DETAILED SYLLABI

FOR

B. TECH DEGREE PROGRAMME

IN

MECHANICAL ENGINEERING

SEMESTERS VII & VIII

2020 SCHEME

(AUTONOMOUS)

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY
(Approved by AICTE, Autonomous Institution Affiliated to APJ Abdul Kalam Technological University)
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SYLLABUS
SEMESTER VII

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U40A	DESIGN OF MACHINE ELEMENTS	PCC	2	1	0	3	2020

i) PRE-REQUISITE: ME1U30F Dynamics and Design of Machinery

ii) COURSE OVERVIEW:

This course focuses on important topics in design of machine elements. It covers the topics of shaft design with due consideration based on strength and rigidity. The course also includes the design procedure of flat belts and connecting rod of IC engines. The other topics included are journal bearings design, ball and roller bearings, spur gear and helical gear deign considerations. The syllabus also covers design procedure of bevel gear and worm gear.

iii) COURSE OUTCOMES:

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

CO No	Course Outcomes	Level
CO1	Design shafts based on strength, rigidity and design for static and fatigue loads, design flat belts and connecting rod of IC engines	Apply
CO2	Design clutches and brakes	Apply
CO3	Analyse sliding contact bearings and understand design procedure of journal, ball and roller bearings.	Apply
CO4	Design Spur gear and helical gear	Apply
CO5	Design Bevel gears and worm gears	Apply

iv) SYLLABUS:

Shafting: - material, design considerations, causes of failure in shafts, design based on strength, rigidity, and critical speed, design for static and fatigue loads, repeated loading, reversed bending.

Design of flat belt: - material for belts, slip of the belts, creep, centrifugal tension, Power transmitted by flat belts, Design procedure of flat belts

Design of connecting rod in IC engine.

Design of clutches: -single and multiple plate clutch, cone clutch, centrifugal clutch.

Design of brakes: -band brakes, block brakes, simple and differential band brake, internal expanding shoe brake.

Sliding contact bearing: - lubrication, lubricants, viscosity, journal bearings, hydrodynamic theory, Petroff's equation, bearing characteristic number, Sommerfeld number, Heat generated in bearings, Heat dissipated by bearings, Design procedure of Journal bearings.

Ball and roller bearings: - Types, bearing life, static and dynamic load capacity, Stribeck's Equation, selection of bearings, selection of taper roller bearings, Design procedure of Ball and roller bearings, Needle bearings.

Gears: - Materials of gears, terminology of spur Gear, Interference and undercutting, Gear tooth failures, Beam strength of Gear tooth, Estimation of module, Buckingham's equation for dynamic load, wear load, endurance strength of tooth, Gear proportions, Merits and demerits of each type of gears, Design procedure of Spur gear.

Helical gears: - Terminology, Virtual or equivalent number of teeth, Tooth proportions, Beam strength, and Wear strength of Helical gears, Design procedure of Helical gear

Bevel gears: - Classification, Terminology, Pitch angle for bevel gears, Strength of bevel gear, beam strength, wear tooth load, Formative number of teeth, Design procedure of Bevel gear.

Worm gears: - Characteristics of worm gears, Terminology, Advantages and disadvantages, Applications, Terms in Worm gear, Strength of Worm gear, Dynamic strength, Wear tooth load, Design procedure of Worm gear.

v **Design Data Books** (permitted for reference in the end semester examination)

1. Mahadevan, K., and K. Balaveera Reddy, Design Data Handbook, Mechanical Engineers in SI and Metric Units. CBS Publishers & Distributors, New Delhi, 2018.
2. NarayanaIyengar B.R &Lingaiah K, Machine Design Data Handbook, Tata McGraw Hill/Suma Publications, 1984
3. PSG Design Data, DPV Printers, Coimbatore, 2012

b) REFERENCES

1. J. E. Shigley, Mechanical Engineering Design, McGraw Hill,2003
2. Ali M Sadegh & William M Worek, Marks' Standard Handbook for Mechanical Engineers, McGraw Hill Education, 2018
3. Jalaludeen, Machine Design, Anuradha Publications, 2016
4. V.B.Bhandari, Design of Machine elements, McGraw Hill, 2016
5. Juvinall R.C &Marshek K.M., Fundamentals of Machine Component Design, John Wiley, 2011
6. M. F. Spotts, T. E. Shoup, Design of Machine Elements, Pearson Education, 2006
7. RajendraKarwa, Machine Design, Laxmi Publications (P) LTD, New Delhi, 2006
8. Siegel, Maleev& Hartman, Mechanical Design of Machines, International Book Company, 1983

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Shafting: - material, design considerations, causes of failure in shafts, design based on strength, rigidity, and critical speed, design for static and fatigue loads, repeated loading, reversed bending. Design of flat belt:- material for belts, slip of the belts, creep, centrifugal tension, Power transmitted by flat belts, Design procedure of flat belts Design of connecting rod in IC engine.	**9**
II	Design of clutches: -single and multiple plate clutch, cone clutch, centrifugal clutch. Design of brakes: -band brakes, block brakes, simple and differential band brake, and internal expanding shoe brake.	**9**
III	Sliding contact bearing: - lubrication, lubricants, viscosity, journal bearings, hydrodynamic theory, Petroff's equation, bearing characteristic number, Sommerfeld number, Heat generated in bearings, Heat dissipated by bearings, Design procedure of Journal bearings. Ball and roller bearings: - Types, bearing life, static and dynamic load capacity, Stribeck's Equation, selection of bearings, selection of taper roller bearings, Design procedure of Ball and roller bearings, Needle bearings.	**9**
IV	Gears: - Materials of gears, terminology of spur Gear, Interference and undercutting, Gear tooth failures, Beam strength of Gear tooth, Estimation of module, Buckingham's equation for dynamic load, wear load, endurance strength of tooth, Gear proportions, Merits and demerits of each type of gears, Design procedure of Spur gear. Helical gears: - Terminology, Virtual or equivalent number of teeth, Tooth proportions, Beam strength, and Wear strength of Helical gears, Design procedure of Helical gear	**9**
V	Bevel gears: - Classification, Terminology, Pitch angle for bevel gears, Strength of bevel gear, beam strength, wear tooth load, Formative number of teeth, Design procedure of Bevel gear. Worm gears: - Characteristics of worm gears, Terminology, Advantages and disadvantages, Applications, Terms in Worm gear, Strength of Worm gear, Dynamic strength, Wear tooth load, Design procedure of Worm gear.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
NC0U40A	INDUSTRIAL SAFETY ENGINEERING	MNC	2	1	0	-	2020

i) PRE-REQUISITE: NIL

ii) COURSE OVERVIEW:

Objective of the course to impart knowledge of various safety management principles, various safety systems, various machine guarding devices, hazard identification techniques, energy sources, systems & applications and the need in the present context.

iii) COURSE OUTCOMES:

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

CO No	Course Outcomes	Level
CO1	Describe the theories of accident causation and preventive measures of industrial accidents)	Understand
CO2	Explain about personal protective equipment, its selection, safety performance & indicators and importance of housekeeping.	Understand
CO3	Explain different issues in construction industries.	Understand
CO4	Explain various hazards associated with different machines and mechanical	Understand
CO5	Explain different hazard identification tools in different industries with the knowledge of different types of chemical hazards.	Understand

iv) SYLLABUS:

Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety organization- objectives, types, functions, Role of management,

Personal protection in the work environment, Types of PPEs, Personal protective equipment- respiratory and non-respiratory equipment. Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Typical industrial models and methodology.

Introduction to construction industry and safety issues in construction Safety in various construction operations – Excavation and filling – Under-water works – Under-pinning &

Shoring – Ladders & Scaffolds – Tunneling – Blasting – Demolition – Confined space – Temporary Structures. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders**.**

Machinery safeguard-Point-of-Operation, Principle of machine guarding -types of guards and devices. Safety in turning, and grinding. Welding and Cutting-Safety Precautions of Gas welding and Arc Welding, Material Handling equipment-operation & maintenance.
. Hearing Conservation Program in Production industries.

Hazard and risk, Types of hazards –Classification of Fire, Types of Fire extinguishers. Identification of hazards: Inventory analysis, Fire and explosion hazard rating of process plants - Hazard and Operability study (HAZOP)) –Hazardous properties of chemicals, Material Safety Data Sheets

a) TEXTBOOKS

1) R.K Jain (2000) Industrial Safety, *Health and Environment management systems*, Khanna Publications.

2) Paul S V (2000), *Safety management System and Documentation training* Programme handbook, CBS Publication.

3) Krishnan, N.V. (1997). *Safety management in Industry*. Jaico Publishing House, New Delhi.

b) REFERENCES

1) AIChE/CCPS. (1992). *Guidelines for Hazard Evaluation Procedures*. (second edition). Centre for Chemical Process Safety, American Institute of Chemical Engineers, New York.

2) Alan Waring. (1996). *Safety management system*. Chapman & Hall, England.

