



**CURRICULUM
2023
(Autonomous)
Version 2.0**

S7 S8 SYLLABUS

**B.TECH
Mechanical Engineering**



MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

B. TECH DEGREE PROGRAMME

IN

MECHANICAL ENGINEERING

2023 SCHEME

S7 S8 SYLLABUS

Items	Board of Studies (BoS)	Academic Council (AC)
Date of Approval	23/02/2026	12/03/2026

Head of the Department
Chairman, Board of Studies



Principal
Mar Baselios College
of Engineering & Technology
Chairman, Academic Council
Mar Ivanios Vidyanagar, Nalanchira
Thiruvananthapuram-695015

S7 S8 SYLLABUS

FOR

B. TECH DEGREE PROGRAMME IN **MECHANICAL ENGINEERING**

**2023 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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Semester VII										
Slot	Course Code	Category	Course Name	Credit Structure				SS	Hours	Credits
				L	T	P	J			
A	23MEJ40A	PCC	Design of Machine Elements	2	1	0	1	4.5	4	4
B	23MEL40B	PCC	Robotics and Automation	3	1	0	0	5	4	4
C	23MEL42X	PEC	Program Elective II	X	X	0	0	4.5	3	3
E	23IEL42X	IEC	Institute Elective II	X	X	0	0	4.5	3	3
S	23MEP40A	PCC	Mechanical Engineering Lab	0	0	3	0	1.5	3	2
T	23MEV48A	PWS	Comprehensive Viva Voce	0	0	2	0	1	2	1
U	23MEJ48A	PWS	Project	0	0	10	0	10	10	5
1/2	23MEI48A	PWS	Internship*							
M	23MEJ4MX	VAC	Minor Mini Project	0	0	6	0	6	6	3
H	23MEL4HX	VAC	Honours Course	2	1	0	0	3.5	3	3
Total								31/34.5/40.5	29/32/35	22/25

Semester VIII										
Slot	Course Code	Category	Course Name	Credit Structure				SS	Hours	Credits
				L	T	P	J			
A	23MEL43X	PEC	Programme Elective III	X	X	0	0	4.5	3	3
B	23MEL44X	PEC	Programme Elective IV (Management Course)	X	X	0	0	4.5	3	3
C	23MEL45X	PEC	Programme Elective - VV	X	X	0	0	4.5	3	3
D	23MEL46X	PEC	Programme Elective VI	X	X	0	0	4.5	3	3
U	23MEJ48B	PWS	Project	0	0	10	0	10	10	5
1/2	23MEI48A	PWS	Internship*							
H	23MEJ4HX	VAC	Honours Mini-Project	0	0	6	0	13	6	3
Total								28/41	22/28	17/20

* Students can opt for Internship either in S7 or S8. However the internship can be permitted only if there are no pending Programme/Course requirements in the semester, that need to be completed in College in the offline mode, such as laboratory sessions.

S7: PROGRAMME ELECTIVE II**Courses offered**

Course Code	Course Name
23MEL42A	Power plant engineering
23MEL42B	Compressible fluid flow
23MEL42C	Advancements in Digital Manufacturing
23MEL42D	Design for Additive Manufacturing
23MEL42E	Failure Analysis and Design
23MEL42F	Biomechanics

S8: PROGRAMME ELECTIVE III**Courses offered**

Course Code	Course Name
23MEL43A	Cryogenic engineering
23MEL43B	Non-Conventional Machining Processes
23MEL43C	Experimental stress analysis

S8: PROGRAMME ELECTIVE IV**Management courses**

Course Code	Course Name
23MEL44A	Product Design and Development
23MEL44B	Material Handling and Facilities Planning
23MEL44C	Supply chain and Logistics Management
23MEL44D	Technology Management

S8: PROGRAMME ELECTIVE V**Courses offered**

Course Code	Course Name
23MEL45A	Aerospace Engineering
23MEL45B	Fundamentals of Unmanned Aerial Vehicles
23MEL45C	Non Destructive Testing
23MEL45D	Acoustics and Noise Control
23MEL45E	Composite Materials

S8: PROGRAMME ELECTIVE VI**Courses offered**

Course Code	Course Name
23MEL46A	Refrigeration and Air Conditioning
23MEL46B	Advanced Metal Joining Techniques
23MEL46C	Numerical Methods in Engineering
23MEL46D	Optimization Techniques in Engineering
23MEL46E	Pressure Vessels Design

INSTITUTE ELECTIVES – 2023 SCHEME

BASKET 1

COURSE CODE	COURSE NAME	L-T-P-J	CREDITS
23IEL31Q	3D Printing	3-0-0-0	3
23IEL31R	Maintenance Engineering	3-0-0-0	3
23IEL31S	Renewable and Non-conventional energy engineering	3-0-0-0	3
23IEL31T	Sports Engineering and Management	3-0-0-0	3

BASKET 2

COURSE CODE	COURSE NAME	L-T-P-J	CREDITS
23IEL42Q	Industrial Engineering	3-0-0-0	3
23IEL42R	Sustainable Manufacturing	3-0-0-0	3
23IEL42S	Marketing Management	3-0-0-0	3
23IEL42T	Alternate Fuels	3-0-0-0	3

B.Tech MINORS

Semester	BASKET I				BASKET II				BASKET III			
	Supply Chain and Logistics				Unmanned Aerial Vehicle (UAV)				Computational Design Engineering			
	Course code	Course Name	L-T-P-J	Credits	Course code	Course Name	L-T-P-J	Credits	Course code	Course Name	L-T-P-J	Credits
S3	23MEL2MA	Supply chain and Logistics Management	3-0-0-0	3	23MEL2MC	Introduction to Unmanned Aerial Vehicles	2-1-0-0	3	23MEL2ME	Computer Aided Design	2-0-1-0	3
S4	23MEL2MB	Emerging Technologies in SCM	2-1-0-0	3	23MEL2MD	Elements of UAV system	2-1-0-0	3	23MEL2MF	Finite Element Methods	2-0-1-0	3
S5	23MEL3MA	Green Logistics and operations management	2-1-0-0	3	23MEL3MC	Design and Simulation of UAV	2-1-0-0	3	23MEL3ME	Computational Mechanics	2-1-0-0	3
S6	23MEL3MB	Digital Manufacturing Transformation	2-1-0-0	3	23MEL3MD	Fabrication and Testing of UAV	2-1-0-0	3	23MEL3MF	Optimization Techniques	2-1-0-0	3
S7/S8	23MEJ4MA	Mini Project	0-0-6-0	3	23MEJ4MC	Mini Project	0-0-6-0	3	23MEJ4ME	Mini Project	0-0-6-0	3
S7/S8	23MEJ4MA	Mini Project	0-0-6-0	3	23MEJ4MC	Mini Project	0-0-6-0	3	23MEJ4ME	Mini Project	0-0-6-0	3

B.Tech HONORS

<u>Semester</u>	<u>Basket 1: Power Plant and Energy Engineering</u>				<u>Basket 2: Manufacturing Engineering</u>			
	Course Code	Course Name	L-T-P-J	Credit	Course Code	Course Name	L-T-P-J	Credit
4	23MEL2HB	Thermal and Nuclear Power Plants	2-1-0-0	3	23MEL2HD	Additive Manufacturing	2-1-0-0	3
5	23MEL3HA	Emerging Technologies in Renewable Energy Sources	2-1-0-0	3	23MEL3HC	Theory of Metal Forming	2-1-0-0	3
6	23MEL3HB	Equipment Design for Thermal Systems	2-1-0-0	3	23MEL3HD	Reliability Engineering	2-1-0-0	3
7	23MEL4HA	Environmental and Safety Engineering	2-1-0-0	3	23MEL4HC	Manufacturing Automation	2-1-0-0	3
8	23MEJ4HB	Mini Project	0-0-6-0	3	23MEJ4HD	Mini Project	0-0-6-0	3

Semester	Basket 3: Machine Design				Basket 4: Sports Engineering and Management			
	Course Code	Course Name	L-T-P-J	Credit	Course Code	Course Name	L-T-P-J	Credit
4	23MEL2HF	Continuum Mechanics	2-1-0-0	3	23MEL2HH	Sports Psychology	2-1-0-0	3
5	23MEL3HE	Advanced Design Synthesis	2-1-0-0	3	23MEL3HG	Sports Analytics	2-1-0-0	3
6	23MEL3HF	Design of Pressure Vessels	2-1-0-0	3	23MEL3HH	Sports Engineering	2-1-0-0	3
7	23MEL4HE	Advanced Theory of Vibrations	2-1-0-0	3	23MEL4HG	Sports Product Design	2-1-0-0	3
8	23MEJ4HF	Mini Project	0-0-6-0	3	23MEJ4HH	Mini Project	0-0-6-0	3

Department of Mechanical Engineering

S7 SYLLABUS

2023 SCHEME

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23MEJ40A	Design of Machine Elements	PCC	2	1	0	1	4	2023

i) COURSE OVERVIEW

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

ii) COURSE OUTCOMES

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

CO1	Design belt drives and gears.	Apply
CO2	Design connecting rod in IC engines and shafts under static and fatigue loads.	Apply
CO3	Design clutches and brakes.	Apply
CO4	Design journal, ball and roller bearings.	Apply
CO5	Make use of a simulation software to analyse a machine element.	Analyse

iii) SYLLABUS

Belt drives: Flat belts, V belts and pulleys, **Gears:** - Materials of gears, Design procedure of Spur, helical and bevel gears. **Design of shafts** based on strength, rigidity, and critical speed, design for static and fatigue loads, Design of connecting rod in IC engine, **Design of clutches and brakes.** **Bearings:** Lubrication, hydrodynamic theory, Petroff's equation, Design procedure of Journal bearings, bearing life, static and dynamic load capacity, Stribeck's Equation, selection of bearings, Design procedure of Ball and roller bearings,

iv) a) 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. Narayana Iyengar B.R & Lingaiah K, Machine Design Data Handbook, Tata McGraw Hill/Suma Publications, 1984
3. PSG Design Data, DPV Printers, Coimbatore, 2012
4. Eugene Avallone, Theodore Baumeister, Ali Sadegh, Marks' Standard Handbook for Mechanical Engineers, 11th edition, McGraw-Hill Education, 2006

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. Juvinal 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. Rajendra Karwa, Machine Design, Laxmi Publications (P) LTD, New Delhi, 2006
8. Siegel, Maleev & Hartman, Mechanical Design of Machines, International Book Company, 1983

v) COURSE PLAN

Module	Contents	No. of hours
I	<p>Belt drives: Selection of V belts and pulleys, selection of Flat belts and pulleys. velocity ratio, Power Transmitted, Design Procedure.</p> <p>Gears: - Materials of gears, 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, Design procedure of Spur gear.</p>	12
II	<p>Helical gears: - Terminology, Virtual or equivalent number of teeth, Tooth proportions, Beam strength, and Wear strength of Helical gears, Design procedure of Helical gear.</p> <p>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.</p>	12
III	<p>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.</p> <p>Design of connecting rod in IC engine.</p>	12
IV	<p>Design of clutches: -single and multiple plate clutch, cone clutch.</p> <p>Design of brakes: -band brakes, block brakes, simple and differential band brake, and internal expanding shoe brake.</p>	12
V	<p>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.</p> <p>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.</p>	12
	Total	60

vi) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 60: 40

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Course Project	:	20 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	60 marks
End Semester Examination	:	40 marks
TOTAL	:	100 marks

NB: It is mandatory that a course project relating to machine design stream shall be undertaken by each student for this course. Evaluations will be performed on the project and upon successful completion a brief report must be submitted by the student.

