renewable Energy sources – Geothermal, Tidal, Wave, MHD power generation. Fuel cells – general description, types, applications. Hydrogen energy conversion systems, hybrid systems- Economics and technical feasibility.	9
V	Environmental impact of energy conversion – ozone layer depletion, global warming, greenhouse effect, loss of biodiversity, eutrophication, acid rain, air and water pollution, land degradation, thermal pollution, Sustainable energy, promising technologies, development pathways.	9
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U44F	ADDITIVE MANUFACTURING	PEC	2	1	0	3	2020

i) PRE-REQUISITE: NIL

ii) COURSE OVERVIEW:

This course addresses additive manufacturing principles, variety and its concept, scope of additive manufacturing and areas of application.

iii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain various additive manufacturing processes	Understand
CO2	Explain slicing operations in additive manufacturing	Understand
CO3	Identify the use of liquid and solid based additive manufacturing system	Understand
CO4	Select powder based on use and pre requirement of AM	Understand
CO5	Apply rapid prototyping techniques for obtaining solutions	Apply

iv) SYLLABUS:

Introduction to Additive manufacturing: Importance of Additive Manufacturing- Basic principle of additive manufacturing. Data Processing for Additive Manufacturing Technology: CAD model preparation — Part Orientation and support generation — Model Slicing —Tool path Generation- Introduction to slicing softwares. Fused Deposition Modelling (FDM), Selective Laser Sintering (SLS), Stereo Lithography (SLA). Laminated Object Manufacturing (LOM), Electron Beam Melting (EBM), Laser Engineering Net Shaping (LENS)

3D Printing-STL Format, STL File Problems, consequence of building valid and invalid tessellated models, STL file Repairs: Generic Solution, other Translators, Newly Proposed Formats. Rapid Prototyping, Rapid Tooling. Rapid Manufacturing; Indirect Processes.

v a) TEXTBOOKS

1) Gibson, I, Rosen, D W., and Stucker,B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing,Springer, 2010

2) Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", Third Edition, World Scientific Publishers, 2010

3) Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014

4) Gebhardt A., "Rapid prototyping", Hanser Gardener Publications, 2003

b) REFERENCES

1) Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007

2) Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", Third Edition, World Scientific Publishers, 2010

3) Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018

4) Ehsan Toyserkani, Amir Khajepour, Stephen F. Corbin, "Laser Cladding", CRC Press, 2004

vi) COURSE PLAN:

Module	Contents	No. of hours
I	Introduction to Additive manufacturing: Importance of Additive Manufacturing Basic principle of additive manufacturing- Procedure of product development in additive manufacturing. Classification of additive manufacturing processes, Materials used in additive manufacturing Benefits & Challenges in Additive Manufacturing	**9**
II	Basic Concept — Digitization techniques — Model Reconstruction .Data Processing for Additive Manufacturing Technology CAD model preparation — Part Orientation and support generation. Model Slicing —Tool path Generation. Introduction to slicing softwares: Cura.	**9**
III	Principle, process, advantages and applications of: Fused Deposition Modelling (FDM).Principle, process, advantages and applications of: Selective Laser Sintering (SLS), Stereo Lithography (SLA), Principle, process, advantages and applications of: Laser Engineering Net Shaping (LENS).Principle, process, advantages and applications of: Laminated Object Manufacturing (LOM), Electron Beam Melting (EBM).	**9**
IV	Principle, process, advantages and applications of: Selection Laser Melting (SLM), Jetting, 3D Printing Principle, process, advantages and applications of 3D Printing.STL Format, STL File Problems, consequence of building valid and invalid tessellated models.STL file Repairs: Generic Solution, other Translators, Newly Proposed Formats.	**9**

V	Direct processes: - Rapid Prototyping, Rapid Tooling. Rapid Manufacturing Indirect Processes: - Indirect Prototyping. Indirect Tooling, Indirect Manufacturing. Applications and case studies of Additive Manufacturing: –Biomedical Manufacturing, Aerospace, Automotive- Food- Electronics.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U44G	POWER PLANT ENGINEERING	PEC	2	1	0	3	2020

i) PRE-REQUISITE: ME1U30B Thermal Engineering

ii) COURSE OVERVIEW:

Power Plant Engineering focuses on power generation principles for real world applications. This course is focused on application of energy principles and power generation cycles. The main purpose of implementing this course in curriculum is to learn about how the power is generated in a power plant and its applications

iii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO No	Course Outcomes	Level
CO1	Explain the layout, construction and working of the components inside athermal power plant	Understand
CO2	Explain the layout, construction and working of the components inside a Diesel, Gas and Combined cycle power plants.	Understand
CO3	Explain the layout, construction and working of the components inside nuclear power plants.	Understand
CO4	Explain the layout, construction and working of the components insideRenewable energy power plants.	Understand
CO5	Identify applications of power plants, plant economics, environmental hazards and estimate the costs of electrical energy production.	Understand

iv) SYLLABUS:

COAL BASED THERMAL POWER PLANTS
Major components and its working, operating cycle and its performance

DIESEL, GAS TURBINE AND COMBINED CYCLE POWER PLANTS
Major components and its working, operating cycles and their performance

NUCLEAR POWER PLANTS
Major components and its working, different types and safety measures

POWER FROM RENEWABLE ENERGY
Major renewable sources, extraction of energy from renewable sources

ENERGY, ECONOMIC AND ENVIRONMENTAL ISSUES OF POWER PLANTS
Energy Economics and environmental aspect of power generation.

v a) TEXTBOOKS

1) P.C.Sharma, "Power Plant Engineering", S.K.Kataria Publication, 3rd Edition, 2019.