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety, organization- objectives, types, functions, Role of management, supervisors, workers, unions, government and voluntary agencies in safety. Safety policy. Safety Officer-responsibilities, authority. Safety committee-need, types, advantages.	**9**

II	Personal protection in the work environment, Types of PPEs, Personal protective equipment-respiratory and non-respiratory equipment. Standards related to PPEs. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping. Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces. Technology generation and development, technology generation, process, technology development, importance of technology generation and development.	**9**
III	Introduction to construction industry and safety issues in construction Safety in various construction operations – Excavation and filling – Under-water works – Under-pinning & Shoring – Ladders & Scaffolds – Tunneling – Blasting – Demolition – Confined space –Temporary Structures. Familiarization with relevant Indian Standards and the National Building Code provisions on construction safety. Relevance of ergonomics in construction safety. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders.	**9**
IV	Machinery safeguard-Point-of-Operation, Principle of machine guarding -types of guards and devices. Safety in turning, and grinding. Welding and Cutting-Safety Precautions of Gas welding and Arc Welding. Material Handling-Classification-safety consideration- manual and mechanical handling. Handling assessments and techniques- lifting, carrying, pulling, pushing, palletizing and stocking. Material Handling equipment-operation & maintenance. Maintenance of common elements-wire rope, chains slings, hooks, clamps. Hearing Conservation Program in Production industries.	**9**
V	Hazard and risk, Types of hazards –Classification of Fire, Types of Fire extinguishers, fire explosion and toxic gas release, Structure of hazard identification and risk assessment. Identification of hazards: Inventory analysis, Fire and explosion hazard rating of process plants - The Dow Fire and Explosion Hazard Index, Preliminary hazard analysis, Hazard and Operability study (HAZOP)) – methodology, criticality analysis, corrective action and follow-up. Control of Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U48A	Mechanical Engineering Lab	PCC	0	0	3	2	2020

i) PRE-REQUISITE: ME1U30A Mechanics of Machinery, ME1U30D Machine Tools and Metrology

ii) COURSE OVERVIEW:

Objective of the course is to enable the students to get and exposure to equipment and exercises related to machine dynamics, basics of pneumatic devices, basics of FDM printers and NDT techniques, basic ideas of data acquisition and automation.

iii) COURSE OUTCOMES

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

CO	Course Outcomes	Level
CO 1	Determine mode shapes, critical speeds and natural frequencies of different vibration systems.	Apply
CO 2	Determine the effect of gyroscopic couple in a motorized gyroscope apparatus.	Apply
CO 3	Analyse the response of a system in time and frequency domain.	Apply
CO 4	Inspect cracks using non-destructive testing method.	Apply
CO 5	Develop spur gear using milling machine.	Apply
CO 6	Develop models using 3D printer.	Apply
CO 7	Create pneumatic circuits using basic pneumatic trainer kit and electro-pneumatic trainer kit.	Apply

iv) LIST OF EXPERIMENTS

1. Experiment on Whirling of shaft
2. Experiment on Gyroscope
3. Experiment on Free vibration analysis
4. Experiment on Forced vibration analysis
5. Experiment on any Non-destructive test.
6. Exercises on Milling Machine
7. Exercises on pneumatic circuits using pneumatic trainer unit
8. Exercises on electro pneumatic and electro hydraulic circuits using trainer units
9. Exercises on 3-D printing

10. Exercises on PC based data acquisition system with any software.

v) References

1. C. E. Wilson, P. Sadler, Kinematics and Dynamics of Machinery, Pearson Education, 2005
2. D. H. Myskza, Machines and Mechanisms Applied Kinematic Analysis, Pearson Education, 2013
3. W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Person Education Limited, New Delhi, 2007
4. K. P. Ramachandran, G. K. Vijayaraghavan, M. S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Wiley India Pvt. Ltd., New Delhi, 2008.
5. Serope Kalpakjian, Steven R. Schmid - Manufacturing Engineering and Technology, Pearson

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U49A	SEMINAR	PWS	0	0	3	2	2020

i) **PRE-REQUISITE:** Nil

ii) **COURSE OVERVIEW:**

Objective of the course is to

i) To do literature survey in a selected area of study.

ii) To understand an academic document from the literature and give a presentation about it.

iii) To prepare a technical report

iii) **COURSE OUTCOMES:**

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

CO No	Course Outcomes	Level
CO1	Identify academic documents from the literature that are related to her/his areas of interest.	Understand
CO2	Analyze an academic document from the literature that is related to her/ his areas of interest.	Analyse
CO3	Demonstrate about an academic document through presentation.	Apply
CO4	Summarize the findings through a technical report.	Understand

iv) **General Guidelines**

i) The Department shall form an Internal Evaluation Committee (IEC) for the seminar with academic coordinator for that program as the Chairperson/Chairman and seminar coordinator & seminar guide as members. During the seminar presentation of a student, all members of IEC shall be present.

ii) Formation of IEC and guide allotment shall be completed within a week after the University examination (or last working day) of the previous semester.

iii) Guide shall provide required input to their students regarding the selection of topic/ paper.

iv) Choosing a seminar topic: The topic for a UG seminar should be current and broad based rather than a very specific research work. It's advisable to choose a topic for the Seminar to be closely linked to the final year project area. Every member of the project team could choose or be assigned Seminar topics that covers various aspects linked to the Project area.

v) A topic/paper relevant to the discipline shall be selected by the student during the semester break.

vi) Topic/Paper shall be finalized in the first week of the semester and shall be submitted to the IEC.

vii) The IEC shall approve the selected topic/paper by the second week of the semester.

viii) Accurate references from genuine peer reviewed published material to be given in the report and to be verified.

Evaluation pattern

Total marks: 100, only CIE, minimum required to pass 50

Seminar Guide: 20 marks (Background Knowledge – 10 (The guide shall give deserving marks for a candidate based on the candidate's background knowledge about the topic selected), Relevance of the paper/topic selected – 10).

Seminar Coordinator: 20 marks (Seminar Diary – 10 (Each student shall maintain a seminar diary and the guide shall monitor the progress of the seminar work on a weekly basis and shall approve the entries in the seminar diary during the weekly meeting with the student), Attendance – 10).

Presentation: 40 marks to be awarded by the IEC (Clarity of presentation – 10, Interactions – 10 (to be based on the candidate's ability to answer questions during the interactive session of her/his presentation), Overall participation – 10 (to be given based on her/his involvement during interactive sessions of presentations by other students), Quality of the slides – 10).

Report: 20 marks to be awarded by the IEC (check for technical content, overall quality, templates followed, adequacy of references etc.).

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U49B	Project Phase-I	PWS	0	0	6	2	2020

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 8th semester. 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.

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.

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 work 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

PROJECT PHASE I

Phase I Targets

- Literature study/survey of published literature on the assigned topic
- Formulation of objectives
- Formulation of hypothesis/design/methodology

- Formulation of work plan and task allocation.
- Block level design documentation
- Seeking project funds from various agencies
- PreliminaryAnalysis/Modeling/Simulation/Experiment/Design/Feasibilitystudy
- Preparation of Phase1report

Evaluation Guidelines & Rubrics

Total: 100 marks(Minimum required to pass:50 marks).

- Project progress evaluation by guide: 30 Marks.
- Interim evaluation by the Evaluation Committee: 20 Marks.
- Final Evaluation by the Evaluation Committee: 30 Marks.
- Project Phase –I Report (By Evaluation Committee):20Marks.

(The evaluation committee comprises HoD or a senior faculty member Project coordinator and project supervisor).

Evaluation by the Guide

The guide/supervisor shall monitor the progress being carried out by the project groups on a regular basis. In case it is found that progress is unsatisfactory it shall 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. Proj ect evaluation by the guide: 30 Marks. This mark shall be awarded to the students in his/hergroup by considering the following aspects:

Topic Selection: innovativeness, social relevance etc.(2)

Problem definition: Identification of the social, environmental and ethical issues of the project problem.(2)

Purpose and need of the project: Detailed and extensive explanation of the purpose and need of the project. (3)

Project Objectives: All objectives of the proposed work are well defined; Steps to be followed to solve the defined problem are clearly specified. (2)

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.(3)

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 adhered 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. (7)

EVALUATION RUBRICS for PROJECT Phase I: Interim Evaluation						
No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
1-a	Topic identification, selection, formulation of objectives and/or literature survey. (Group assessment) [CO1]	10	The team has failed to come with a relevant topic in time. Needed full assistance to find a topic from the guide. They do not respond to suggestions from the evaluation committee and/or the guide. No literature review was conducted. The team tried to gather easy information without verifying the authenticity. No objectives formed yet.	The team has identified a topic. The originally selected topic lacks substance and needs to be revised. There were suggestions given to improve the relevance and quality of the project topic. Only a few relevant references were consulted/ studied and there is no clear evidence to show the team's understanding on the same. Some objectives identified, but not clear enough.	Good evidence of the group thinking and brainstorming on what they are going to build. The results of the brainstorming are documented and the selection of topic is relevant. The review of related references was good, but there is scope of improvement. Objectives formed with good clarity, however some objectives are not realistic enough.	The group has brainstormed in an excellent manner on what they were going to build. The topic selected is highly relevant, real world problem and is potentially innovative. The group shows extreme interest in the topic and has conducted extensive literature survey in connection with the topic. The team has come up with clear objectives which are feasible.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
1-b	Project Planning, Scheduling and Resource/ Tasks Identification and allocation. (Group assessment) [CO4]	10	No evidence of planning or scheduling of the project. The students did not plan what they were going to build or plan on what materials / resources to use in the project. The students do not have any idea on the budget required. The team has not yet decided on who does what. No project journal kept.	Some evidence of a primary plan. 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 details. Some evidence on task allocation among the team members.	Good evidence of planning done. Materials were listed and thought out, but the plan wasn't quite complete. Schedules were prepared, but not detailed, and needs improvement. Project journal is presented but it is not complete in all respect / detailed. There is better task allocation and individual members understand about their tasks. There is room for improvement.	Excellent evidence of enterprising and extensive project planning. Gantt charts were used to depict detailed project scheduling. A project management/version control tool is used to track the project, which shows familiarity with modern tools. All materials / resources were identified and listed and anticipation of procuring time is done. Detailed budgeting is done. All tasks were identified and incorporated in the schedule. A well-kept project journal shows evidence for all the above, in addition to the interaction with the project guide. Each member knows well about their individual tasks.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
Phase 1 Interim Evaluation Total Marks: 20						

EVALUATION RUBRICS for PROJECT Phase I: Final Evaluation						
Sl. No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
1-c	Formulation of Design and/or Methodology and Progress. (Group assessment) [CO1]	5	None of the team members show any evidence of knowledge about the design and the methodology adopted till now/ to be adopted in the later stages. The team has not progressed from the previous stage of evaluation.	The students have some knowledge on the design procedure to be adopted, and the methodologies. However, the team has not made much progress in the design, and yet to catch up with the project plan.	The students are comfortable with design methods adopted, and they have made some progress as per the plan. The methodologies are understood to a large extent.	Shows clear evidence of having a well- defined design methodology and adherence to it. Excellent knowledge in design procedure and its adaptation. Adherence to project plan is commendable.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
1-d	Individual and Teamwork Leadership (Individual assessment) [CO3]	10	The student does not show any interest in the project activities, and is a passive member.	The student show some interest and participates in some of the activities. However, the activities are mostly easy and superficial in nature.	The student shows very good interest in project, and takes up tasks and attempts to complete them. Shows excellent responsibility and team skills. Supports the other members well.	The student takes a leadership position and supports the other team members and leads the project Shows clear evidence of leadership.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
1-e	Preliminary Analysis/ Modeling / Simulation/ Experiment / Design/ Feasibility study [CO1]	10	The team has not done any preliminary work with respect to the analysis/modeling/ simulation/experiment/design/feasibility study/ algorithm development.	The team has started doing some preliminary work with respect to the project. The students however are not prepared enough for the work and they need to improve a lot.	There is some evidence to show that the team has done good amount of preliminary investigation and design/ analysis/ modeling etc. They can improve further.	Strong evidence for excellent progress in the project. The team has completed the required preliminary work already and are poised to finish the phase I in an excellent manner. They have shown results to prove their progress.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)