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 40
- Exam Duration: 2 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL40B	Robotics and Automation	PCC	3	1	0	0	4	2023

i) COURSE OVERVIEW

The objective of this course is to impart the fundamentals of Robotics and Automation. Students are introduced to the basic components of robots, their configurations, and end-effectors. The course covers forward and inverse kinematics of manipulators, differential kinematics, trajectory planning, and basic dynamic and force analysis. Foundations of robot programming, control, sensor integration, machine vision, and industrial applications are also introduced.

ii) COURSE OUTCOMES

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

	Course Outcomes	Learning Level
CO 1	Explain the fundamentals of robotics and industrial automation.	Understand
CO 2	Apply the principles of manipulator kinematics to solve forward and inverse kinematics problems using transformation matrices and D–H representation.	Apply
CO 3	Illustrate differential kinematics, Jacobian formulation, and basic dynamic modeling to analyze motion and develop joint- and Cartesian-space trajectory schemes.	Understand
CO4	Explain robot programming concepts, control architectures, and the role of sensors in robotic systems.	Understand
CO5	Explain machine vision fundamentals and identify major robotics applications.	Understand

iii) SYLLABUS

Robotics and Industrial Automation – definition and history – types and classification of robots – fixed, programmable and flexible automation – anatomy of a robotic manipulator: links, joints, actuators, sensors, controllers – robot configurations: PPP, RPP, RRP, RRR – end effectors: mechanical, magnetic, vacuum, adhesive, active and passive grippers. **Manipulator kinematics**: rotation matrix, homogeneous transformation matrix, D–H representation – direct and inverse kinematics for industrial robots – position and orientation problems. **Differential kinematics** – Jacobian and velocity relations – statics and basic dynamics – Lagrangian and Newton–Euler formulation for simple manipulators – general considerations in **trajectory planning** – joint-space and Cartesian-space schemes. **Robot programming**: basics of robot programming and languages – online and offline programming – **robot control systems and components** – open-loop and closed-loop control – sensors – feedback control and real-time monitoring. **Machine vision**: image sensing and digitizing – image processing and analysis – applications in inspection, guidance and automation. **Robot applications** in manufacturing: material handling, welding, assembly, machining and inspection – robotics in healthcare, defense and security, service and domestic sectors, agriculture, logistics and warehouse automation, space robotics and collaborative robots. Demonstration and simulation of robot manipulators and tools

using software such as RoboDK.

iv) a) TEXTBOOKS

1. Craig, J.J., Introduction to Robotics Mechanics and Control, Addison Wesley, 1999.
2. Saha, Subir Kumar, Introduction to robotics, Tata McGraw-Hill Education, 2014.
3. Ashitava Ghosal, Robotics-Fundamental concepts and Analysis, Oxford University Press
4. Groover, M.P., Weiss, M., Nagel, R.N., and Odrey, N.G., Industrial Robotics: Technology, Programming, and Applications, McGraw-Hill, 1986

b) REFERENCES

1. Kevin M. Lynch, Frank C. Park, Modern Robotics: Mechanics, Planning, and Control, Cambridge University Press, 2017.
2. Spong, Mark W., Seth Hutchinson, and Mathukumalli Vidyasagar, Robot modeling and control, New York: Wiley, 2006.
3. Fu, K.S., Gonzalez, R.C., and Lee, C.S.G., Robotics control, Sensing, Vision and Intelligence, McGraw-Hill Publishing company, New Delhi, 2003.
4. Klafter, R.D., Chmielewski, T.A., and Negin. M, Robot Engineering: An Integrated Approach, Prentice Hall of India, New Delhi, 2002.

v) COURSE PLAN

Module	Contents	Hours
I	Introduction to Robotics and Industrial Automation - Definition and history of robotics - Types of robots - Overview of robotic systems in industrial automation – Fixed, Programmable and Flexible Automation Anatomy of a robotic manipulator – links, joints, actuators, sensors, and controller – Robot configurations – PPP, RPP, RRP, RRR Classification of End effectors – mechanical grippers, magnetic grippers, vacuum grippers, adhesive grippers, active and passive grippers.	12
II	Manipulator kinematics and dynamics – Manipulators Kinematics, Rotation Matrix, Homogenous Transformation Matrix, D-H representation - Direct and Inverse Kinematics for industrial robots for position and orientation – problems.	14
III	Differential Kinematics, statics and basic dynamics – Jacobian, Lagrangian Formulation, Newton – Euler formulation for RR or RP manipulator. General considerations in trajectory planning - joint- space schemes, cartesian-space schemes (Basic concepts only)	14
IV	Robot Programming and Control - Basics of Robot Programming - Introduction to robot programming languages - Offline and online programming – Overview of Robot Control Systems and components Sensor Integration and Feedback - Types of sensors used in robotics Feedback control and real-time monitoring - Open-loop and closed-loop control	10
V	Introduction to Machine Vision – Image Sensing and Digitizing – Image processing and Analysis - Applications Robot applications – Applications in Manufacturing – Robotics for	10

	Healthcare, Defense and Security, Service and Domestic, Agricultural, Logistics and Warehouse automation, Space Robotics, Collaborative Robots. Demonstration of different types of Robots and tools using Robot Simulator Software like RoboDK.	
	Total	60

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment	
Attendance	: 5 marks
Assignments	: 15 marks
Assessment through Tests	: 20 marks
Total Continuous Assessment	: 40 marks
End Semester Examination	: 60 marks
TOTAL	: 100 marks

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEP40A	MECHANICAL ENGINEERING LAB	PCC	0	0	3	0	2	2023

i) 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.

ii) COURSE OUTCOMES

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

	Course Outcomes	
CO 1	Apply principles of mechanical vibrations and rotor dynamics to perform experiments on whirling of shaft, free and forced vibrations, and gyroscopic systems, and evaluate key system parameters.	Apply
CO 2	Conduct NDT techniques using RAM to inspect and classify industrial metallic components and tuning forks, and assess defects, material quality, and calibration accuracy.	Apply
CO 3	Apply fluid power concepts to design, assemble, and operate pneumatic, electro-pneumatic, and electro-hydraulic circuits using trainer units.	Apply
CO 4	Apply additive manufacturing principles to design and fabricate 3-D printed components by selecting appropriate materials and process parameters.	Apply
CO 5	Apply PC-based data acquisition systems and software tools to acquire and analyze experimental data for performance evaluation and reporting.	Apply

iii) 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 to categorize industrial metallic parts using NDT - RAM
6. Experiment to check the quality and calibrate the tuning fork using NDT - RAM
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.

iv) REFERENCES

1. C. E. Wilson, P. Sadler, Kinematics and Dynamics of Machinery, Pearson Education, 2005
2. D. H. Myszka, 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

(v) CONTINUOUS ASSESMENT EVALUATION PATTERN**Continuous Assessment: 100 marks**

Attendance	: 5 marks
Lab work/ Viva	: 55 marks
Final Exam	: 40 marks
Total	: 100 marks

vi) END SEMESTER EXAMINATION PATTERN

Maximum marks: **40 marks**

Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23MEV48A	Comprehensive Viva Voce	PWS	0	0	2	0	1	2023

i) COURSE OVERVIEW

The objective of this course is to evaluate the students' basic understanding and application capability in the core domains of their respective engineering branch.

iii) COURSE OUTCOMES

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

CO1	Apply the comprehensive knowledge gained in basic courses relevant to the branch of study.	Apply
CO2	Comprehend the questions asked and answer them with confidence.	Understand
CO3	Communicate engineering concepts, solutions, and reasoning effectively using appropriate technical terminology.	Understand
CO4	Demonstrate sound technical understanding of core engineering concepts and apply them to solve fundamental engineering problems pertaining to the society.	Apply

iii) SYLLABUS

Engineering Mechanics: Free body diagrams, equilibrium equations, Kinematics and kinetics of particles and rigid bodies, Work-energy & impulse-momentum methods

Mechanics of Solids: Stress and strain, Principal stresses and Principal planes, Mohr's circle Axial loading, torsion of circular shafts Bending of beams, shear stresses, thin and thick cylinders, pressure vessels Thermal stresses

Mechanics of Machinery: Kinematics of mechanisms, Degrees of freedom, Velocity and acceleration analysis, Instantaneous centre of rotation, Gears and gear trains.

Machine Design: Design of machine elements (shafts, gears, bearings), Failure theories

Thermodynamics & Thermal engineering: First & second law, entropy, Reversible & irreversible processes, Availability, Otto, Diesel cycles Brayton & Rankine cycles Boilers, compressors, turbines IC engine fundamentals Refrigeration Cycles Air-conditioning basics

Fluid mechanics & fluid machinery: Fluid properties & fluid statics Continuity, momentum, energy equations Bernoulli equation & applications Laminar & turbulent flow Boundary layer concepts Pipe flow: losses, friction factor, Pumps and turbines

Heat & mass transfer: 1D steady-state conduction Composite walls, cylinders, sphere Basics of transient conduction, Forced & natural convection, Heat exchangers ,Radiation fundamentals

Manufacturing Process & Industrial engineering: Casting, Forming, Rolling, forging, extrusion, drawing, Sheet metal operations

Machining Chip formation & tool geometry, Tool wear & tool life, Machining operations Engineering metrology, sensors and transducers, Operations management, Operations research

Material science & metallurgy Crystal structures & imperfections Dislocations & strengthening mechanisms, Iron–carbon equilibrium diagram, Heat treatment: Failures: ductile/brittle fracture, fatigue, creep

iv) a) **TEXTBOOKS**

1. Prescribed textbooks for the core courses from the first to the sixth semester

b) **REFERENCES**

1. Prescribed reference books for the core courses from the first to sixth semester

v)	COURSE PLAN	
Module	Contents	No. of hours
I	Engineering Mechanics and Solid Mechanics	3
	Machine Design and Mechanics of Machinery	3
II	Thermodynamics	3
	Thermal Engineering	3
III	Fluid Mechanics & Machinery	3
	Heat & Mass Transfer	3
IV	Manufacturing – Casting & Forming	3
	Manufacturing Process	3
V	Operations Management, Machine tools and Metrology	3

	Materials Science & Metallurgy	3
	Total	30 hours

vi) COURSE GUIDELINES AND EVALUATION

a) The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed in the curriculum. Mock tests, mock viva voce sessions, technical discussions may be conducted by the faculty in charge during the hours assigned for the course.

b) **Total marks: 50**

Continuous internal evaluation-25 marks

Attendance – 5 marks

Multiple choice questions test and comprehensive viva (minimum 2 each) - 20 marks

Final viva voce examination-25 marks

The mark will be treated as internal and should be uploaded along with internal marks of other courses.

The final viva voce examination shall be conducted by a panel of two evaluators. The panel shall consist of one senior faculty member from the Department and an expert from Industry/research institute/academia **or** two senior faculty members from the Department.