2) Arora and S. Domkundwar, "A Course in Power Plant Engineering", Dhanpat rai & Co Publication, 5th Edition, 2019.

3) P.K. Nag, "Power Plant Engineering", TMH Publication, 8th Edition, 2020.

b) REFERENCES

1) R.K. Rajput, "A Text Book of Power Plant Engineering", Laxmi Publications, 5th Edition, 2019.

2) K. K. Ramalingam, "Power plant Engineering", Scitech Publishers, 2nd Edition, 2019

3) G.D. Rai, "An Introduction to Power Plant Technology", Khanna Publishers, 3rd Edition, 2021.

4) C. Elanchezhian, "Power Plant Engineering", I.K. International Publications, 2nd Edition, 2020.

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	COAL BASED THERMAL POWER PLANTS Rankine cycle – improvisations, Layout of modern coal power plant, Super Critical Boilers, FBC Boilers, Turbines, Condensers, Steam & Heat rate, Subsystems of thermal power plants. Fuel and ash handling, Draught system. Feed water treatment. Binary Cycles and Cogeneration systems	10
II	DIESEL, GAS TURBINE AND COMBINED CYCLE POWER PLANTS Otto, Diesel, Dual & Brayton Cycle – Analysis & Optimisation. Components of Diesel and Gas Turbine power plants. Combined Cycle Power Plants. Integrated Gasifier based Combined Cycle systems.	9
III	NUCLEAR POWER PLANTS Basics of Nuclear Engineering, Layout and subsystems of Nuclear Power Plants, Working of Nuclear Reactors Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), Canada Deuterium-Uranium reactor (CANDU), Breeder, Gas Cooled and Liquid Metal Cooled Reactors. Safety measures for Nuclear Power plants.	9
IV	POWER FROM RENEWABLE ENERGY Hydro Electric Power Plants – Classification, Typical Layout and associated components including Turbines. Principle, Construction and working of Wind, Tidal, Solar Photo Voltaic (SPV), Solar Thermal, Geo Thermal, Biogas and Fuel Cell power systems.	9

V	ENERGY, ECONOMIC AND ENVIRONMENTAL ISSUES OF POWER PLANTS Power tariff types, Load distribution parameters, load curve, Comparison of site selection criteria, relative merits & demerits, Capital & Operating Cost of different power plants. Pollution control technologies including Waste Disposal Options for Coal and Nuclear Power Plants.	**8**
	Total hours	**45**

S8 MINORS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME0M49B	**MINI PROJECT**	VAC	0	1	6	4	2020

i) PRE-REQUISITE:

ii) COURSE OVERVIEW:

Mini Project Phase I: A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The object of Project Work I is to enable the student to take up investigative study in the broad field of Chemical Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the guidance of a supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment to normally include:

- ♦ Survey and study of published literature on the assigned topic.
- ♦ Preparing an Action Plan for conducting the investigation, including teamwork.
- ♦ Working out a preliminary Approach to the Problem relating to the assigned topic.
- ♦ Block level design documentation
- ♦ Conducting preliminary Analysis/ Modelling/ Simulation/ Experiment/ Design/ Feasibility.
- ♦ Preparing a Written Report on the Study conducted for presentation to the Department

iii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO No	Course Outcomes
CO1	Identify and synthesize problems and propose solutions to them.
CO2	Build work plan and liaison with the team in completing as per schedule.
CO3	Support the above solutions by theoretical calculations and through. experiments.
CO4	Develop technical reports and proper communication skills.
CO5	Demonstrate the data and defend ideas.

iv) CONTINUOUS INTERNAL ASSESSMENT EVALUATION PATTERN

Sl. No.	Level of Evaluation	Marks
1	Interim evaluation by the committee	20
2	Project Guide	30
3	Final Seminar evaluation by the committee	30
4	The report evaluated by the evaluation committee	20
	Total	100
	Minimum required to pass	50

The evaluation committee comprises a panel of HoD or a senior faculty member, Project.coordinator and project supervisor

S8 HONOURS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1H49A	**MINI PROJECT**	VAC	0	1	6	4	2020

i) PRE-REQUISITE:

ii) COURSE OVERVIEW:

Mini Project Phase I: A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The object of Project Work I is to enable the student to take up investigative study in the broad field of Chemical Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the guidance of a supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment to normally include:

♦ Survey and study of published literature on the assigned topic.

♦ Preparing an Action Plan for conducting the investigation, including teamwork.

♦ Working out a preliminary Approach to the Problem relating to the assigned topic.

♦ Block level design documentation

♦ Conducting preliminary Analysis/ Modelling/ Simulation/ Experiment/ Design/ Feasibility.

♦ Preparing a Written Report on the Study conducted for presentation to the Department

iii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO No	Course Outcomes
CO1	Identify and synthesize problems and propose solutions to them.
CO2	Build work plan and liaison with the team in completing as per schedule.
CO3	Support the above solutions by theoretical calculations and through experiments.
CO4	Develop technical reports and proper communication skills.
CO5	Demonstrate the data and defend ideas.

iv) CONTINUOUS INTERNAL ASSESSMENT EVALUATION PATTERN

Sl. No.	Level of Evaluation	Marks
1	Interim evaluation by the committee	20
2	Project Guide	30
3	Final Seminar evaluation by the committee	30
4	The report evaluated by the evaluation committee	20
	Total	100
	Minimum required to pass	50

The evaluation committee comprises a panel of HoD or a senior faculty member, Projectcoordinator and project supervisor