1-f	Documentation and presentation. (Individual & group assessment). [CO6]	5	The team did not document the work at all. The project journal/diary is not presented. The presentation was shallow in content and dull in appearance. The individual student has no idea on the presentation of his/her part.	Some documentation is done, but not extensive. Interaction with the guide is minimal. Presentation include some points of interest, but overal quality needs to be improved Individual performance to be improved.	Most of the project details were documented well enough. There is scope for improvement. The presentation is satisfactory. Individual performance is good.	The project stages are extensively documented in the report Professional documentation tools like LaTeX were used to document the progress of the project along with the project journal. The documentation structure is well planned and can easily grow into the project report. The presentation is done professionally and with great clarity The individual's performance is excellent.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
Total		**30**	**Phase - I Final Evaluation Marks: 30**			

EVALUATION RUBRICS for PROJECT Phase I: Report Evaluation

Sl. No.	Parameters	Marks	Poor	Fair	Very Good	Outstanding
1-g	Report [CO6]	20	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.	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.	Project report shows evidence of systematic documentation. Report is following the standard format and there are only a few issues. Organization of the report is good. Most of references are cited 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 standard styles.
			(0 - 7 Marks)	(8 - 12 Marks)	(13 - 19 Marks)	(20 Marks)
			Phase - I Project Report Marks: 20			

PROGRAMME ELECTIVE II

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U41A	ADVANCED METHODS IN NON DESTRUCTIVE TESTING	PEC	2	1	0	3	2020

i) PRE-REQUISITE: NIL

ii) COURSE OVERVIEW:

This course enables students to develop a fundamental knowledge about the advanced techniques and the recent developments in non-destructive testing so as to control the quality in manufacturing engineering components, gain practical knowledge in non-destructive testing (NDT) processes and provide a detailed discussion on the advanced non-destructive testing methods, knowledge of different NDT methods in complex geometries and enable them to select the appropriate methods for better evaluation

iii) COURSE OUTCOMES:

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

CO No	Course Outcomes	Level
CO1	Explain the theoretical and practical aspects in methods of non-destructive testing processes	Understand
CO2	Explain the knowledge of advanced methods in ultrasonic testing which enables learners to perform inspection of samples.	Understand
CO3	Analyse complete theory and techniques in radiographic testing, interpretation and evaluation.	Analyse
CO4	Develop the recent advances in the field of non-destructive testing.	Apply
CO5	Outline the recent and advanced developments in radiography testing.	Understand

iv) SYLLABUS:

Visual Testing -Liquid Penetrant Testing-Magnetic Particle Testing- Magnetic Particle Testing Equipment- Eddy Current Testing – Selection of testing methods- Codes, Standards and Specifications. Fundamentals of Ultrasonic Waves, Fresnel and Fraunhofer effects– wave propagation in other engineering materials. Generation of ultrasonic waves– contact

testing, immersion testing. Ultrasonic Guided Waves- Electro –Magnetic Acoustic Transducer -Optical methods in Ultrasonics- Laser Ultrasonics –Principles of Radiography -Film Radiography -Radiographic Image Quality and Radiographic Techniques -Radiation Detectors and Safety - Principle of radiation- Special Radiographic Techniques and Interpretation of radiographs of Fluoroscopy-Real-time radioscopy – Principle of neutron radiography - Phased Array Techniques. Beam shaping, steering –Scanning with phased array probes- linear, sectorial, C scan. Time of Flight Diffraction Theory and principles of Time-of-Flight Diffraction (TOFD)–Data acquisition and interpretation– TOFD techniques codes and standards–interpretation, evaluation, applications. Synthetic Aperture Focusing Technique (SAFT). Structural Health Monitoring (SHM)-methods- strain gauging- genetic algorithm Acoustic emission inspection-Leak Testing - -Thermographic NDE- Contact and non-contact thermal inspection methods– Heat sensitive paints – Heat sensitive papers - Inspection methods – Infrared radiation and infrared detectors– thermo mechanical behaviour of materials– IR imaging in aerospace applications-Digital Radiography and Computed Tomography (CT) -computed radiography (CR) and direct radiography (DR) - industrial CT.

v) a) TEXTBOOKS

1) J.Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGraw-Hill Education, 2nd edition (2011).
2) B.Raj, T. Jayakumar and M. Thavasimuthu, Practical Non Destructive Testing, Alpha Science International Limited, 3rd edition (2007).
3) J. L. Rose, Ultrasonic waves in solid media, Cambridge University Press, (2004).
4) A.S. Paipetis,T. E Matikas and D. G. Aggelis, Emerging Technologies in Non-Destructive Testing, CRC Press, (2012).

b) REFERENCES

1) X. P. V. Maldague, Nondestructive evaluation of materials by infrared thermography, Springer-Verlag, 1st edition, (1993
2) Non-Destructive Examination and Quality Control, ASM International, Vol.17, 9th edition (1989)
3) J. Krautkramer and H. Krautkramer, Ultrasonic Testing of Materials, Springer, 4th edition (1990).
4) L. W. Schmerr, Fundamentals of Ultrasonic Phased Arrays, Springer, (2014)

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	**Visual Testing** Fundamentals of Visual Testing – vision, lighting, material attributes, environmental factors, visual perception, direct and indirect methods **Liquid Penetrant Testing** Principles – types and properties of liquid penetrants – developers – advantages and limitations of various methods - selection of penetrant method - Applicable codes and standards. **Magnetic Particle Testing** Theory of magnetism – ferromagnetic, paramagnetic materials – characteristics of magnetic fields. **Magnetic Particle Testing Equipment** Selecting the method of magnetization, inspection materials, magnetic particle inspection of castings and welding – Dry continuous method, wet residual method- Applicable codes and standards **Eddy Current Testing** Generation of eddy currents – effect of change of impedance on instrumentation – properties of eddy currents – eddy current sensing elements, probes, type of coil arrangement Applicable codes and standards.	9
II	**Fundamentals of Ultrasonic Waves** Nature of sound waves, wave propagation in metals– modes of sound wave generation – longitudinal waves, transverse waves, surface waves, lamb waves– Snell's law and critical angles – Fresnel and Fraunhofer effects– wave propagation in other engineering materials. **Generation of ultrasonic waves** Methods of ultrasonic wave generation – piezo electric effect, piezo electric materials and their properties – crystal cuts and mode of vibration – Ultrasonic search Units (transducers), types (straight, angle, dual) **Ultrasonic Inspection Methods and Equipment** Principle of pulse echo method, through transmission method, resonance method – Advantages, limitations – contact testing, immersion testing. **Ultrasonic Guided Waves-** Basics of guided waves– Generation of guided waves–Introduction to Electro –Magnetic Acoustic Transducer -EMAT Optical methods in Ultrasonics- Laser Ultrasonics –bulk wave and lamb wave generation mechanisms – optical detection of ultrasound – measurement of in plane displacement and velocity – Laser shearography – Applications	9

III	**Basic Principles of Radiography -** Radio isotopic sources X-ray source generation and properties – industrial X-ray tubes **Film Radiography** -X-ray film – structure and types for industrial radiography – sensitometric properties – use of film, characteristic curves (H & D curve). **Radiographic Image Quality and Radiographic Techniques** Radiographic sensitivity –single and double wall Radiography – panoramic radiography-procedure shooting sketch/technique sheets **Radiation Detectors and Safety** Special and SI Units of radiation – Principle of radiation	**8**
IV	**Special Radiographic Techniques and Interpretation of radiographs** Principles and applications of Fluoroscopy/Real-time radioscopy **–** advantages and limitations **–**recent advances, intensifier tubes, vidicon tubes etc**–** Principle of neutron radiography - attenuation of neutrons - direct and indirect technique - advantages and limitations – Principle and application of in-motion and flash radiography. *Interpretation of radiographs:-* Interpretation for welds, castings etc, applications, various case studies, Inspection standards - applicable codes, standards and specifications (ASME, ASTM, AWS, BS, IBR etc. **Phased Array Techniques** Principles of phased array inspection **–** phased array probes and their characteristics **–** Phased array wedges **–** Focal law**–** Beam shaping, steering **–**Scanning with phased array probes- linear, sectorial, C scan. **Time of Flight Diffraction** Theory and principles of Time-of- Flight Diffraction (TOFD)**–**Data acquisition and interpretation**–** TOFD techniques **–** selection of probe angle**–** calibration and optimization, optimizing angles**–** flaw location and sizing**–** codes and standards**–** interpretation, evaluation, applications *Introduction to Synthetic Aperture Focusing Technique (SAFT).* **Structural Health Monitoring (SHM)**-methods- strain gauging-genetic algorithm-	**9**

V	**Acoustic emission inspection** Principles and Theory – Signal Propagation – Physical Considerations – The AE Process Chain - Time Considerations – AE Parameters –AE testing during grinding – pipelines – steam turbines – AE location of faults in power transformers. **Leak Testing** Introduction to leak testing– objectives – terminologies – measurement of leakage –Types of leaks – Types of flow in leaks – Principles of Fluid dynamics – Leak Testing of Pressure Systems Without and with a Tracer Gas – Halogen diode leak testing – Helium mass spectrometer leak testing and subsystems –Leak testing for special applications-standards. **Thermographic NDE** Introduction and fundamentals to infrared and thermal testing– Heat transfer – Active and passive techniques – Lock in and pulse thermography– Contact and non contact thermal inspection methods– Heat sensitive paints – Heat sensitive papers – thermally quenched phosphors liquid crystals -Inspection methods – Infrared radiation and infrared detectors–thermo mechanical behavior of materials **Digital Radiography and Computed Tomography (CT)** Principles of Digital Radiography-Methods of digital radiography – digitization of X-ray films – computed radiography (CR) and direct radiography (DR) – process of image formation in CR – comparison of film, CR and DR method. Computed Tomography – industrial CT.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U41B	Optimization Techniques and Applications	PEC	2	1	0	3	2020

i) PRE-REQUISITE:

ii) COURSE OVERVIEW:

This course introduces the students to the concept of solving engineering problems by developing linear and non-linear mathematical models. The models involve objectives and constraints in terms of the relevant design variables. The student learns to apply a suitable mathematical programming technique to solve the developed model. The course includes Linear Programming, Integer Programing, Dynamic Programming, Classical Optimization and Metaheuristic techniques

iii) COURSE OUTCOMES:

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

CO No	Course Outcomes	Level
CO1	Formulate engineering problems as mathematical programming problems	Apply
CO2	Apply Simplex and dual Simplex methods to solve linear programming problems	Apply
CO3	Analyse the sensitivity of the model parameters	Apply
CO4	Solve integer programming problems	Apply
CO5	Apply Dynamic Programming techniques to solve sequential optimization problems	Apply
CO6	Apply classical optimization techniques and algorithms to solve nonlinear	Apply

iv) SYLLABUS:

Formulation of engineering problems, Duality concept in LPP, Dynamic Programming, Classical optimization techniques, Algorithms for unconstrained optimization**.**

v a) TEXTBOOKS

1) Hamdy A. Taha, "Operations Research, An Introduction", Pearson Education, 10th edition, 2019

2) S. S. Rao, "Engineering Optimization, Theory and Practice", New Age International, 3rd edition, 2013

b) REFERENCES

1. N. V. S. Raju, " Optimization Methods for Engineers", Prentice-Hall of India, 1st edition, 2014

2. Ravindran, Philips and Solberg, "Operations Research, Principles and Practice", Wiley, 2nd edition, 2007

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Formulation of engineering problems as mathematical programming models: Linear Programming formulations. Solutions to Linear Programming Problems: Simplex method – Big-M and 2-phase methods – Sensitivity Analysis for the objective function coefficients and right hand side coefficients of constraints - Exceptional cases in LPP	9
II	Duality concept in LPP - Dual Simplex method. Integer Programming problem: Applications of Integer Programming problems – Integer Programming algorithms - Cutting Plane method - Branch and Bound method	9
III	Dynamic Programming: Bellman's principle of optimality - Forward recursion and backward recursion - Application problems- Shortest route and Knapsack problems.	9
IV	Classical optimization techniques: Single variable optimization - Multivariable optimization with no constraints - Optimization with equality constraints - Method of Lagrange Multipliers - Optimization with inequality constraints - Kuhn-Tucker conditions	9
V	Algorithms for unconstrained optimization: Fibonacci search method - Golden section search method -Hooke and Jeeve's method - Newton-Raphson method - Cauchy's (Steepest descent) method	9
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U41C	FINITE ELEMENT METHOD	PEC	2	1	0	3	2020

i) **PRE-REQUISITE:** ME1U20A MECHANICS OF SOLIDS

ii) **COURSE OVERVIEW:**

This course is meant to serve as an introduction to the basic aspects of Finite Element formulation for the undergraduate student. Some formulation schemes for the numerical solution of field problems leading to matrix equations amenable for solution with the aid of computer, forms content of this course.

iii) **COURSE OUTCOMES:**

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

CO No	Course Outcomes	Level
CO1	Apply Matrix methods for solution of some one-dimensional Stress problems based on FEM approach.	Apply
CO2	Analyse some structural analysis problems involving beams and trusses, using FEM.	Apply
CO3	Develop computational scheme for two-dimensional structural analysis based on Total Potential Energy Method.	Apply
CO4	Apply the strategy of coordinate transformation using natural coordinates, and subsequent solution, employing the Isoparametric formulation.	Apply
CO5	Solve simple one dimensional (1- D) problem and 1D natural frequency problems using Galerkins weighted residual technique	Apply

iv) **SYLLABUS:**

Matrix Methods in Computational Mechanics- overview of similar numerical methods (FDM, FEM, FVM, BEM)-overview of general formulation methods leading to Matrix equations (Stiffness (direct) method, Potential energy method, Galerkins etc.) - commercial and free FEM packages. Direct approach of formulating the FEM equations for 1D-stress problems. Application of the Principle of Total Potential energy to formulate FEM equations for 1-D spring element, Plane truss element formulation, Beam element, review of Constitutive Matrix [D] for Plane-stress and Plane-strain formulations, coordinate transformation using natural coordinates, Serendipity and Lagrange's Interpolation methods, Isoparametric formulation, Strong and Weak form, Galerkin's weighted residual FEM formulation ; One dimension axially loaded bar, heat flow in a bar- numerical problems, FEM formulation for (undamped) Natural frequency estimation in 1-D structural problems −simple examples

v a) TEXTBOOKS

1) Daryl L. Logan, "A First Course in the Finite Element Method", Cengage Learning India Pvt. Ltd., 5th edition, 2012.

2) Seshu P., "Textbook of Finite Element Analysis", PHI Learning Private Ltd., Ninth printing, 2010.

b) REFERENCES

1) Robert D Cook, David S Malkus, Michael E. Plesha and Robert J. Witt , "Concepts And Applications of Finite Element Analysis", Wiley Student Edition, 4th Edition, 2007.

2) J. N. Reddy, "An Introduction to the Finite Element Method", McGraw Hill International 4th Edition, 2018.

3) S. S. Rao, "The Finite Element Method in Engineering", Butterworth-Heinemann Ltd; 3rd Revised edition, 1999.

4) K. J. Bathe, "Finite Element Procedures in Engineering Analysis", Prentice Hall, Pearson Education Inc., 2nd edition, 2014.

5) O. C. Zienkiewics, R. L. Taylor, "The Finite Element Method," Vol I & II, John Wiley & Sons Inc. 5th edition, 2000.

vi) COURSE PLAN:

Module	Contents	No. of hours
I	FEM as a numerical computational tool in Computer Aided Design & Analysis- general features of numerical solutions-general strategy of Matrix Methods in Computational Mechanics-overview of similar numerical methods (FDM, FEM, FVM, BEM)-overview of general formulation methods leading to Matrix equations (Stiffness (direct) method, Potential energy method, Galerkins etc.) - commercial and free FEM packages. Direct approach of formulating the FEM equations for 1D stress problems:− element stiffness − assembly of elements − properties of [K] matrix − treatment of boundary conditions- stress computation − support reaction − simple problems. Application of the Principle of Total Potential energy to formulate FEM equations for 1-D spring element. Simple problems involving assemblage of spring elements.	10
II	Plane truss element formulation − coordinate transformation − local and global coordinates −element matrices − assembly of elements − treatment of boundary conditions − stress calculation − Planar truss problems . Beam element: Beam relationships − 1-D beam element FE formulation - element stiffness matrix − load considerations − boundary conditions −solution of problems	9

III	Review of Constitutive Matrix [D] for Plane-stress and Plane-strain formulations- derivation of two-dimensional FEM equations for stress-analysis, using the Total Potential energy approach- Shape functions, equations for displacement field in terms of nodal displacements for (i) the 3noded triangular element (CST) and (ii) four-node-rectangular elements. Strain displacement gradient matrix [B] for the above elements- numerical problems involving 3-node-triangular elements.	8
IV	Motivation for Coordinate transformation using natural coordinates, deduction of shape functions in terms of natural coordinates: Serendipity and Lagrange's Interpolation methods- Isoparametric formulation for (i) the general four- node-Quadrilateral element and (ii) eight-node- Quadrilateral element (curved boundaries) - Gauss Quadrature in 2-dimensions- Illustrative examples.	10
V	Strong and Weak form, Galerkin's weighted residual FEM formulation ; One dimensional axially loaded bar, heat flow in a bar- numerical problems. FEM formulation for (undamped) Natural frequency estimation in 1-D structural problems −simple examples. Practical considerations in FEM analysis: aspect ratio and element types, use of symmetry in analysis, natural subdivisions at discontinuities, h and p methods of refinement, handling concentrated point loads and infinite stress in some geometries (re-entrant corners)-treatment of infinite medium, connecting different types of elements. Convergence of solution (demonstration of the above aspects in a FEM software environment recommended).	8
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U41D	AEROSPACE ENGINEERING	PEC	2	1	0	3	2020

i) **PRE-REQUISITE:** NIL

ii) **COURSE OVERVIEW:**

This course provides fundamentals of aerospace engineering and understanding of flight instruments. To educate students the fundamental aerospace disciplines necessary to carry out the design of an aerospace vehicle or systems.

iii) **COURSE OUTCOMES:**

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

CO No	Course Outcomes	Level
CO1	Explain the characteristics of atmosphere	Understand
CO2	Apply airfoil theory for a 2D, 3D or Finite aero foils	Apply
CO3	Explain performance analysis of flight dynamics of aircrafts	Understand
CO4	Explain different flight instruments	Understand
CO5	Explain the basic ideas of stability of an aero plane	Understand
CO6	Explain the principles of wind tunnel testing and basics of space travel	Understand

iv) **SYLLABUS:**

The atmosphere - characteristics of troposphere, stratosphere, thermosphere, and ionosphere - pressure, temperature and density variations in the atmosphere. **Application of dimensional analysis** – aerodynamic force – model study and similitude. **2D aero foils** -Nomenclature and classification- pressure distribution in inviscid and real flows- momentum and circulation theory of aero foil- characteristics.

3D or finite aero foils – effect of releasing the wingtips- wing tip vortices- replacement of finite wing by horse shoe vertex system, lifting line theory-wing load distribution – aspect ratio, induced drag calculation of induced drag from momentum considerations. Skin friction and from drag- changes in finite wing plan shape.

Propellers – momentum and blade element theories –propeller coefficients and charts. Aircraft performance-straight and level flight –power required and power available graphs for propeller and jet aircraft. **Gliding and climbing** –rate of climb-service and absolute ceilings-

gliding angle and speed of flattest glide takeoff and landing performance – length of runway required- aircraft ground run- circling flight – radius of tightest turn-jet and rocket assisted take –off high lift devices-range and endurance of airplanes-charts for piston and jet engine aircrafts.

Flight Instruments-airspeed indicator, calculation of true air speed-altimeter, gyro horizon - direction indicator-vertical speed indicator –turn and back indicator-air temperature indicator. (Brief description and qualitative ideas only). **Ideas on stability**-static and dynamic stability-longitudinal, lateral and directional stability- controls of an aero plane- aerodynamic balancing of control surfaces- mass balancing (Qualitative ideas only).