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEJ48A, 23MEJ48B	PROJECT	PWS	0	0	10	0	5	2023

i. COURSE OVERVIEW The aim of this course is to apply engineering knowledge in solving practical problems, to foster innovation in design of products, processes or systems, and to develop creative thinking in finding viable solutions to engineering problems. The course is mainly intended to evoke the innovation and invention skills of 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. There are two options to conduct the course:

Option 1:

- This option is recommended for students who are expected to undertake an internship in either 7th or 8th semester as per the department guidelines.
- The project shall be completed within a single semester, either in the 7th or the 8th semester.
- In the event that a student fails to undertake an internship in one of the semesters, the student shall be required to complete one more project during the next semester.
- The final project evaluation shall be conducted at the end of the semester.

Option 2:

The project is conducted in **two phases**:

- This option is applicable for students not opting for internships.
- Phase I (7th semester): Completion of 50% of the project work.
- Phase II (8th semester): Remaining 50% of the work to be completed.
- The final project evaluation shall be conducted at the end of the 7th and 8th semester.

- **Desirable:** The project outcome should be published in a peer-reviewed journal or presented at a conference, or a patent application should be filed.

It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies.

ii. COURSE OUTCOMES After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Apply multidisciplinary knowledge to model and solve real world problems.	Apply
CO 2	Apply innovative and creative problem-solving to develop sustainable and socially relevant products, processes, or technologies.	Create
CO 3	Exhibit effective teamwork and leadership skills in diverse environments, with the ability to comprehend and carry out designated responsibilities.	Apply
CO 4	Execute tasks by planning effectively and utilizing available resources to meet deadlines, while adhering to ethical and professional standards.	Apply
CO 5	Effectively document, present, and communicate technical and scientific outcomes in professional written and verbal formats.	Apply

iii. Evaluation Guidelines & Rubrics

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

- Project progress evaluation by guide: **20** Marks.
- Two interim evaluations by the Evaluation Committee: **30** Marks (15 marks for each evaluation).
- Final evaluation by the Final Evaluation committee: **30** Marks
- Quality of the report evaluated by the evaluation committee: **20** Marks

Interim Evaluation:

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

Final Evaluation:

The final evaluation committee comprises of Project coordinator, domain expert from the Department and expert from Industry/research/academic Institute / senior faculty from a sister department.

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23MEI48A	INTERNSHIP	PWS	0	0	-	0	5	2023

i) COURSE OBJECTIVES

The internship is an integral component of the undergraduate programme aimed at providing students with immersive learning through practical exposure in industry, research organizations, or academic institutions.

BENEFITS OF INTERNSHIP

Benefits to Students

- Provides practical exposure to real-world industrial and organizational environments, enabling the application of theoretical knowledge gained in classrooms.
- Enhances professional competencies such as communication, teamwork, time management, interpersonal skills, and workplace ethics.
- Facilitates the development of technical and domain-specific skills, thereby strengthening overall professional readiness.
- Assists students in assessing their career interests and determining the suitability of a particular industry or profession.
- Improves employability by strengthening profiles for placements, higher education, and potential recruitment by the host organization.
- Encourages professional networking and relationship - building with industry experts and peers.
- Offers an opportunity to evaluate the organization and work culture before committing to full-time employment.

Benefits to the Institute

- Strengthens industry - academia collaboration.
- Facilitates smoother and more effective placement processes.
- Enhances institutional credibility and brand value.
- Supports student engagement and retention.
- Enables curriculum updates based on industry and student feedback.
- Improves the overall teaching - learning process through industry relevance.

Benefits to the Industry

- Provides access to a pool of motivated, job-ready students who can contribute immediately.
- Offers a cost-effective mechanism to evaluate and recruit potential employees.
- Enables the availability of a flexible workforce for temporary, project-based, or seasonal requirements.
- Brings fresh perspectives and innovative approaches to problem-solving.
- Enhances organizational visibility and employer branding within academic institutions.
- Strengthens corporate image by contributing to education and skill development.

TYPES OF INTERNSHIPS

- Industry Internship with/without Stipend
- Government / PSU Internship (BARC/Railway/ISRO etc.)
- Internship with prominent education/ Research Institutes
- Internship with Incubation centres /Start-ups

ii) COURSE OVERVIEW

Students can undertake an internship at an industry, research organization, or a reputed academic institution with prior approval of the respective Head of the Department. Each student shall be assigned a faculty guide/supervisor for monitoring and evaluation. The internship shall be relevant to the student's stream of study and can be carried out in Semester **VII** or Semester **VIII**, as specified by the Department, for a minimum duration of **three months**.

A student shall be permitted to undertake the internship only after the respective semester registration. During the internship period, any other courses or academic activities shall be pursued in online mode or as specified by the Department, to ensure timely fulfillment of all academic requirements.

On successful completion of the internship, students are expected to demonstrate improved technical competence, professional conduct, and the ability to address practical problems in their chosen field.

iii) COURSE OUTCOMES

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

CO1	Apply theoretical knowledge and engineering principles to practical problems encountered in professional practice.	Apply
CO2	Demonstrate technical competence and understanding of tools, techniques, and processes relevant to the chosen field of specialization.	Apply
CO3	Analyse social, environmental, economic, safety, and administrative factors influencing industrial operations and decision-making processes.	Analyze
CO4	Communicate effectively through technical reports, presentations, and professional interactions in an industrial or research environment.	Apply
CO5	Apply professional ethics, teamwork, and adaptability while performing assigned tasks in a multidisciplinary work setting.	Apply

iv) GUIDELINES FOR STUDENTS

- Duration of internship is three to six months (One semester).
- Students may undertake mini projects, case studies, or related technical tasks during the internship with the prior approval of the competent authority at the host organisation.
- Students shall strictly adhere to the rules, regulations, code of conduct, and working hours prescribed by the host organisation.

- Prior permission shall be obtained from the host organisation before using or reproducing any data, documents, drawings, photographs, or proprietary information for academic purposes.
- Students shall follow all ethical practices, confidentiality requirements, and Standard Operating Procedures (SOPs) of the host organisation.
- Students shall comply with all health, safety, and environmental guidelines prescribed by the host organisation during the internship period.
- Students shall maintain regular contact with the assigned faculty guide/supervisor and submit weekly progress updates on the work carried out.
- Each student shall maintain a diary/logbook recording daily activities, learning outcomes, and progress throughout the internship period.
- On completion of the internship, students shall submit the following documents to the Department:
 - ✓ Internship report detailing the work carried out and learning outcomes
 - ✓ Internship Completion Certificate issued by the host organisation
 - ✓ Feedback from the employer
 - ✓ Proof of stipend received, if applicable

v) ASSESSMENT PATTERN

The marks awarded for the Internship will be based on the following:

- (i) Evaluation done by the industry,
- (ii) Student's diary,
- (iii) Internship report, and
- (iv) Internship viva voce.

Continuous Assessment		
Student's diary/ Daily Log	:	25 marks
Evaluation done by the industry	:	25 marks
Total Continuous Assessment	:	50 marks
Summative Assessment		
Internship Report	:	25 Marks
Internship Viva Voce	:	25 marks
Total Summative Assessment	:	50 marks
TOTAL	:	100 marks

Student's Diary/ Daily Log

The purpose of maintaining a daily diary is to cultivate systematic documentation habits and to encourage students to record observations, impressions, information gathered and suggestions, if any, during the internship period. The diary shall contain a day-to-day record of activities, learning experiences, technical details, and relevant sketches or drawings related to the work carried out. The daily diary shall be signed regularly by the industry supervisor and shall be verified and ratified by the faculty guide during the interim review.

The interim review shall be conducted midway through the internship by the Internship Review Committee, comprising the internship coordinator, faculty supervisor, and a senior faculty member of the Department. The review may be conducted in online or offline mode, based on the feasibility of the student's physical presence on campus.

Internship Report

On completion of the internship, each student shall prepare and submit a comprehensive internship report to the faculty supervisor. The report shall present a systematic account of the activities undertaken, observations made and knowledge gained during the training period. Students may consult the industry supervisor during the preparation of the final report, subject to compliance with the confidentiality policies and norms of the host organisation. The completed report shall be duly certified and signed by the Industry Supervisor, Faculty guide and the Head of the Department.

The internship report shall be evaluated based on the following criteria:

- Originality and technical content
- Adequacy, clarity and relevance of the written presentation
- Organization, format, use of drawings, sketches, language and overall style
- Variety and relevance of learning experiences documented
- Demonstration of practical applications and linkage with theoretical concepts covered in the curriculum

Evaluation done by the industry

The performance of the student during the internship shall be evaluated by the industry supervisor or the person-in-charge using a prescribed evaluation format provided by the institution. The evaluation shall cover key parameters such as professional behaviour, technical competence, learning ability, initiative, quality of work, communication skills, teamwork, discipline, time management, and overall professional attitude.

The faculty guide shall share the evaluation format with the host organisation and coordinate the assessment process. The completed evaluation form shall be duly signed and sealed by the industry supervisor and submitted to the Department as part of the internship assessment records.

Internship Viva Voce

The viva voce examination shall be conducted by the Internship Review Committee. The committee shall assess the student's understanding of the internship work, technical competence, learning outcomes, and professional orientation.

S7: PROGRAMME ELECTIVE - II

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL42A	Power plant Engineering	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW:

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

ii) COURSE OUTCOMES

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

CO 1	Explain the layout, construction and working of the components inside a thermal power plant.	Understand
CO 2	Explain the layout, construction and working of the components inside a Diesel, Gas And Combined cycle power plants.	Understand
CO 3	Explain the layout, construction and working of the components inside nuclear power Plants.	Understand
CO 4	Explain the layout, construction and working of the components inside Renewable Energy power plants..	Understand
CO 5	Solve for capital & operating cost of power plants, economics of power generation. Identify environmental issues and pollution control technologies	Apply

iii) SYLLABUS

COAL FIRED THERMAL POWER PLANTS

Rankine cycle – improvisations, Layout of modern coal fired thermal power plant, Subsystems of thermal power plants, Super Critical Boilers, Fluidised bed combustion Boilers(FBC), Steam &Heat rate,. Binary Cycles and Cogeneration systems.

DIESEL, GAS TURBINE AND COMBINED CYCLE POWER PLANTS

Otto, Diesel & Brayton Cycle – Analysis & Optimization. General layout of diesel power plant and their components. Comparison and types of gas turbine power plants and their components, combined gas and steam power plants – Advantages of combined cycle power plant.

NUCLEAR POWER PLANTS

Basics of Nuclear Engineering, Layout and subsystems of Nuclear Power Plants, Working of Nuclear Reactors: Boiling Water Reactor. (BWR), Pressurized Water Reactor (PWR), Canada Deuterium Uranium reactor (CANDU), Breeder, Gas Cooled and Liquid Metal Cooled Reactors. Safety measures for Nuclear Power plants.

POWER FROM RENEWABLE ENERGY

Hydro Electric Power Plants – General layout, working and Classification. Principle, Construction and working of Wind, Tidal, Solar thermal, Solar Photo Voltaic (SPV), Geo Thermal, Biogas and Fuel Cell power systems

ENERGY, ECONOMIC AND ENVIRONMENTAL ISSUES OF POWER PLANTS

Site selection criteria, capital & Operating Cost for Coal, Hydroelectric, Solar, Wind, and Nuclear power plants- Pollution control technologies including Waste Disposal Options used in Thermal and nuclear power plant. Economics of power generation -Power tariff types, Load distribution parameters, load curve,

(a) TEXT BOOKS

- 1) P.C.Sharma, “Power Plant Engineering”, S.K.Kataria Publication, 3rd Edition, 2015.
- 2) Arora and S. Domkundwar , “A Course in Power Plant Engineering”, Dhanpat rai & CoPublication, 5th Edition, 2016.
- 3) P.K. Nag, “Power Plant Engineering”, TMH Publication, 4th Edition, 2017.

(b) REFERENCES

- 1) R.K. Rajput, “A Text Book of Power Plant Engineering”, Laxmi Publications, 5th Edition,2016..
- 2) K. K. Ramalingam, “Power plant Engineering”, Scitech Publishers, 2nd Edition, 2015
- 3) G.D. Rai, “An Introduction to Power Plant Technology”, Khanna Publishers, 3rd Edition,2011.
- 4) C. Elanchezhian , “Power Plant Engineering” , I.K. International Publications, 2nd Edition,2013

V) COURSE PLAN

Module	Contents	No. of hours
I	Coal Fired Thermal Power Plants Rankine cycle – improvisations, Layout of modern coal fired thermal power plant, Subsystems of thermal power plants, Super Critical Boilers, Fluidised bed combustion Boilers(FBC), Steam &Heat rate,. Binary Cycles and Cogeneration systems	8
II	Diesel, Gas Turbine And Combined Cycle Power Plants Otto, Diesel & Brayton Cycle – Analysis & Optimisation. General layout of diesel power plant and their components. Comparison and types of gas turbine power plants and their components, combined gas and steam power plants – Advantages of combined cycle power plant.	9
III	Nuclear Power Plants Basics of Nuclear Engineering, Layout and subsystems of Nuclear Power Plants, Working of Nuclear Reactors: Boiling Water Reactor. (BWR), Pressurized Water Reactor (PWR), Canada Deuterium Uranium reactor (CANDU), Breeder, Gas Cooled and Liquid Metal Cooled Reactors. Safety measures for Nuclear Power plants.	10
IV	Power From Renewable Energy Hydro Electric Power Plants – General layout, working and Classification. Principle, Construction and working of Wind, Tidal, Solar thermal, Solar Photo Voltaic (SPV), Geo Thermal, Biogas and Fuel Cell power systems	10
V	Energy, Economic And Environmental Issues Of Power Plants	8

	Site selection criteria, capital & Operating Cost for Coal, Hydroelectric, Solar, Wind, and Nuclear power plants- Pollution control technologies including Waste Disposal Options used in Thermal and nuclear power plant. Economics of power generation -Power tariff types, Load distribution parameters, load curve.	
	Total	45

VI) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40 : 60

Continuous Assessment	
Attendance	: 5 marks
Assignments	: 15 marks
Continuous Assessment Tests (2 Nos)	: 20 marks
Total Continuous Assessment	: 40 marks
End Semester Examination	: 60 marks
Total	: 100 marks

VII) CONTINUOUS ASSESMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

VII) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL42B	Compressible Fluid Flow	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW:

This course is designed to develop students' understanding of compressible flow phenomena encountered in a wide range of engineering applications. Topics addressed include nozzle flows, shock wave behavior, Fanno flow, Rayleigh flow, and propulsion systems.

ii) COURSE OUTCOMES

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

CO 1	Explain the basic concepts of compressible fluid mechanics and various flow visualization and measurement techniques.	Understand
CO 2	Analyze the problems in one-dimensional steady compressible flow of isentropic flow through varying area.	Apply
CO3	Analyze the problems in one-dimensional steady compressible flow through constant area duct with friction (Fanno flow)	Apply
C04	Analyze the problems in one-dimensional steady compressible flow through constant area flow with heat transfer (Rayleigh flow).	Apply
CO 5	Analyze the variation in flow properties across normal and oblique shock waves	Apply

iii) SYLLABUS

Introduction to Compressible Flow, Wave propagation, One dimensional steady isentropic flow. Irreversible discontinuity in supersonic flow, Flow in a constant area duct with friction (Fanno Flow), Flow through constant area duct with heat transfer (Rayleigh Flow), Compressible flow field visualization and measurement, measurement in compressible flow, Wind tunnels

iv) (a) TEXT BOOKS

- 1) Fundamentals of compressible fluid dynamics P. Balachandran PHI Learning Pvt. Ltd.2006
- 2) Rathakrishnan E., Gas Dynamics, PHI Learning, 2014
- 3) Yahya S. M., Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion, New Age International Publishers, 2023

(b) REFERENCES

- 1) Modern Compressible Flow: With Historical Perspective John D. Anderson T.D. McGraw-Hill, Inc 4th edition, 2021
- 2) Elements of Gas Dynamics, By H. W., Liepmann, and A. Roshko, Dover Publications, Mineola, NY: 2001. Originally from Wiley, 1957..

(c) GAS TABLES

- 1) Yahya S. M., Gas Tables, New Age International, 2011

2) Balachandran P., Gas Tables, Prentice-Hall of India Pvt. Limited, 2011

V) COURSE PLAN

Module	Contents	No. of hours
I	Fundamentals of compressible flow: Various regimes of flow, Reynolds transport theorem-Governing equations for compressible flows. Mach number, Mach waves, Mach cone, and Mach angle, Sonic boom. Concept of stagnation state, stagnation properties. Adiabatic energy equation, various regions of flow, adiabatic ellipse	12
II	One-dimensional isentropic flow: adiabatic and isentropic flow of a perfect gas, isentropic flow in ducts of varying cross-sections, nozzles, mass flow rate, critical properties, choking, impulse function, operation of nozzle under varying pressure ratios–Use of gas tables.	12
III	Irreversible discontinuity in supersonic flow- one-dimensional shock wave-stationary normal shock- governing equations- Prandtl- Meyer relations- Shock strength- Rankine- Hugoniot Relation- Normal Shock on T-S diagram- working formula- curves and tables-Oblique shock waves - supersonic flow over compression and expansion corners	12
IV	Flow in a constant area duct with friction: Assumptions, Governing equations, Fanno curve on h-s and P-v diagram, Fanno flow relations for a perfect gas, variation of Mach number with duct length, choking due to friction, Use of gas tables for Fanno flow	12
V	Flow through constant area duct with heat transfer (Rayleigh Flow): Assumptions, Governing equations, Rayleigh line on h-s and P-v diagram, Rayleigh relation for perfect gas, maximum possible heat addition, location of maximum enthalpy and entropy points. Compressible flow field visualization and measurement- Shadowgraph-Schlieren technique- interferometer- subsonic compressible flow field -measurement Wind tunnel types, measurement of velocity, pressure, and temperature	12
	Total	60

VI) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40 : 60

Continuous Assessment	
Attendance	: 5 marks
Assignments	: 15 marks
Continuous Assessment Tests (2 Nos)	: 20 marks
Total Continuous Assessment	: 40 marks
End Semester Examination	: 60 marks

Total : 100 marks

VII) CONTINUOUS ASSESMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

VII) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL42C	ADVANCEMENTS IN DIGITAL MANUFACTURING	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW

The objective of this course is to develop comprehensive knowledge of additive manufacturing technologies, digital process modelling, and smart manufacturing systems. The course enables students to understand design principles for additive manufacturing, process mechanics, metallurgy, digital twin concepts, and emerging industrial applications

ii) COURSE OUTCOMES

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

	Course Outcomes	Learning Level
CO 1	Apply design principles and computational tools for additive manufacturing, including material selection, support structure design, multi-material considerations, and functionalization.	Apply
CO 2	Explain the classification, methodology, and process parameters of major additive manufacturing technologies.	Understand
CO 3	Explain metallurgical aspects of additive manufacturing such as defect formation, microstructure evolution, and powder characterization.	Understand
CO4	Apply Multiphysics modelling, simulation tools, and digital twin concepts for monitoring, analysis, and optimization of additive manufacturing processes.	Apply
CO5	Apply additive manufacturing concepts to evaluate and propose solutions for advanced industrial applications including smart materials and multi-dimensional printing.	Apply

iii) SYLLABUS

Design for Additive Manufacturing (DfAM): Introduction to additive manufacturing; geometric modelling and CAD for AM; design considerations including material selection, assembly, support structures, multi-material printing, and functionalization; design for optimal material usage; computational tools and simulation for design validation; standardisation and certification practices.

Additive Manufacturing Processes: Classification of AM processes – powder-based, liquid-based, sheet-based and wire-based systems. Vat photopolymerization, material jetting, binder jetting, extrusion-based processes, sheet lamination, powder bed fusion, directed energy deposition. Process methodology, process parameters, process mechanics, and post-processing techniques.

Metallurgy of Additive Manufacturing: Fundamentals of materials science in AM;

hydrodynamics of printing; defects in additive manufacturing; metal powder production methods; powder characterization and quality control; multifunctional and graded materials; metallurgical failure analysis; role of solidification rate; grain structure and microstructure evolution; surface characterization and post-processing.

Process Modelling and Digital Twin Concepts: Multiphysics computational modelling; introduction to COMSOL-based simulation; application of AI and ML techniques in additive manufacturing; data acquisition and sensors; real-time 3D printer health monitoring; print quality assessment and post-processing optimisation.

Recent Research Trends and Industrial Applications: Smart practices in additive manufacturing; printing of advanced materials such as smart materials, metamaterials, lattice metamaterials; printability challenges in multi-dimensional printing (3D/4D/5D/6D); applications in biomedical, aerospace, and spacecraft industries; case studies and workshops..

iv) a) TEXTBOOKS

1. Diegel, O., Nordin, A., and Motte, D., A Practical Guide to Design for Additive Manufacturing, Springer, 2020.
2. Gibson, I., Rosen, D. W., and Stucker, B., Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Springer.
3. Redwood, B., Schoffer, F., and Garret, B., The 3D Printing Handbook: Technologies, Design and Applications, 3D Hubs, 2017.
4. Lu, L., Fuh, J. Y. H., and Wong, Y. S., Laser-Induced Materials and Processes for Rapid Prototyping, Springer, 2001.

b) REFERENCES

1. Venuvinod, P. K., and Ma, W., Rapid Prototyping: Laser-based and Other Technologies, Springer, 2004.
2. Chua, C. K., Leong, K. F., and Lim, C. S., Rapid Prototyping: Principles and Applications, World Scientific Publishing.
3. Tao, F., and Zhang, M. (Eds.), Digital Twin Driven Smart Manufacturing, Academic Press.

v) COURSE PLAN

Module	Contents	Hours
I	Introduction to additive manufacturing, Geometric modelling, Computer Aided Design (CAD), Design considerations – Material and assembly, Design for multi-materials and functionalization, Design for optimal material usage- Mechanical strength, support structure, Design based computational tool and simulation, Design standardisation and certification. Introduction to any design software (Fusion 360 or Blender)	10
II	Classification – Powder, liquid, sheet, wire-based processes, Vat Photopolymerization, Material Jetting, Binder Jetting, Extrusion- Based, Sheet Lamination, Powder Bed Fusion, Directed Energy Deposition Methodology, Process parameter, Process Mechanics, Post processing- need	8

	and techniques.	
III	Material science, hydrodynamics of printing, defects in additive manufacturing, Metal powder production, Powder characterisation and Quality control, Multifunctional and graded materials Metallurgical failure analysis, Characterisation of printed surfaces and post processing.	8
IV	Multiphysics computational modelling, Introduction to COMSOL, Simulation, Application of AI and ML techniques in additive manufacturing. Digital twin concepts. Data acquisition and sensors. Real time 3D printer health monitoring, print quality and post processing.	9
V	Smart practices in additive manufacturing, Printing of advanced materials – smart material, meta material, lattice meta materials, Printability issues in multi-dimensional printing (3D,4D/5D/6D). Additive manufacturing for Bio-medical/aerospace/spacecraft applications. Case studies and workshops.	10
	Total	45

vi) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40: 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	40 marks
End Semester Examination	:	60 marks
TOTAL	:	100 marks