Principles of wind tunnel testing –open and closed type wind tunnels-wind tunnel balance supersonic wind tunnels. Study of subsonic, Transonic, and supersonic aircraft engines (Description with figures only). **Elementary ideas on space travel**-calculation of earth orbiting and escape velocities ignoring air resistance and assuming circular orbit.

v **a) TEXTBOOKS**

1) Anderson, Fundamentals of Aerodynamics, McGraw-Hill, 2010
2) A.C. Kermode, Mechanics of flight, Prentice Hall, 2007
3) EHJ Pallett, Aircraft Instruments and Integrated systems, Longman,1992

b) REFERENCES

1) Houghton and brock, Aerodynamics for Engineering Student, Hodder & Stoughton,1977

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	The atmosphere - characteristics of troposphere, stratosphere, thermosphere, and ionosphere - pressure, temperature and density variations in the atmosphere. Application of dimensional analysis – aerodynamic force – model study and similitude 2D aero foils -Nomenclature and classification- pressure distribution in inviscid and real flows- momentum and circulation theory of aero foil-characteristics.	9
II	3D or finite aero foils – effect of releasing the wingtips- wing tip vortices- replacement of finite wing by horse shoe vertex system, lifting line theory-wing load distribution – aspect ratio, induced drag calculation of induced drag from momentum considerations. Skin friction and from drag-changes in finite wing plan shape	9

III	Propellers – momentum and blade element theories – propeller coefficients and charts. Aircraft performance- straight and level flight – power required and power available graphs for propeller and jet aircraft. Gliding and climbing –rate of climb-service and absolute ceilings-gliding angle and speed of flattest glide takeoff and landing performance – length of runway required- aircraft ground run- circling flight – radius of tightest turn- jet and rocket assisted take –off high lift devices-range and endurance of airplanes-charts for piston and jet engine aircrafts.	**9**
IV	Flight Instruments-airspeed indicator, calculation of true air speed-altimeter, gyro horizon -direction indicator- vertical speed indicator – turn and back indicator-air temperature indicator (Brief description and qualitative ideas only). Ideas on stability-static and dynamic stability- longitudinal, lateral and directional stability- controls of an aero plane- aerodynamic balancing of control surfaces- mass balancing (Qualitative ideas only).	**9**
V	Principles of wind tunnel testing –open and closed type wind tunnels-wind tunnel balance supersonic wind tunnels. Study of subsonic, Transonic, and supersonic aircraft engines. Elementary ideas on space travel- calculation of earth orbiting and escape velocities ignoring air resistance and assuming circular orbit.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U41E	**HYBRID AND ELECTRIC VEHICLES**	PEC	2	1	0	3	2020

i) **PRE-REQUISITE:** NIL

ii) **COURSE OVERVIEW:**

This course aims to introduce the students to general overview of Hybrid Electric vehicle, Architecture of Hybrid Electric Drive Trains, control of various motors and drive with its different configuration. The course will also cover the power transmission of Electric vehicles and its components. The energy storage system with its management, charging methods and various sensors of Electric vehicles has been included. This course also covers the vehicle validation with its integration, Hardware & Software Interfaces, Chassis design, and Battery Positioning of Hybrid Electric vehicle.

iii) **COURSE OUTCOMES:**

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

CO No	Course Outcomes	Level
CO1	Explain the general architecture of Electric vehicles	Understand
CO2	Describe various motors and drives of Electric vehicles	Understand
CO3	Explain details of power transmission of Electric vehicles and select the appropriate components based on requirement	Understand
CO4	Describe charging, various sensors and battery management of Electric vehicles	Understand
CO5	Apply vector tool simulation, do vehicle validation, chassis design and battery positioning of Electric vehicles	Apply

iv) **SYLLABUS:**

Introduction to Hybrid Electric Vehicles(HEV): History of hybrid and electric vehicles, social,environment importance of hybrid and electric vehicles- Induction motors and drives, configuration, controls and applications in EV/HEV's- Motor Controllers/Inverters, Selection of automotive IGBT and MOSFET's, Field Oriented Control (FOC) & Space Vector Pulse Width Modulation (SVPWM) of Motors- EV charging, Fast charger, DC charger, AC charger, Battery swapping, Different charging protocols- Vehicle Validation, System Integration, Controller Area Networking (CAN) and Vector Tools Simulation,

v **a) TEXTBOOKS**

1) Husain I," Electric and Hybrid Vehicles": Design Fundamentals BocaRaton,CRC Press 2003

b) REFERENCES

1 James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

2 Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

3 Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

4 Sandeep Dhameja, "Electric Vehicle Battery Systems", Newnes, 2000

.http://nptel.ac.in/courses/108103009/

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Introduction to Hybrid Electric Vehicles(HEV): History of hybrid and electric vehicles, Types of EVs, Review of Vehicle dynamics; Hybrid Electric Drive train. General configuration of Electric hybrid vehicle, Electric Vehicle (EV) Drive train Alternatives Based on Drive train Configuration	9
II	Induction motors and drives, configuration, controls and applications in EV/HEV's, Permanent magnet motors, neodymium and ferrite and samarium cobalt types and drives configuration, Brushless DC Motor (BLDC), Interior Permanent magnet (IPM), Switch reluctance motors (SRM), W-Axial,3 phase Induction controls and applications in EV/HEV's, 3 phase Induction controls and applications in EV/HEV's	9
III	Motor Controllers/Inverters, Selection of automotive IGBT and MOSFET's, Field Oriented Control (FOC) & Space Vector Pulse Width Modulation (SVPWM) of Motors, Gearbox, selection of gear ratio, Different kinds of gearboxes, Gearbox optimisation, Transmission, Different kinds of transmission	9

IV	EV charging, Fast charger, DC charger, AC charger, Battery Swapping, Different charging protocols CHAdeMO,CCS2,GB/T, Customised charging protocols, Battery Box Engineering, Battery Management, Bus Bar design, Battery Pack Design, Various Sensors and Sensing methods, Battery Safety Standards, Thermal Management – Batter	**9**
V	Vehicle Validation, System Integration, Controller Area Networking (CAN) and Vector Tools Simulation, Vehicle Sensors specific to EV sensors interfaced to the ECU's in the vehicle network, Chassis design, Battery Positioning	**9**
	Total Hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U41F	OPERATIONS MANAGEMENT	PEC	2	1	0	3	2020

i) **PRE-REQUISITE:** NIL

ii) **COURSE OVERVIEW:**

Objective of the course is to facilitate the students to acquire knowledge about operations management concepts, tools and techniques

iii) **COURSE OUTCOMES:**

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

CO No	Course Outcomes	Level
CO1	Explain operations, production system and perform facility location analysis.	Understand
CO2	Explain knowledge of facility layout, layout planning and perform line balancing.	Understand
CO3	Explain demand forecast and forecast accuracy.	Understand
CO4	Explain aggregate planning and materials requirement planning.	Understand
CO5	Apply various algorithms for production scheduling.	Apply

iv) **SYLLABUS:**

Operations management – Operations function, Operations strategy, Types of production system, Facilities location, Facility location factors, location analysis techniques

Capacities and facilities – Capacity planning, facility layout, types of layout , systematic layout planning, layout design procedures **,** Assembly line balancing

Demand forecasting – Components of forecasting demand, time series methods , linear regression , seasonal adjustments, forecast accuracy.

Aggregate planning – Aggregate planning strategies ,Materials requirement planning, Master production schedule, bill of materials, Economic order quantity method for lot sizing

Production scheduling – Performance measures, Gantt chart, single machine scheduling , mean weighted flow time ,McNaughton's algorithm, flow shop scheduling ,extension of Johnson's rule for 3 machine problem , Palmer's heuristic

v a) TEXTBOOKS

1) Roberta S. Russell and Bernard W. Taylor III, Operations Management, John Wiley & Sons, Inc., Seventh Edition, 2011.

2) Heizer and Render, Operations Management, Pearson Education, Eleventh Edition

3) P. B. Mahapatra, Operations Management: A Quantitative Approach, PHI, 2010.

b) REFERENCES

1) R. Paneerselvam, Production and Operations Management, PHI, 2010

2) G. Sreenivasan, Quantitative Models in Operations and Supply Chain Management,PHI.

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	**Introduction to operations management:** Operations function, operations strategy, system, types of production system – job shop production – batch production – mass production, process planning, make or buy decisions, process reengineering. Facilities location: Facility location factors, location analysis techniques – location factor rating – center of gravity technique – load distance technique.	8
II	**Capacities and facilities**: Capacity planning, facility layout – objectives, types of layout –process layout – product layout – fixed position layout – cellular layout, systematic layout planning, layout design procedures – CRAFT – CORELAP – ALDEP.Assembly line balancing: methods for line balancing – rank positional weight method –COMSOAL.	9
III	**Demand forecasting**: Components of forecasting demand, time series methods – moving average – weighted moving average – exponential smoothing –adjusted exponential smoothing – linear regression – seasonal adjustments, forecast accuracy.	10
IV	**Aggregate planning**: Aggregate planning strategies – heuristic method. Materials requirement planning: Master production schedule, bill of materials, MRP calculations, lot sizing in MRP – economic orderquantity method for lot sizing –minimum cost per period method – periodic order quantity method – least unit cost method, evolution fromMRP to manufacturing resource planning (MRP II).	9

V	**Introduction to production scheduling**: Processing characteristics and constraints– performance measures, Gantt chart, single machine scheduling – SPT rule to minimize mean flow time – EDD rule to maximum lateness, parallel processors – minimization of make span – mean weighted flow time – McNaughton's algorithm, flow shop scheduling –extension of Johnson's rule for 3 machine problem – Palmer's heuristic	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1U41G	AIR CONDITIONING AND REFRIGERATION	PEC	2	1	0	3	2020

i) **PRE-REQUISITE:**ME1U20DEngineering Thermodynamics

ii) **COURSE OVERVIEW:**

Objective of the course is to enable students to analyze refrigeration systems and components, choose appropriate refrigerants and determine capacity requirement for air conditioning equipment for various applications

iii) **COURSE OUTCOMES:**

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

CO No	Course Outcomes	Level
CO1	Analyze air refrigeration systems.	Apply
CO2	Analyze vapour compression refrigeration system and improve the performance.	Apply
CO3	Describe vapour absorption and steam refrigeration system.	Understand
CO4	Describe refrigeration system components and selecting suitable refrigerants for different applications.	Apply
CO5	Evaluate the cooling load and capacity requirement of AC machine	Apply

iv) **SYLLABUS:**

Introduction to refrigeration Thermodynamics of refrigeration- reversed Carnot cycle, Limitations, heat pump, COP, Unit of refrigeration- Air refrigeration systems. Numerical examples.