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL42D	Design for Additive Manufacturing	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW

The objective of this course is to impart the fundamentals of Additive Manufacturing (AM) and its design methodologies. Students are introduced to AM process steps, technologies, and design freedom offered by layer-based fabrication. The course covers principles of Design for Additive Manufacturing (DfAM), including part consolidation, topology optimization, lattice and generative design for lightweight and functional structures. Computational tools for design analysis, build simulation, and support optimization are introduced. Design considerations for polymer and metal AM, addressing anisotropy, residual stresses, and geometric constraints, are also discussed.

ii) COURSE OUTCOMES

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

	Course Outcomes	Learning Level
CO 1	Explain the need and general guidelines for Design for Additive Manufacturing (DfAM)	Understand
CO 2	Explain the guidelines and considerations for part consolidation in DfAM	Understand
CO 3	Interpret topology optimization, generative design, and lattice structures for improved performance.	Understand
CO4	Apply computational and simulation tools to execute model slicing, generate manufacturing toolpaths, and validate designs prior to fabrication.	Apply
CO5	Differentiate the key design considerations and constraints specific to polymer and metal additive manufacturing processes	Understand

iii) SYLLABUS

Additive Manufacturing (AM) – introduction, classification, and generic process chain – geometric modeling and design freedom in AM – need and principles of Design for Additive Manufacturing (DfAM) – CAD vs. DfAM tools – guidelines for minimizing print time and post-processing – economics of AM.

Design for part consolidation – design for function, material and assembly considerations, moving parts and fasteners – opportunities and challenges in part consolidation.

Design for improved functionality – multi-scale and multi-material design, biomimetics, generative design, and functionally graded materials – topology optimization: modeling, constraints, and analysis for weight reduction, stiffness, and displacement – design of lattice and cellular structures – design and optimization of support structures.

Computational tools for DfAM – build process simulation: model slicing, hatching, and toolpath generation – analysis of AM parts: material data, surface finish, and geometry simplification.

Design for polymer AM – anisotropy, layer thickness, support strategies, warpage, hollowing,

and fill styles – **Design for metal AM** – powder characteristics, residual stress, overhangs, shrinkage, and wall thickness guidelines – design considerations for holes, fillets, channels, bosses, threads, and part positioning.

iv) a) TEXTBOOKS

1. Diegel, O., Nordin, A., and Motte, D., A Practical Guide to Design for Additive Manufacturing, Springer, 2020.
2. Redwood, B., Schoffer, F., and Garret, B., The 3D Printing Handbook: Technologies, Design and Applications, 3D Hubs, 2017.
3. Martin, L., Design for Additive Manufacturing, Elsevier Science, 2019.

b) REFERENCES

1. Laroux, K., and Gillespie, Design for Advanced Manufacturing: Technologies and Process, McGraw-Hill, 2017.
2. Gibson, I., Rosen, D. W., Stucker, B., and Khorasani, M., Additive Manufacturing Technologies, Springer, 2021.
3. Lu, L., Fuh, J. Y. H., and Wong, Y. S., Laser-Induced Materials and Processes for Rapid Prototyping, Springer, 2001.
4. Rogers, D. F., and Adams, J. A., Mathematical Elements for Computer Graphics, Tata McGraw-Hill, 2008.
5. Mortenson, M. E., Geometric Modeling, Tata McGraw-Hill, 2013.

v) COURSE PLAN

Module	Contents	Hours
I	Introduction to Additive Manufacturing (AM) , Generic steps in additive manufacturing, process chain, Types of Additive Manufacturing technologies. Introduction to Design for Additive Manufacturing (DfAM) : Introduction to geometric modelling, Design freedom with AM, Need for Design for Additive Manufacturing (DfAM), CAD tools vs. DfAM tools, General Guidelines for DfAM, The Economics of Additive Manufacturing, Design to Minimize Print Time, Design to Minimize Post-processing.	9
II	Design Guidelines for Part Consolidation : Design for Function, Material Considerations, Number of Fasteners, Knowledge of Conventional DFM/DFA, Assembly Considerations, Moving Parts, Part redesign, Opportunities for part consolidation, challenges with part consolidation.	9
III	Design for Improved Functionality : Multi scale design for Additive manufacturing, Mass customization, Biomimetics, Generative design, Design of multi-materials and functionally graded materials. Design for Minimal Material Usage : Topology Optimization, Modelling of Design space, defining design and manufacturing constraints, performing analysis for weight reduction, maximize stiffness, minimize displacement, Post-processing and Interpreting Results, Applications of TO, TO tools, Design of cellular and lattice structures, Design of support structures.	9
IV	Computational Tools for Design Analysis : Considerations for Analysis of	9

	AM Parts, Material Data, Surface Finish, Geometry, Simplifying Geometry, Mesh-Based Versus Parametric Models, Build Process Simulation: Model Slicing, Contour Data Organization, Layer-by-Layer Simulation, Hatching Strategies, Scan Pattern Simulation and Tool Path Generation.	
V	<p>Design for Polymer AM: Anisotropy, Wall Thicknesses, Overhangs, Support Material, Accuracy, Tolerances, Layer Thickness, Resolution, Print Orientation, Warpage, Hollowing Parts, Horizontal Bridges, Connections, Fill Style, holes, fillets, ribs, font sizes and small details.</p> <p>Design for Metal AM: Powder Morphology, Powder Size Distribution, Material Characteristics, Designing to Minimize Stress concentrations, Residual Stress, Overhangs, shrinkage, warpage and Support Material, Design Guidelines for Wall Thickness, Vertical Slots, Circular Holes, fillets, channels, vertical Bosses, circular pins, External Screw Threads and part positioning.</p>	9
	Total	45

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment	
Attendance	: 5 marks
Assignments	: 15 marks
Assessment through Tests	: 20 marks
Total Continuous Assessment	: 40 marks
End Semester Examination	: 60 marks
TOTAL	: 100 marks

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
23MEL42E	Failure Analysis and Design	PEC	2	1	0	3	2023

i) COURSE OVERVIEW:

The course familiarizes with failure modes and analysis of failed components, and imparts knowledge of vibration-based condition monitoring for early fault detection and improved system reliability.

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

CO 1	Explain the fundamentals, causes, classification, and procedures involved in engineering failure analysis using appropriate tools and techniques.	Understand
CO 2	Apply machine condition monitoring and vibration analysis techniques to detect faults and assess the health of mechanical systems.	Apply
CO 3	Explain fracture and fatigue failures using stress concentration, fracture mechanics, and fractography approaches.	Understand
CO 4	Explain wear, corrosion, and elevated temperature failure mechanisms, including creep behaviour.	Understand
CO 5	Apply failure analysis principles to investigate failures in cast, welded, and rotating components such as shafts, bearings, and gears.	Apply

ii) SYLLABUS

Introduction to failure analysis; causes, classification, and procedures; tools, materials analysis, metallography, and NDT methods; **Machine condition monitoring** and vibration analysis; temperature, lubricant, and acoustic emission monitoring; rotating machinery and gearbox condition monitoring; **Failure mechanisms;** overload, ductile and brittle fracture; fracture mechanics and fatigue; fractography and damage-tolerant approach; **Wear and corrosion failures;** elevated temperature failures and creep; and case studies on failures of cast, welded, and rotating components including shafts, bearings, and gears.

iii) a) TEXTBOOKS

1. Jones D. R. H., "Engineering Materials 3–Materials Failure Analysis: Case Studies and Design Implications", Pergamon Press, 1993.
2. ASM Handbook, Vol. 11, "Failure Analysis and Prevention" Edited by, ASM Publications, 2002.

b) REFERENCES

1. ASM Handbook, Vol. 11, "Failure Analysis and Prevention" Edited by, ASM Publications, 2002.
2. Colangelo Vito J. and Heiser F., "Analysis of Metallurgical Failures", Second Edition, John Wiley & Sons, Inc., 1987.
3. Jones D. R. H., "Failure Analysis and Case Studies", Elsevier Publications, 1998.
4. Robert Bond Randall, "Vibration-Based Condition Monitoring: Industrial, Aerospace and Automotive Applications", John Wiley & Sons, 2011.

iv) COURSEPLAN

Module	Contents	No. of hours
I	Introduction to failure analysis, causes of failures, classification of failures, steps in failure analysis, tools and techniques, sample selection and treatment, materials analysis, equipment used in failure analysis, metallography, and commonly used non-destructive testing (NDT) methods.	9
II	Machine condition monitoring principles, vibration monitoring, temperature monitoring, lubricant analysis, acoustic emission techniques, condition monitoring of rotating machinery, and condition monitoring of gearboxes.	9
III	Failure mechanisms, overload failure, ductile fracture, brittle fracture, ductile-to-brittle transition, stress concentration approach, fracture mechanics approach, fatigue mechanisms, classical fatigue prevention and prediction, fractography, and damage-tolerant fatigue approach.	9
IV	Wear failures, adhesive wear, abrasive wear, erosive wear, corrosive wear, corrosion failures, types of corrosion, identification of corrosion failures, elevated temperature failures, creep, and creep crack branching.	9
V	Failure analysis applications, case studies on failures of cast components, welded components, rotating components, shafts, bearings, and gears.	9
	Total hours	45

v) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	40 marks
End Semester Examination	:	60 marks
TOTAL	:	100 marks

vi) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

vii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
23MEL42F	Biomechanics	PEC	2	1	0	3	2023

i) COURSE OVERVIEW:

This course introduces essential biological terminology, and progressively builds toward static analysis, postural analysis, and gait analysis. It also covers the mechanical behaviour of biomaterials, including both hard and soft tissues.

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

CO 1	Explain the fundamental principles of mechanics and the human musculoskeletal system, including skeletal muscles and mechanisms of force production.	Understand
CO 2	Apply the concepts of muscle mechanics and joint biomechanics to interpret forces and movements in upper and lower limb joints.	Apply
CO 3	Apply kinematic models, forward and inverse kinematics, Denavit–Hartenberg parameters, velocity analysis, and Jacobians to human movement analysis.	Apply
CO 4	Apply 3D orientation and motion representation using rotation matrices, quaternions, and related concepts such as singularity and gimbal lock.	Apply
CO 5	Explain the mechanics of biological tissues (hard and soft), viscoelasticity, tendon and ligament behaviour, and perform basic stability, gait, and hand kinematics analysis.	Understand

ii) SYLLABUS

Introductory mechanics, statics, dynamics, basic principles, human body as a biomechanical system, biomechanical terminologies, skeletal muscles, mechanism of force production, **Sliding filament theory**, force–length relationship, **Biomechanical analysis** of shoulder, elbow, wrist, hand and fingers, spine, hip, knee, and ankle joints, multi-link serial chain model of human movement, forward kinematics, inverse kinematics, Denavit–Hartenberg parameters, velocity analysis, Jacobians, **Measurement of orientation in 3D space**, rotation matrices, composite and relative rotations, complex numbers, quaternions, singularity, gimbal lock, parameterization, **Mechanics of hard tissues**, bone microstructure, properties of bone, Wolff’s law of bone remodelling, elastic properties, stress–strain relationship, viscoelastic properties of soft tissues, Maxwell, Voigt, and Kelvin models, cartilage, ligaments, tendons, enslaving, IMU-based finger and hand kinematics, stability, gait analysis.

iii) a) TEXTBOOKS

1. **Kerr, Andrew**, *Introductory Biomechanics*, 1st Edition, Churchill Livingstone / Elsevier Health Sciences, 2010.

2. **An Introduction to Human Movement and Biomechanics** — Edited by Andrew Kerr & Philip Rowe, 7th Edition, Elsevier Health Sciences, 2019.

3. **Biomechanics of Human Motion: Basics and Beyond** — Barney F. LeVeau, 1st Edition, Slack Incorporated / Taylor & Francis, 2010.

b) REFERENCES

1. **Biomechanics: Principles and Applications** — Edited by Donald R. Peterson & Joseph D. Bronzino, 2nd Edition, CRC Press / Taylor & Francis Group, 2008.
2. **Biomechanics: Concepts and Computation** — Cees Oomens, Marcel Brekelmans, Sandra Loerakker & Frank Baaijens, *Cambridge Texts in Biomedical Engineering*, 2nd Edition, Cambridge University Press, 2018.
3. **Biomechanics: Mechanical Properties of Living Tissues** — Y. C. Fung, 2nd Edition, Springer-Verlag, New York, 1993.
4. **Human Orthopaedic Biomechanics: Fundamentals, Devices and Applications** — Edited by Bernardo Innocenti & Fabio Galbusera, 1st Edition, Academic Press / Elsevier Science Publishing Co Inc, 2022.
5. **Basic Biomechanics of the Musculoskeletal System** — Margareta Nordin & Victor H. Frankel, 4th Edition (International Edition), Wolters Kluwer Health / Lippincott Williams & Wilkins, 2012.

iv) COURSEPLAN

Module	Contents	No. of hours
I	Introductory mechanics, statics, dynamics, basic principles, human body as a biomechanical system, basic biomechanical terminologies, skeletal muscles, mechanism of force production in skeletal muscles.	9
II	Sliding filament theory, force-length relationship, biomechanical analysis of shoulder joint, biomechanical analysis of elbow joint, biomechanical analysis of wrist joint, biomechanical analysis of hand and fingers, biomechanical analysis of spine, biomechanical analysis of hip joint.	9
III	Biomechanical analysis of knee joint, biomechanical analysis of ankle joint, multi-link serial chain model of human movement, forward kinematics, inverse kinematics, Denavit-Hartenberg parameters, velocity analysis, Jacobians.	9
IV	Measurement of orientation in 3D space, rotation matrices, composite rotation matrix, relative orientation, complex numbers, quaternions, singularity, gimbal lock and parameterization.	9
V	Mechanics of hard tissues, bone microstructure and properties of bone, Wolff's law of bone remodelling, elastic properties and stress-strain relationship, viscoelastic properties of soft tissues, Maxwell, Voigt, and Kelvin models, cartilage, ligaments, and tendons, enslaving, IMU-based finger and hand kinematics, stability and gait analysis.	9
	Total hours	45

v) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	40 marks
End Semester Examination	:	60 marks
TOTAL	:	100 marks

vi) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

vii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

SEMESTER VIII
2023 SCHEME

S8: PROGRAMME ELECTIVE III

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL43A	Cryogenic Engineering	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW:

This course bridges classical thermodynamics with modern low-temperature applications. It covers the behavior of materials at cryogenic temperatures, liquefaction cycles (Air, H₂, He, LNG), refrigeration systems (Cryocoolers), gas separation (ASU), storage vessel design, instrumentation, and safety protocols essential for the Hydrogen and LNG sectors.

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

CO 1	Explain the low-temperature properties of engineering materials/fluids and the significance of cryogenics in modern energy sectors (LNG, Hydrogen).	Understand
CO 2	Analyze thermodynamic cycles for the liquefaction of permanent gases (Air, Hydrogen, Helium).	Apply
CO 3	Analyze cryogenic refrigeration systems and cryocoolers for various temperature ranges.	Apply
CO 4	Explain the principles of gas separation (ASU), vacuum technology, and cryogenic storage systems.	Understand
CO 5	Explain instrumentation, heat exchangers, and safety protocols for cryogenic facilities.	Understand

ii) SYLLABUS

Introduction & Properties Historical background (Brief). Low-Temperature properties of Engineering Materials: Thermal conductivity, Specific heat, Thermal expansion, and Embrittlement. Electrical properties: Superconductivity. Cryogenic fluids: Properties of LH₂, LOX, LIN, LHe. **Applications:** The Hydrogen Economy (Production/Storage chain), LNG Supply Chain (Liquefaction/Regasification), Superconductivity (MRI, Maglev, Power transmission), and Space applications-cryogenic rocket propulsion (LOX-LH₂ propellant systems).

Liquefaction Systems Performance parameters: FOM, Yield, Work. Ideal Liquefaction system. **Air Liquefaction:** Joule-Thomson effect, Simple Linde-Hampson, Pre-cooled Linde, Claude, and Kapitza systems. Mixed Refrigerant Cycles (MRC) for LNG. **H₂ & He Liquefaction:** Ortho-to-Para conversion in Hydrogen (Heat of conversion, Catalysts). Collins Helium Liquefaction system. Critical components: Expansion Engines vs. Expansion Turbines.

Cryogenic Refrigeration Thermodynamics of Ideal Isothermal and Isobaric refrigeration. **Gas-based Refrigerators:** Stirling cycle, Gifford-McMahon (GM) Cryocoolers, and **Pulse Tube Cryocoolers** (Basic working principle). **Magnetic Refrigeration:** Magnetocaloric effect, Magnetic cooling cycle (Adiabatic Demagnetization) – Principles and applications only.

Separation & Storage Gas Separation: Ideal work of separation. Principles of Rectification and Plate columns. Air Separation Units (ASU): Linde Single-Column and Double-Column systems. Argon separation (Brief). **Storage & Transfer:** Inner/Outer vessel design. Insulation: Vacuum, Powder, Multi-Layer Insulation (MLI/Super Insulation). Vacuum Technology: Outgassing, Cryo-pumping. Transfer lines.

Instrumentation & Safety Instrumentation: Temperature: RTDs (Pt-100), Silicon Diodes, Cernox sensors. Pressure: Capacitance Manometers, Piezoelectric sensors. Flow: Turbine, Coriolis, and Venturi meters. Level: Capacitance and Superconducting probes. **Heat Exchangers:** Plate-Fin Heat Exchangers (PFHE) and Coil-Wound Heat Exchangers CWHE). **Safety:** Oxygen Deficiency Hazards (ODH), Oxygen compatibility, Pressure build-up hazards, Safety relief valves.

iii) (a) TEXT BOOKS

- 1) Randal F. Barron, Cryogenic systems, McGraw Hill, (2nd Ed), 1985
- 2) K. D. Timmerhaus and T. M. Flynn, Cryogenic Process Engineering, Springer, 2013
- 3) S.S Thipse, Cryogenics, Narrosa, 2012
- 4) M Mukhopadhyay, Fundamentals of Cryogenic Engineering, PHI Learning , 2010

iv) REFERENCES

- 1) A. R. Jha, Cryogenic Technology and applications, Elsevier Science, 2011
- 2) Edeskuty & Stewart ,Safety in the Handling of Cryogenic Fluids, 1996
- 3) Jack Ekin, Experimental Techniques for Low-Temperature Measurements, 2006
- 4) R. B. Scott, Cryogenic Engineering, Van Nostrand Co., 1989
- 5) M. D. Atrey (Ed.) Cryocoolers: Theory and Applications, 1st ed., 2020

V) COURSE PLAN

Module	Contents	No. of hours
I	<p>Introduction & Properties</p> <p>Intro to Cryogenics & Temperature Scale definition. Brief History.</p> <p>Mechanical Properties: Strength, Ductility, Brittle Fracture at Low Temperatures.</p> <p>Thermal Properties: Specific Heat (Debye Model concept), Thermal Conductivity, Thermal Contraction.</p> <p>Superconductivity: Type I & II, Meissner Effect, Critical Current/Field.</p> <p>Applications: Detailed look at Liquid Hydrogen (Fuel Cells/Rocketry), LNG Supply Chain and Cryogenic rocket propulsion (LOX–LH₂ propellant systems)</p>	9
II	<p>Liquefaction Systems</p> <p>System Performance: Yield, Work, FOM. Ideal Liquefaction.</p> <p>Air Liquefaction: Simple & Pre-cooled Linde Hampson (Cycle analysis).</p>	9

	Air Liquefaction: Claude System and Kapitza System. LNG Focus: Mixed Refrigerant Cycles (MRC) overview. Hydrogen: Inversion curve, Ortho-Para conversion issues & catalysts. Helium: Collins Liquefier (2-expander system).	
III	Cryogenic Refrigeration Introduction: Difference between Liquefiers and Refrigerators. Stirling Cycle Refrigerators: Ideal vs. Actual, Regenerator function. Gifford-McMahon (GM) Coolers: Valve timing, P-V diagram. Pulse Tube Cryocoolers: Basic/Orifice Pulse Tube (No moving parts). Magnetic Refrigeration: Magnetocaloric effect, Salt pills (Qualitative).	9
IV	Separation & Storage Gas Separation: Principles of Distillation, T-s diagram of mixtures. Air Separation Units (ASU): Linde Single & Double Column analysis. Cryogenic Storage: Vessel Geometry, Boil-off rate calculations. Insulation: Expanded foams, Perlite powder, Vacuum, MLI (Super Insulation). Vacuum: Materials for vacuum service, Outgassing, Cryo-pumping mechanics.	9
V	Instrumentation & Safety Temperature: Selection criteria (Sensitivity vs Range). Diodes vs Resistors Pressure & Flow: Capacitance gauges (Vacuum), Coriolis/Turbine (Flow). Level Measurement: Capacitance and Superconducting probes. Heat Exchangers: Plate-Fin (PFHE) geometry and effectiveness. Safety: Physiological hazards , O2 compatibility, Pressure relief design.	9
	Total	45

VI) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40 : 60

Continuous Assessment	
Attendance	: 5 marks
Assignments	: 15 marks
Continuous Assessment Tests (2 Nos)	: 20 marks
Total Continuous Assessment	: 40 marks
End Semester Examination	: 60 marks
Total	: 100 marks

VII) CONTINUOUS ASSESMENT TEST

- No. of tests: 02

- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

VII) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL42B	NON-CONVENTIONAL MACHINING PROCESS	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW

The objective of this course is to impart knowledge of non-conventional (non-traditional) machining principles and techniques, highlighting where conventional methods are inadequate. The course covers mechanical, chemical, electrochemical, thermal, and hybrid machining processes. Emphasis is placed on industrial need, process selection, advantages, limitations, emerging technologies, and nano-finishing applications.

ii) COURSE OUTCOMES

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

	Course Outcomes	Learning Level
CO 1	Classify Non-Conventional Machining (NCM) processes, emphasizing the fundamental principles and applications of Mechanical Energy-based techniques.	Understand
CO 2	Explain the principles and key operational parameters involved in Chemical and Electrochemical machining processes.	Understand
CO 3	Apply the fundamental principles and mechanisms of Thermo-electric machining processes.	Apply
CO 4	Explain the fundamentals and applications of Nano-Finishing processes	Understand
CO 5	Explain the features and operational characteristics of emerging hybrid machining processes.	Understand

iii) SYLLABUS

Basics of Non-Conventional Machining (NCM) – Need, classification, comparison with conventional machining, applications, advantages, limitations.