Vapour compression refrigeration - representation on T- s and P- h Diagrams. COP- – methods of improving COP of simple cycle- actual cycle.Multi pressure systems - numerical examples.

Vapour absorption and steam jet refrigeration Vapour absorption systems, Steam jet refrigeration. Applications, relative merits and demerits.

Refrigeration system components- Compressors, condensers, expansion devices, evaporators. Cooling towers. Refrigerant leakage and detection – charging of refrigerant. Refrigerants and their properties, selection of refrigerants for different applications

Air conditioning Psychrometric properties, psychrometers, psychometric chart-

Psychometric processes– Numerical examples.

Air conditioning- applications, Comfort air conditioning- Unitary and central system comparison. Capacity determination-cooling load estimation, Numerical examples.

v a) TEXTBOOKS

1) Refrigeration and Air Conditioning, Arora C.P, Tata McGraw hill.
2) A Course in Refrigeration and air conditioning Arora S. C. and S. Domkundwar, Dhanpat Rai and Company. 2002
3) A Text Book of Refrigeration and air conditioning – R.K .Rajput, KatariaPublications.
4) Heating, Ventilating, and Air Conditioning: Analysis and Design, Faye C. McQuiston, Jerald D. Parker, Jeffrey D. Spitler, John Wiley and sons. New York

b) Data Books

1) Refrigeration tables and charts including air conditioning data, C P Kothandaraman , New Age International.
2) Refrigeration and air conditioning data book, Domkunduwar and Domkundwar, Dhanpat Rai & co

c) REFERENCES

1) ASHRAE Handbook 201(Volume 1,2,3)
2) Principles of heating ventilation and air conditioning in building, John Dixon, Delmar learning
3) Analysis and design of heating ventilation and air conditioning system, Herbert W Sanferd and Adam F Spach, CRC press -Taylor and Francis.

vi) COURSE PLAN:

Module	Contents	No. of hours
I	Introduction–applications of refrigeration. Thermodynamics of refrigeration-reversed Carnot cycle and its Limitations, Heat pump, COP, Unit of refrigeration. Air refrigeration systems- Reversed Joule cycle. Aircraft refrigeration systems, comparison. Bootstrap system. Numerical examples.	**9**

II	Vapour compression systems- representation on T-s and P-h Diagrams. COP- Effect of operating parameters on COP Methods of improving COP of simple cycle- super- heating, under cooling, Liquid suction heat exchanger, actual cycle. Multi pressure systems - multi compression and multi evaporator, systems, inter cooling - flash inter cooling and flash gas removal Numerical examples	**9**
III	Vapour absorption systems - simple system- drawbacks Lithium Bromide-Water system. Electrolux- comparison with vapour compression system. Steam jet refrigeration. Applications, relative merits and demerits	**9**
IV	Refrigeration system Components-Compressors, condensers, expansion devices, evaporators. Cooling towers- Different types and their application fields Refrigerant leakage and detection – charging of refrigerant. Refrigerants and their properties, CFC, HCFC, HFC, HC refrigerants - Eco-friendly Refrigerants, ODP, GWP, selection of refrigerants for different applications.	**9**
V	Psychrometric properties- dry, wet and dew point temperature – humidity, specific humidity, absolute humidity, relative humidity and degree of saturation- enthalpy of moisture Adiabatic saturation process, Psychrometers, Psychometric chart. Psychometric processes- adiabatic mixing- sensible heating and cooling- humidifying and dehumidifying, air washer – bypass factor- sensible heat factor-RSHF and GSHF line- Design condition- Apparent dew point temperature. Numerical examples. Air conditioning- applications. Comfort air conditioning- factors affecting human comfort. Effective temperature – comfort chart. Unitary and central system comparison. Capacity determination, cooling load estimation. COP, EER, IEER, IPLV, star rating, Specification of capacity TONs, HP. Numerical examples.	**9**
	Total hours	**45**

OPEN ELECTIVE

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME0U41A	INTRODUCTION TO BUSINESS ANALYTICS	OEC	2	1	0	3	2020

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

Objective of the course is to facilitate the students to acquire knowledge about operations management concepts, tools and techniques

iii) COURSE OUTCOMES:

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

CO No	Course Outcomes	Level
CO1	Explain the fundamentals of business intelligence, analytics, and data science.	Understand
CO2	Apply real life data for effective decision making using statistical models.	Apply
CO3	Explain the basic concepts of data warehousing and use of data mining techniques for business analytics.	Understand
CO4	Explain text analytics and understand the need for text mining.	Understand
CO5	Explain the essence of business performance management and business reporting.	Understand
CO 6	Explain emerging technologies, legal and ethical issues that may impact analytics and business intelligence.	Understand

iv) SYLLABUS:

Business Intelligence- Business Intelligence System and its components.

Business Analytics, Transaction Processing and Analytic Processing- Fundamentals ofOLAP and OLTP.Introduction to Big Data Analytics

Data- Sources of Data- Steps in data pre-processing. Statistical Modelling for Business Analytics- Regression Modelling for Inferential Statistics- Linear Regression, Logistic

Regression and Time Series Forecasting.

Data Warehousing- Data warehousing process, Data Mining, Text and Web Analytics: Fundamentals of Social media analytics

Business Reporting- Business Performance Management: Business performance management cycle-Performance Measurement System

Recent Trends, Privacy and Managerial Considerations in Analytics- Internet of Things for Business Analytics, Cloud Computing and Business Analytics, Privacy and Ethics-Impacts of Analytics in Organizations

v a) TEXTBOOKS

1) J. R. Evans, "Business Analytics", Pearson, 3rd Edition, 2019.

2) Business Analytics for Managers: Taking Business Intelligence Beyond Reporting, 2nd Edition, Wiley, 2016

b) REFERENCES

1) R. N. Prasad and S. Acharya, "Fundamentals of Business Analytics", Wiley, 2nd Edition,2016
2) A. Maheshwari, "Data Analytics", McGraw Hill Education, 1st Edition, 2017

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	**Introduction to Business Intelligence-** Evolution of Business Intelligence System and its components. Introduction to Business Analytics- Levels of Analytics –Descriptive, Predictive and Prescriptive Analytics- Application of business analytics in industries-case studies. Transaction Processing and Analytic Processing-Fundamentals of OLAP and OLTP Introduction to Big Data Analytics- Characteristics- Sources of Big Data.	8

II	**Data-** Sources of Data- Readiness Level of Data for Analytic study- Unstructured and structured data- classification of data- Data pre-processing- Steps in data pre-processing. Statistical Modelling for Business Analytics- Descriptive Statistics- Measures of Central Tendency and Dispersion- Quartiles and inter-quartile range. Regression Modelling for Inferential Statistics- Linear Regression, Logistic Regression and Time Series Forecasting.	**9**
III	**Data Warehousing**: Design Considerations for data warehouse-Data warehousing process- Data Lakes. Data Mining: Concepts - Data mining process- Applications- Software Tools. Text and Web Analytics: Text analytics and text mining overview - Text mining applications - Sentiment Analysis- Web mining overview- Fundamentals of Social media analytics.	**10**
IV	**Business Reporting**- Different types of charts and graphs- Data Visualization and Visual Analytics Business Performance Management: Business performance management cycle- Performance Measurement System- Key Performance Indicators Analytics in Business Support Functions- Sales & Marketing, Human Resources, Financial Analytics, Production and operations analytics for lot sizing – minimum cost per period method – periodic order quantity method – least unit cost method, evolution from MRP to manufacturing resource planning (MRP II).	**9**
V	**Recent Trends**, Privacy and Managerial Considerations in Analytics: Use of Internet of Things for Business Analytics - Cloud Computing and Business Analytics- Location Based Analytics for Organizations - Issues of Legality, Privacy and Ethics- Impacts of Analytics in Organizations	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME0U41B	QUANTITATIVE TECHNIQUES FOR ENGINEERS	OEC	2	1	0	3	2020

i) **PRE-REQUISITE:** NIL

ii) **COURSE OVERVIEW:**

Objective of the course is to facilitate the students to acquire knowledge about operations management concepts, tools and techniques

iii) **COURSE OUTCOMES:**

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

CO No	Course Outcomes	Level
CO1	Solve problems using linear programming methods.	Apply
CO2	Solve transportation problems and assignment problems.	Apply
CO3	Solve sequencing problems and perform network analysis.	Apply
CO4	Apply decision theory and game theory	Apply
CO5	Apply queuing theory and perform simulation for queuing problems.	Apply

iv) **SYLLABUS:**

Quantitative techniques –Operations research, Linear programming – problem formulation – graphical method – simplex method – big-m method – two–phase method – duality in linear programming

Transportation problem –Balanced & unbalanced transportation problems –north west corner rule – least cost method – Vogel's approximation method – stepping stone method. Assignment problem – optimal solution – Hungarian algorithm

Sequencing problem –Problems with n jobs through m machines. Network analysis – network construction – time analysis – critical path method (CPM) – programme evaluation and review technique (PERT) – cost considerations in network analysis – crashing.

Decision theory – decision making conditions -Game theory – games with saddle points – games without saddle points – 2 x 2 games –graphical method for m x 2 & 2 x n games

Introduction to queuing theory – classification of queuing models .Simulation – generation of random numbers –Monte Carlo simulation – queuing simulation model

v a) TEXTBOOKS

1) Miller, D. M. and Schmidt, J. W., Industrial Engineering and Operations Research,John Wiley & Sons
2) Banks, J., Carson, J. S., Nelson, B. L., and Nicol, D. M., Discrete-Event System Simulation, Third Edition, Pearson Education, Inc.

b) REFERENCES

1) Paneerselvam, R., Operations Research, Prentice Hall of India, New Delhi, 2017.
2) Taha, H. A., Operations Research: An Introduction, Pearson, 2013.