Mechanical Energy-Based NCM Processes – AJM, AWJM, USM, WJM: principles, equipment, parameters, advantages, limitations.

Chemical and Electrochemical NCM Processes – CHM, ECM, ECG, ECH, and Deburring: principles, equipment, parameters, applications, advantages, limitations.

Thermo-Electric NCM Processes – EDM, Wire EDM, LBM, PAM, EBM, IBM: principles, equipment, parameters, applications, advantages, limitations.

Nano-Finishing Processes: AFM, chemo-mechanical polishing, magnetic and magnetorheological finishing methods – principles, equipment, parameters, applications, advantages, limitations.

Hybrid NCM Processes: Introduction, comparison, selection, advancements, and selection criteria.

iv) a) TEXTBOOKS

1. Adithan, M., Unconventional Machining Processes, Atlantic Publishers, New Delhi, 2009.

- Anand Pandey, Modern Machining Processes, Ane Books Pvt. Ltd., New Delhi, 2nd Edition, 2014.

b) REFERENCES

- Vijay Kumar Jain, Advanced Machining Processes, Allied Publishers Pvt. Ltd., New Delhi, 2007.
- Pandey, P.C. and Shan, H.S., Modern Machining Processes, Tata McGraw-Hill, New Delhi.
- Ghosh, A. and Mallik, A.K., Manufacturing Science, East-West Press Pvt. Ltd., New Delhi.
- Jagadeesha T., "Non-Traditional Machining Processes", I.K. International Publishing House Pvt. Ltd., New Delhi, India, 2017, ISBN-13: 978-9385909122.

v) COURSE PLAN

Module	Contents	Hours
I	Introduction to NCM: Need, classification, comparison with conventional machining, Applications, advantages, limitations. Mechanical energy-based processes: Abrasive Jet Machining (AJM), Abrasive water jet machining (AWJM), Ultrasonic machining (USM), and Water jet machining (WJM): Principles, equipment, parameters, advantages, limitations.	9
II	Chemical & Electrochemical processes: Chemical Machining (CHM), Electro-chemical Machining (ECM), Electro-chemical Grinding (ECG), Electro-chemical Honing (ECH), and Deburring: Principles, equipment, parameters, advantages, limitations.	9
III	Thermo-electric processes: Electric discharge machining (EDM), Simple problems on EDM, Wire EDM, Laser beam machining (LBM), Plasma arc machining (PAM), Electron beam machining (EBM), Simple problems on EBM, Ion beam machining (IBM): Principles, equipment, parameters, applications, advantages, limitations.	9
IV	Nano-finishing processes: Abrasive Flow Machining (AFM), Chemo-mechanical polishing, Magnetic abrasive finishing, Magnetorheological finishing, Magnetorheological abrasive flow finishing. Principles, equipment, parameters, applications, advantages, limitations.	9
V	Hybrid NCM processes: Introduction, comparison and selection of hybrid NCM operations. Electrical Discharge Diamond Grinding (EDDG), Electrochemical Discharge Machining (ECDM), Laser Beam Micro Machining Process (LBMM), Abrasive Jet Micromachining (AJMM), Ultrasonic Micro Machining: (USMM), Overview of latest advancements on NCM technologies.	9
Total		45

vi) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40: 60

Continuous Assessment

Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks

Total Continuous Assessment	:	40 marks
End Semester Examination	:	60 marks
TOTAL	:	100 marks

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23MEL43C	Experimental Stress Analysis	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW

Goal of this course is to impart to the students, the basic aspects of theory of elasticity and stress-strain relationship as well as experimental stress analysis techniques that includes the most versatile techniques like photo elasticity, strain gauges and non-destructive test (NDT) methods

ii COURSE OUTCOMES

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

CO1	Explain the principles of the Theory of Elasticity and its measurements.	Understand
CO2	Apply analytical and graphical methods in stress analysis for elastic bodies	Apply
CO3	Explain the fundamentals of strain measurement systems and associated instrumentation circuits	Understand
CO4	Apply statistical techniques for uncertainty analysis and curve fitting of experimental data, as well as data reduction for strain rosettes.	Apply
CO5	Explain the principles of photo elasticity and brittle coating techniques	Understand
CO6	Explain the fundamental principles of various non-destructive testing (NDT) methods.	Understand

iii) SYLLABUS

Overview of stress analysis: Theory of Elasticity, Plane stress and plane strain conditions, compatibility conditions, Principal stresses and strains-analytical and graphical approaches. Stress analysis approaches.

Strain measurement: Strain gauges and Stress gauges – Types. Gauge characteristics, Gauge sensitivity - Strain rosettes. Residual stresses, Moire Method of Strain Analysis.

Instrumentation: Strain Circuits, Principles of Measurements, Uncertainty analysis, Curve fitting, Cathode Ray Oscilloscope, Transducers.

Photo elasticity: The Polariscope, stress optic law, Dark Field and Light field, Isochromatics and Isoclinics, Jones Calculus, Partial fringe value and compensation techniques. Introduction to three dimensional photo elasticity, Use of photo elastic coatings

Brittle coatings: Coating stresses, Failure theories, Brittle coating crack patterns, Types of coatings. Non-destructive testing (NDT) methods.

iv) a) TEXTBOOKS

1. J. W. Dally and W. F. Riley, Experimental Stress Analysis - McGraw Hill, 1991

2. J. P. Holman, Experimental methods for engineers, McGraw-Hill Mechanical Engineering, 2009.
3. L.S. Srinath, M.R. Raghavan, K. Lingaiah, G. Gargesa, B. Pant, and K. Ramachandra, Experimental Stress Analysis, Tata McGraw Hill, 1984.

b) REFERENCES

1. Jayamangal Prasad, C. G. Krishnadas Nair, Non-Destructive Test and Evaluation Of Materials, Tata McGraw-Hill, 2008.
2. Sadhu Singh, Experimental Stress Analysis, Khanna Publishers, 1996.

v) COURSE PLAN

Module	Contents	No. of hours
I	Overview of stress analysis: Theory of Elasticity, Plane stress and plane strain conditions, compatibility conditions, problem using plane stress and plane strain conditions, three-dimensional stress strain relations. Principal stresses and strains. Mohr's circle-measurement of strains and stresses. Stress analysis – Analytical, Numerical and Experimental approaches.	9
II	Strain measurement: Strain gauges and Stress gauges. Mechanical, Optical and Electrical gauges- construction and applications. Variable resistance strain gauges, Gauge characteristics, Gauge sensitivity, static and dynamic strains- reduction of strain gauge data-compensation-strain measurement over long period at high and low temperature. Strain rosettes- Rectangular rosette, Delta rosette. Residual stresses: Beneficial and harmful effects. Principle of residual stress measurement- methods only. Moire Method of Strain Analysis	9
III	Instrumentation : Strain Circuits, Potentiometer Circuits ,Range and sensitivity, The Wheatstone Bridge , Sensitivity, Galvanometer, Transient response, Principles of Measurement: Errors, Accuracy and Precision, Uncertainty analysis, Curve fitting Oscillograph, Cathode Ray Oscilloscope, Transducers- Displacement, Force, Pressure, Velocity, Acceleration	9
IV	Photo elasticity: The Polariscope, stress optic law, Photo elastic model materials, Polariscope arrangements – Plane polariscope and Circular polariscope. Dark Field and Light field, Isochromatics and Isoclinics, Jones Calculus, Partial fringe value and compensation techniques. Introduction to three dimensional photo elasticity, Use of photo elastic coatings	9
V	Brittle coatings: Coating stresses, Failure theories, Brittle coating crack patterns produced by direct loading, refrigeration, load release, Crack detection, Types of coatings, Steps in brittle coating tests, Coating selection, Surface preparation.	9

	Non-destructive testing (NDT) methods: Types – dye penetrate methods, Radiography-X-ray and Gamma Ray, X-ray fluoroscopy- Penetrometer- Magnetic particle method. Introduction to lasers in NDT – Ultrasonic flaw detection	
	Total	45

vi) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40 : 60

Continuous Assessment

Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	40 marks
End Semester Examination	:	60 marks
TOTAL	:	100 marks

viii CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

PROGRAMME ELECTIVE IV
(Management Courses)

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
23MEL44A	Product Design and Development	PEC	2	1	0	3	2023

i) COURSE OVERVIEW:

The course explores to develop a platform where the students can enhance their engineering knowledge in the product design and development domain.

ii) COURSE OUTCOMES

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

CO 1	Explain the life cycle of a product and product development Process.	Understand
CO 2	Develop knowledge of robust design and conceptual design.	Apply
CO 3	Explain the concept of Design for Manufacturing and Assembly in product design.	Understand
CO 4	Explain value engineering in the development of product.	Understand
CO 5	Explain ergonomics and rapid prototyping in product development.	Understand

iii) SYLLABUS

Introduction-Classification/ Specifications of Products, Product life cycle, product mix. product design, Modern product development process

Creativity Techniques- Creative thinking, conceptualization, brain storming, primary design, drawing, simulation, detail design. Industrial design, Robust Design: Design of experiments.

Design for Manufacturing and Assembly-Methods of designing for Manufacturing and Assembly. Design for Maintenance. Design for Environment. Ergonomics in product design

Value Engineering / Value Analysis- Methodology, Case studies. Product costing

Concurrent Engineering -Elements of concurrent engineering, Rapid prototyping, Reverse engineering

iv) a) TEXTBOOKS

1. Karl T Ulrich, Steven D Eppinger, Product Design & Development. Tata McGraw Hill, 2020.
2. P B Mahapatra, Operations Management- A Quantitative Approach, PHI, 2010

b) REFERENCES

1. Hollins B and Pugh S ,Successful Product Design. Butter worths London, 1990
2. Bralla J G (Ed.), ,Handbook of Product Design for Manufacture, McGraw Hill, New York, 1986.

v) COURSEPLAN

Module	Contents	No. of hours
I	Introduction: Classification/ Specifications of Products, Product life cycle, product mix. Introduction to product design, Modern product development process Design by evolution, Design by innovation, Morphology of design Ethics in product design and legal factors	9
II	Creativity Techniques: Creative thinking, conceptualization, brain storming, primary design, drawing, simulation, detail design. Conceptual Design: Generation, selection & embodiment of concept, Product architecture. Industrial design: process, need. Robust Design: Design of experiments.	9
III	Design for Manufacturing and Assembly: Methods of designing for Manufacturing and Assembly. Design for Maintenance. Design for Environment. Ergonomics in product design. Aesthetics in product design. Concepts of size and texture colour.	9
IV	Value Engineering / Value Analysis: Definition. Methodology, Case studies. Product costing. Economic analysis: Qualitative & Quantitative. Psychological and Physiological considerations.	9
V	Concurrent Engineering -Elements of concurrent engineering, Benefits Rapid prototyping: concepts, processes and advantages. Reverse engineering: steps in reverse engineering- Tools for product design – Drafting /Modelling software. Patents & IP Acts- Overview, Disclosure preparation.	9
	Total hours	45

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	40 marks
End Semester Examination	:	60 marks
<hr/>		
TOTAL	:	100 marks

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
23MEL44B	Material Handling and Facilities Planning	PEC	2	1	0	3	2023

i) COURSE OVERVIEW:

The course explores the overall facilities planning process, concepts of material handling and safety in industries

ii) COURSE OUTCOMES

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

CO 1	Compare the types of layouts used in manufacturing firms	Understand
CO 2	Identify the tools and techniques for layouts planning	Apply
CO 3	Explain the Safety and Environmental aspects in manufacturing firms.	Understand
CO 4	Compare the different Material handling systems used in Manufacturing firms	Understand
CO 5	Explain the Maintenance, Safety and Ergonomics of Material handling Equipments	Understand

iii) SYLLABUS

Design of layout of factories- Office, Storage area etc. Systematic layout planning, Design of Assembly lines,

Tools and techniques for developing Layout-Layout planning procedure. Visualization of layout, Line balancing methods Computer applications in layout designs, Environmental aspects , Different type of Plant services,

Plant safety- Elements of Industrial safety- Pollution and environmental consideration.