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	**Introduction to quantitative techniques** – basics of operations research – applications. Linear programming – problem formulation – graphical method – simplex method – big-m method –two–phase method – duality in linear programming	8
II	**Transportation problem** – formulation – balanced & unbalanced transportation problems –north west corner rule – least cost method – Vogel's approximation method – stepping stone method. Assignment problem – formulation – optimal solution – Hungarian algorithm – variants of assignment problems.	9
III	**Sequencing problem** – terminology and notations – assumptions – problems with n jobs through two machines – problems with n jobs through three machines – problems with n jobs through m machines. Network analysis – basic terms – network construction – time analysis – critical path method (CPM) – programme evaluation and review technique (PERT) – cost considerations in network analysis – crashing.	10

IV	**Decision theory** – steps in decision theory approach – decision making conditions – decisions under conditions of risk – decisions under uncertainty conditions – decision tree analysis. Game theory – games with saddle points – games without saddle points – 2 x 2 games – graphical method for m x 2 & 2 x n games.	**9**
V	**Introduction to queuing theory** – terminologies – classification of queuing models – single server problems – multi server problems. Simulation – generation of random numbers –Monte Carlo simulation – queuing simulation model	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME0U41C	**AUTOMOTIVE TECHNOLOGY**	OEC	2	1	0	3	2020

i) **PRE-REQUISITE:** ES0U10C Basics of Mechanical Engineering

ii) **COURSE OVERVIEW:**

The objective of this course is

- To know the anatomy of automobile in general
- To understand the working of different automotive systems and subsystems
- To update the latest developments in automobiles

iii) **COURSE OUTCOMES:**

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

CO No	Course Outcomes	Level
CO1	Explain different automotive systems and subsystems	Understand
CO2	Illustrate the working of transmission, suspension, steering and braking systems of an automobile.	Understand
CO3	Summarize the basic technology in electric vehicles.	Understand
CO4	Explain the various safety, security and comfort systems in automotive technology.	Understand

iv) **SYLLABUS:**

Automobile system layout- Engine and its components, SI and CI engine, working principle, Fuel supply and injection system-comparison, multiport fuel injection (MPFI) and common rail direct injection (CRDI) systems. Ignition system, Engine emission and standards. Friction clutch: Principle, dry friction clutch- Pull type diaphragm clutch, multiple diaphragm clutch, multi-plate hydraulically operated automatic transmission clutch, semi-centrifugal clutch, Suspension system: - Types of suspension springs, suspension geometry and terminology, types of suspension systems, independent suspension. Antiroll bar, Hydrogen suspension, Brakes: Principle of brake, classification of brakes-mechanical and hydraulic brakes- Drum and Disc brakes, properties of friction lining and pad materials, Anti-Lock Braking system (ABS), principle of operation and types of ABS, Electric Vehicle Technology (EVT): EV Architecture, types of batteries, battery parameters, super capacitors. Fuel cells and its efficiency. Safety-Active and passive safety, air bags, seat belt tightening system, forward collision warning system, child lock

advanced safety systems. Comfort system –Automotive air-conditioning, aerodynamics lift and drag reduction, adaptive cruise control

v **a) TEXTBOOKS**

1) Heinz Heisler, Vehicle and engine technology, Butterworth-Heinemann, 2nd edition,199

2) R.B. Gupta., Auto design , Satya Prakashan Publishers, New Delhi, 2016 .

3) James Larminie and John Lowry, Electric vehicle technology explained, Wileypublications, 2nd edition, 2015.

4) Kirpal Singh, Automobile Engineering Vol.1 & Vol.2, Standard Publishers, 13th edition,2020.

b) REFERENCES

1) V.A.W. Hillier, Fundamentals of modern vehicle technology, Butterworth-Heinemann, 2ndedition,1998.

2) Tom Denton, Electric and Hybrid Vehicles, Routledge Publishers, 2nd edition, 2020.

3) Ljubo Vlacic, Michel Parent and Fumio Harashima, Intelligent vehicle technologies, Butterworth-Heinemann publications, Oxford 2001.

4) ShimoKim and Rakesh Shresta, Automotive Cyber Security: Introduction Challenges and Standardization, Springer, Singapore, 1st edition. 2020.

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Engine and its components- IC engines, piston, rings, pin, flywheel, connecting rod. SI and CI engine, working principle, Fuel supply and injection system-comparison, MPFI and CRDI systems, Ignition system, Engine emission and standards, Super charging systems	9
II	**Clutch and transmission:** Principle of dry friction clutches- Single plate clutch, Multi plate hydraulically operated automatic transmission clutch. Semi centrifugal clutch, fully automatic centrifugal clutch, Integral single plate diaphragm clutch, Electromagnetic clutch, Clutch friction materials, wet clutches, fluid friction coupling. Need of gear box, power to weight ratio, speed operating range, Epicyclic gear box, Torque convertor, Over drives, Automated manual transmission.	9

III	**Suspension and brake:** Suspension system: - Types of suspension springs, suspension geometry and terminology. Types of suspension systems ,independent suspension. Antiroll bar, Hydrogen suspension, hydro pneumatic suspension. Suspension roll center and body roll. Brakes: Principle of brake, classification of brakes, mechanical and hydraulic brakes. Drum and Disc brakes, properties of friction lining and pad materials Anti-Lock Braking system (ABS), principle of operation and typesof ABS.	**9**
IV	**Steering and Electric vehicle technology:** Ackermann steering mechanism, over steer and under steer. Steering geometry -slip angle, camber, king pin inclination, caster, toe-in and toe-out. Steering gear box, Types of steering gear box, need of power assisted steering. EV Architecture, types of batteries, battery parameters, super capacitors. Tesla , Maglev Train.	**9**
V	**Safety, control and security in automotive technology:** Safety-Active and passive safety, air bags, seat belt tightening system, Forward collision warning system, child lock antilock braking system Comfort system - Automotive air-conditioning, aerodynamics lift and drag reduction Adaptive cruise control, tilt-able steering column, power window and advanced comfort system Anti-theft technology-mechanical, electromechanical and electronic immobilizers. Alarm system and remote keyless entry.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME0U41D	Renewable Energy Engineering	OEC	2	1	0	3	2020

i) PRE-REQUISITE: NIL

ii) COURSE OVERVIEW:

The course is intended to give knowledge of various renewable energy sources, systems and applications and the need in the present context. Students will be able to compare different renewable energy techniques and choose the most appropriate based on local conditions. To equip students in working with projects and to take up research work in connected areas.

iii) COURSE OUTCOMES:

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

CO No	Course Outcomes	Level
CO1	Explain renewable energy sources and evaluate the implication of renewable energy to predict solar radiation at a location	Understand
CO2	Explain the working and characteristics of solar energy collectors, and solar cell.	Understand
CO3	Explain the different types of wind power machines and control strategies of wind turbines	Understand
CO4	Explain the ocean energy and conversion devices and different Geothermal sources	Understand
CO5	Explain biomass energy conversion devices and calculate the net present value and payback period	Understand

iv) SYLLABUS:

The Energy Scenario- Commercial energy sources -World's production and reserves-India' Production and reserves, Energy Alternatives, Need for alternatives. **Solar Energy collectors**- Solar thermal collectors -Flat plate collectors –Solar concentrators. **Wind Energy-** classification of wind turbines and power performance curve, Energy in wind, calculation of energy content, Power coefficients, Betz limit theory, tip speed ratio, solidity of turbine' power control strategies. **Ocean Energy –** Devices for Wave Energy conversion, Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation. **Geothermal energy-** Introduction, hot dry rock resources, magma resources, vapor and liquid dominated systems, binary cycle, advantages and disadvantages **Bio Mass Energy**- Biomass conversion technologies –Bio Gasification, Bio ethanol, Bio Diesel , Biogas production from waste biomass. **Economic Analysis –** Initial and annual cost, basic definitions, present worth calculations.

v a) TEXTBOOKS

1) S P Sukhatme , J K Nayak, Solar Energy: Principles of Thermal Collection and

Storage, Mc Graw Hill ,2015

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

3) Jefferson W Tester et.a., Sustainable Energy Choosing among options,PHI,2006

b) REFERENCES

1) D.P. Kothari Renewable energy resources and emerging technologies, Prentice Hall of India Pvt. Ltd,2011

2) Mehmet KanoğluYunus A. Çengel John M. Cimbala , Fundamentals and Applications of Renewable Energy, Mc Graw Hill ,2019

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

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	The Energy Scenario- Commercial energy sources -World's production and reserves- India' Production and reserves, Energy Alternatives, Need for alternatives –solar option- nuclear options Principles of solar radiation : Solar radiation outside the earth's atmosphere and at the earth's surface , Solar Constant, Basic Sun-Earth Angles, Instruments for measuring solar radiation and sunshine , Solar radiation data	9
II	Solar Energy collectors: Solar thermal collectors -Flat plate collectors –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector)–Solar Air Heaters. Solar thermal electric power generation -Thermal Energy storage, sensible heat storage, latent heat storage , Thermo chemical storage , photovoltaic system for power generation , Solar pond -Solar Cells- Types of solar cells , principle of working and performance characteristics, Production process- Block diagram only	9
III	Wind Energy- classification of wind turbines and power performance curve, Energy in wind, calculation of energy content, Power coefficients, Betz limit theory, tip speed ratio, solidity of turbine' power control strategies, Basic principles of Wind Energy Conversion Systems (WECS), Classification of WECS, Parts of WECS.	9
IV	Ocean Energy – Devices for Wave Energy conversion, Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation – Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle (block diagram description of OTEC); Geothermal energy: Introduction, hot dry rock resources, magma resources, vapor and liquid dominated systems, binary cycle, advantages and disadvantages	9

V	Bio Mass Energy- Biomass conversion technologies –Bio Gasification, Bio ethanol, Bio Diesel , Biogas production from waste biomass, factors affecting biogas generation Bio Gas -KVIC and Janata model ,Hydrogen Energy – various routes for production of Hydrogen energy. Economic Analysis – Initial and annual cost, basic definitions, present worth calculations, repayment of loan in equal and annual installments, annual savings, cumulative saving and cycle cost, economic analysis of add on solar system, payback period(derivation)	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME0U41E	QUALITY ENGINEERING AND MANAGEMENT	OEC	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 various human dimensions of TQM	Understand
CO5	Apply different tools and techniques in TQM	Apply
CO6	Apply different statistical quality control techniques	Apply

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

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)- 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 - quality and the management cycle- obstacles to achieving successful strategic quality management- supplier selection- Concepts of 5S, Six Sigma, Lean, 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	**10**
IV	**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 - Control charts for improving process capability- Taguchi's robust design- Total Productive maintenance- Failure Mode and Effect Analysis	**9**
V	**Quality System**: ISO 9000 family of standards- ISO 9001:2000 model, quality management system- management responsibility- resource management- product realisation- measurement analysis and improvements- ISO 14000 family of standards- Quality auditing- types and benefits.	**9**
	Total hours	**45**

S7 MINORS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME0M49A	**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

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S7 HONOURS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1H40A	Advanced Theory of Vibrations	VAC	3	1	0	4	2020

i) **PRE-REQUISITE:** ME1U30F: Dynamics and Design of Machinery

ii) **COURSE OVERVIEW:**

- To understand the principles of vibration theory.
- To introduce techniques for solving vibration problems.
- To enable development of mathematical model for engineering problems in vibrations.

iii) **COURSE OUTCOMES:**

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

CO No	Course Outcomes	Level
CO1	Analyse the single degree of freedom vibration system with and without damping	Apply
CO2	Analyse forced harmonic vibration and two degree of freedom system	Apply
CO3	Analyse the multi degree of freedom system and the Eigen value problem	Apply
CO4	Solve vibration of continuous systems and transient vibrations	Apply
CO5	Solve linear vibration problems using Numerical methods.	Apply

iv) **SYLLABUS:**

Analysis of un-damped, damped, free and forced SDOF systems, non-periodic excitation of Single DOF systems. Two degree of freedom systems -dynamic vibration absorbers. Multi-degree freedom system Matrix formulation. Matrix Iteration, Holzer method. Vibration of continuous system. Approximate numerical methods, Introduction to nonlinear vibrations.

v **a) TEXTBOOKS**

1) Leonard Meirovitch, Elements of Vibrations Analysis, Tata McGraw Hill - 2007
2) Thomson W.T, Theory of Vibration with Applications, Pearson Education; 5 Edition, 2008.
3) S. Graham Kelly, Mechanical Vibrations, Schaum‟s Outline Series, Tata McGraw Hill 2011 Special Indian Edition
4) S.S Rao, Mechanical Vibrations, Pearson Education India; Sixth edition, 2018.
5) Den Hartog, J P, Mechanical Vibrations, McGrawHill, 1956.

b) REFERENCES

1) Rao V and J Srinivas, Mechanical Vibrations, PHI, New Delhi.
2) V.P. Singh –Mechanical Vibrations‖ Dhanpat Rai& Co (Pvt) Ltd.

vi)

COURSE PLAN:

Module	Contents	No. of hours
I	Introduction to mechanical vibrations- Definitions -Types of vibrations- Degrees of freedom- Oscillatory motion – Periodic motion- Beat phenomenon Free vibration of single degree of freedom systems with damping - Natural frequency using Energy method- Rayleigh method- Newton's method. Free vibration of single degree of freedom systems with damping- Viscous damping- Logarithmic decrement- Coulomb damping- Structural damping.	12
II	Forced harmonic vibration- Magnification Factor-Transmissibility- Vibration Isolation-Base Excitation-Rotating unbalance- whirling of shafts- Resonance Vibration measuring instruments- Seismometer-Accelerometer Two degree of freedom systems- Generalized co-ordinates- Normal mode vibration-Principal co-ordinates-Coordinate coupling.	12
III	Dynamic vibration absorbers- Vibration dampers- Numerical problems Multi degree of freedom systems- Matrix formulation- Influence Coefficients-Flexibility Matrix-Stiffness matrix Eigen Value problem: Eigen value and Eigen Vectors-Natural Frequency- mode shape - Orthogonality of normal modes-Modal analysis	12
IV	Vibration of continuous systems-Vibrating strings- Longitudinal vibration of rods—Torsional vibration of rods Transient vibrations- Impulse excitation- Convolution integral, Response to Arbitrary Loading.	12
V	Numerical methods - Matrix Iteration – Stodola – Dunkerley's method - Rayleigh method – Rayleigh –Ritz method -Holzer procedure.	12
	Total hours	**60**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1H40B	COMPUTATIONAL METHODS IN FLUID FLOW AND HEAT TRANSFER	VAC	3	1	0	4	2020

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

ii) COURSE OVERVIEW:

Objective of the course is to focus on basic concept and principles of numerically solving governing equations for fluid flow and heat transfer problems.

iii) COURSE OUTCOMES:

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

CO No	Course Outcomes	Level
CO1	Explain physical and mathematical classifications partial differential equations, discretization, Tridiagonal matrix algorithm, converting derivatives to their finite difference forms, Taylor's series approach, discretization error, boundary conditions	Understand
CO2	Solve One and two dimensional steady state and transient heat conduction problems in Cartesian coordinates.	Apply
CO3	Explain Explicit, implicit, Crank-Nicholson and ADI schemes, consistency,stability and convergence.	Understand
CO4	Apply finite volume method for diffusion and convection problems	Apply
CO5	Solve problems using SIMPLE, SIMPLER, SIMPLEC and QUICK numerical schemes.	Apply

iv) SYLLABUS:

Introduction to computational fluid dynamics. Physical and mathematical classifications of partial differential equations. Round-off error and accuracy of numerical results, iterative convergence, discretization, converting derivatives and their finite difference forms. Steady, transient one and two-dimensional conduction problem in Cartesian coordinates, types of boundary conditions. Finite volume method for diffusion and convection–diffusion problems. Steady one-dimensional convection and diffusion SIMPLE, SIMPLER, SIMPLEC and QUICK schemes, solution algorithms for pressure velocity coupling in steady flows.

v a) TEXTBOOKS

1) Anderson, D. A, Tannehill, J. C., and R. H. Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer, Second Edition, Taylor & Francis,1995.

2) Muraleedhar, K. and T. Sundararaja, T., Computational Fluid Flow and Heat

Transfer,Second Edition, Narosa Publishing House, 2003

b) REFERENCES

1) T.J. Chung, Computational Fluid dynamics, Cambridge University Press, South Asian
Edition, 2003.

2) Patankar, S. V., Numerical Heat Transfer and Fluid Flow, Hemisphere, 1980..

3) Versteeg, H. K. and W. Malalasekera, An Introduction to Computational Fluid Dynamics:
Hornbeck, R. W., Numerical Marching Techniques for Fluid Flows with Heat Transfer,NASA,

vi) COURSE PLAN:

Module	Contents	No. of hours
I	Introduction of computational methods. Classifications partial differential equations; Validation of numerical results; round-off-error and accuracy of numerical results; iterative convergence, condition for convergence, rate of convergence; under and over relaxations, Termination of iteration; tridiagonal matrix algorithm; discretization, converting derivatives and their finite difference forms, Taylor's series approach, polynomial fitting approach;discretization error.	12
II	Steady one-dimensional conduction in Cartesian coordinates; handling of boundary conditions; two dimensional steady state conduction problems in Cartesian coordinates, Point-by-point and line-by-line method of solution, Dirichlet, Neumannand type boundary conditions. Formation of discritized equations for regular and irregular boundaries and interfaces.	10
III	One-and two-dimensional transient heat conduction problems in Cartesian coordinates, explicit, implicit, Crank Nicholson and ADI schemes. their stability criterion, conservation form and conservative property of partial differential and finite difference equations	14
IV	Finite volume method for diffusion and convection–diffusion problems, steady one dimensional convection and diffusion; upwind, hybrid and power-law schemes, discretization of equation for two dimension, false diffusion,	12

V	SIMPLE, SIMPLER, SIMPLEC and QUICK schemes, solution algorithms forpressure velocity coupling in steady flows; Numerical marching techniques, two-dimensional parabolic flows with heattransfer.	**12**
	Total hours	**60**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1H40C	PRECISION MACHINING	VAC	3	1	0	4	2020

i) **PRE-REQUISITE:** ME1U30D MACHINE TOOLS AND METROLOGY

ii) **COURSE OVERVIEW:**

This course is conceived to help students understand design and process issues associated with precision machining. The course introduces a few precision machining processes as well.

iii) **COURSE OUTCOMES:**

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

CO No	Course Outcomes	Level
CO1	Compare basic premises of normal machining and precision machining	Understand
CO2	Explain the sources of error and role of kinematic design in establishing precision.	Understand
CO3	Explain various sensors and AE based monitoring in precision machining environment	Understand
CO4	Outline the basics of process planning for precision machining	Understand
CO5	Explain various precision machining processes.	Understand

iv) **SYLLABUS:**

Introduction to precision machining: Competitive drivers for precision machining. Measurement of dimension and angle- measurement of form- straightness, flatness and roundness. Measurement of surface roughness. Sources of error in precision machining. Role of kinematic design in precision. Principles of design and utilization of bearings- aerostatic bearings. Sensors in precision machining: Classification of basic sensor types- overview of sensors in manufacturing- applications- AE based monitoring of grinding wheel

Process planning for precision machining: process planning basics-factors that influence precision process capability-relationship between process variability and product specification- process capability as a planning metric. Precision machining processes: Diamond turning and milling, fly cutting diamond machine configuration- features of diamond machine tool design- applications. Configuration for conical circumferential milling- applications.

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v) a) TEXTBOOKS AND REFERENCES

1) David Dornfeld, Dae-Eun Lee, Precision Manfacturing, Springer, 2008

2) V.C. Venkatesh, Sudin Izman, Precision Engineering, Tata McGraw- Hill, 2007

3) Michael N. Morgan, Andrew Shaw, Otar Mgaloblishvili, Precision Machining VI, Transtech publications Ltd, Switzerland, 2012

vi) COURSE PLAN:

Module	Contents	No. of hours
I	Introduction to precision machining. Philosophy of precision machine design. Competitive drivers for precision machining, Definition of terms- accuracy, precision and resolution, Metrology and measurement – Abbe's principle. Measurement of dimension and angle, Measurement of form- straightness, flatness and roundness, Measurement of surface roughness	12
II	Sources of error in precision machining, Mechanical errors – errors due to machine elements, thermal errors, Errors due to compliance and vibration. Error budget, Role of kinematic design in precision. Principles of design and utilization of bearings – Aerostatic bearings	12
III	Sensors in Precision Machining- classification, Overview of sensors and applications.AE based monitoring of grinding wheel dressing, Description of Fast AE RMS analysis of wheel condition monitoring. Topographical mapping of grinding wheel, AE based monitoring of face milling	12
IV	Process planning for precision machining, Process planning basics. Factors influencing precision, Process capability, Relationship between process variability and product specification, Process capability as a planning metric	12
V	Precision machining Processes – Diamond turning and milling, Fly cutting diamond machine configuration, Features of diamond machine tool design-applications. Configuration for conical circumferential milling- applications, Typical single point diamond tool geometry. Abrasive processes- fixed and loose, Nano grinding, Chemical Mechanical Planarization, Precision manufacturing applications	12
	Total hours	60