Material Handling systems- Material Handling principles, Relationship of material handling to plant layout. Material Handling method.

Maintenance of Material Handling Equipments- Safety in handling, Ergonomics of Material Handling equipment, Methods to minimize cost of material handling.

iv) a) TEXTBOOKS

1. K C Arora and Shinde, Aspects of Material handling, Lakshmi Publications,2007
2. S.C. Sharma, Material Management and Material Handling, Khanna Publishers,2000

b) REFERENCES

1. James A Apple, Plant layout and Material Handlin, Krieger Pub Co,2019
2. John A Sehbin, Plant layout and Material Handling,1978

v) COURSEPLAN

Module	Contents	No.of hours
I	Design of layout of factories, Office, Storage area etc. on consideration of facilities of working people, Storage facilities and general equipment for amenities of working people – Product, Process and combination layout –Systematic layout planning, Design of Assembly lines.	9
II	Tools and techniques for developing layout, process chart, flow diagram, string diagram, template and scale models. Layout planning procedure. Visualization of layout, revision and improving existing layout, balancing of fabrication and assembly lines. Line balancing methods. Computer applications in layout designs,	9
III	Plant safety, Elements of Industrial safety- Causes and prevention of accidents – Pollution and environmental consideration. Environmental aspects like lighting, Ventilation, dust control, humidity. Different type of Plant services like steam compressed air etc	9
IV	Material Handling systems- Introduction, Material Handling principles, Classification of Material Handling Equipment, Relationship of material handling to plant layout. Basic Material Handling systems: Selection, Material Handling method- path, Equipment, function oriented systems.	9
V	Methods to minimize cost of material handling- Maintenance of Material Handling Equipments, Safety in handling, Ergonomics of Material Handling equipment	9
	Total hours	45

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	40 marks
End Semester Examination	:	60 marks
TOTAL	:	100 marks

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL44C	Supply chain and Logistics Management	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW

This course will help understand the world of Supply chain and logistics Management in depth through various examples, current technologies, and real-life case studies.

ii)) COURSE OUTCOMES

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

	Course Outcomes	Learning Level
CO 1	Explain the fundamental concepts, structure, and strategic role of supply chain management in organizations.	Understand
CO 2	Apply logistics functions, transportation systems, and distribution strategies used in modern supply chains.	Apply
CO 3	Apply inventory control methods and warehouse management practices for efficient order fulfillment.	Apply
CO 4	Explain the role of digital technologies, information systems, and analytics in supply chain planning and decision-making.	Understand
CO5	Explain sustainable, ethical, and strategic practices in global supply chain and logistics management	Understand

iii) SYLLABUS

Introduction to Supply Chain Management: Evolution and scope of Supply Chain Management (SCM), Components of a supply chain: Supply chain vs. logistics: concepts and differences, Types of supply chains: lean, agile, hybrid, resilient, Role of SCM in business competitiveness and value creation, Key challenges in modern supply chains.

Logistics Management and Transportation, Logistics functions: inbound, outbound, and reverse logistics, Transportation modes: road, rail, air, sea, and multimodal transport, Transportation planning, routing, and scheduling, Warehousing and distribution centre operations, Packaging, material handling, and unitization, Third-party logistics (3PL) and fourth-party logistics (4PL). Case studies

Inventory and Warehouse Management: Inventory concepts and types: raw materials, WIP, finished goods, Demand forecasting techniques, Inventory control models: EOQ, JIT, ABC, VED, safety stock, Warehouse layout, design, and automation, Order picking, cross-docking, and fulfilment strategies, Performance measurement: KPIs and

service levels.

Supply Chain Planning, Technology, and Analytics: Supply chain planning: demand planning, supply planning, SOP, Role of information systems in SCM, ERP, WMS, TMS, and SCM software solutions, Use of data analytics and AI in supply chain decision-making, Digital supply chains: IoT, blockchain, RFID, and GPS tracking, Risk management and supply chain resilience.

Sustainable and Strategic Supply Chain Management: Green logistics and sustainable supply chain practices, Ethical sourcing and supplier relationship management, Global supply chains and trade regulations, Cost optimization and strategic sourcing, Supply chain performance measurement and benchmarking, Case studies on leading supply chain and logistics organizations.

iv) a) TEXTBOOKS

1. Chopra, S., & Meindl, P. (2023). *Supply Chain Management: Strategy, Planning, and Operation*. New Delhi: Pearson Education.
2. Ballou, R.H. (2020). *Business Logistics / Supply Chain Management*. New York: Pearson Education.
3. Bowersox, D.J., Closs, D.J., & Cooper, M.B. (2019). *Supply Chain Logistics Management*. New York: McGraw-Hill Education.
4. Rushton, A., Croucher, P., & Baker, P. (2022). *The Handbook of Logistics and Distribution Management*. London: Kogan Page.

b) REFERENCES

1. Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2021). *Designing and Managing the Supply Chain*. New York: McGraw-Hill Education.
2. Slack, N., Brandon-Jones, A., & Johnston, R. (2022). *Operations Management*. Harlow: Pearson Education

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Supply Chain Management: Evolution and scope of Supply Chain Management (SCM), Components of a supply chain: Supply chain vs. logistics: concepts and differences, Types of supply chains: lean, agile, hybrid, resilient, Role of SCM in business competitiveness and value creation, Key challenges in modern supply chains.	9
II	Logistics Management and Transportation: Logistics functions: inbound, outbound, and reverse logistics, Transportation modes: road, rail, air, sea, and multimodal transport, Transportation planning, routing, and scheduling, Warehousing and distribution centre operations, Packaging, material handling, and unitization, Third-party logistics (3PL) and fourth-party logistics (4PL). Case studies.	9

III	Inventory and Warehouse Management: Inventory concepts and types: raw materials, WIP, finished goods, Demand forecasting techniques, Inventory control models: EOQ, JIT, ABC, VED, safety stock, Warehouse layout, design, and automation, Order picking, cross-docking, and fulfilment strategies, Performance measurement: KPIs and service levels.	9
IV	Supply Chain Planning, Technology, and Analytics: Supply chain planning: demand planning, supply planning, SOP, Role of information systems in SCM, ERP, WMS, TMS, and SCM software solutions, Use of data analytics and AI in supply chain decision-making, Digital supply chains: IoT, blockchain, RFID, and GPS tracking, Risk management and supply chain resilience.	9
V	Sustainable and Strategic Supply Chain Management: Green logistics and sustainable supply chain practices, Ethical sourcing and supplier relationship management, Global supply chains and trade regulations, Cost optimization and strategic sourcing, Supply chain performance measurement and benchmarking, Case studies on leading supply chain and logistics organisation.	9
	TOTAL	45

vi) CONTINUOUS ASSESMENT EVALUATION PATTERN

Attendance	: 5 marks
Continuous Assessment Tests (2 Nos)	: 20 marks
Assignments/Project/Case study etc.	: 15 marks
Total	: 40 marks

vii) CONTINUOUS ASSESMENT EXAMINATION PATTERN

Two tests of 30 marks each (2.5 modules to be covered in each exam)

Duration – **1.5 hours**

viii) END SEMESTER EXAMINATION

Total Marks - **60**

Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL44D	Technology Management	PEC	2	1	0	0	3	2023

I. PRE-REQUISITE: NIL

II. COURSE OVERVIEW:

This course introduces students to the principles and practices of technology management in modern organizations. It provides an understanding of technology acquisition, forecasting, strategy, innovation, intellectual property rights, and the human and sustainability aspects of technological change. The course aims to equip students with the foundational knowledge required to understand and manage technological developments in a competitive and evolving environment.

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

CO1	Explain the concepts and significance of technology management in organizations	Understand
CO2	Explain technology acquisition, forecasting methods and emerging technologies	Understand
CO3	Discuss technology strategy, adoption and competitiveness in organizations	Understand
CO4	Apply basic principles of innovation and intellectual property rights in product or service development scenarios	Apply
CO5	Analyze human and sustainability issues involved in managing technological change	Analyze

III. SYLLABUS

Technology and Technology Management: Concepts and evolution of technology. Role and significance of technology management in organizations. Impact of technology on society and business. Product and process technology. Technology and competition. Introduction to digital transformation and emerging technologies.

Technology Acquisition and Technology Forecasting: Need for technology acquisition. Internal and external sources of technology. Alternatives for acquiring new technologies. Technology life cycle. Basics of technology forecasting and forecasting methods. Technology generation and development.

Technology Strategy and Management: Need for technology strategy. Technology adoption, diffusion, absorption and competitiveness. Elements of technology strategy. Constraints in technology absorption. Technology capability building. Government initiatives and sustainability strategies.

Management of R&D and Innovation: Importance of R&D. Product life cycle and innovation. Types of innovation. Difference between invention and innovation. Framework for innovation management. Intellectual Property Rights. Technology transfer and innovation case discussions.

Human Aspects in Technology Management: Integration of people and technology. Organizational and psychological aspects of technological change. Resistance to change. Skill development in the digital era. HR issues in R&D. Ethical, environmental and sustainability considerations in technology management.

IV. a) TEXT BOOKS

- 1) Narayanan, V. K., Managing Technology and Innovation for Competitive Advantage, Pearson Education,2002
- 2) Paul Trott, Innovation Management and New Product Development, Pearson Education,2004.
- 3) Rastogi, P. N., Management of Technology and Innovation, SAGE Publications,2009

IV. b) REFERENCES

- 1) Afuah, A., Innovation Management: Strategies, Implementation and Profits, Oxford University Press,2009
- 2) Burgelman, Christensen & Wheelwright, Strategic Management of Technology and Innovation, McGraw-Hill Education,2009
- 3) Tushman, M. L. & Anderson, P., Managing Strategic Innovation and Change, Oxford University Press,2004

V. COURSE PLAN

Module	Contents	No. of hours
I	Technology and Technology Management: Technology – evolution and growth of technology, concepts and definitions of technology management, role and significance of technology management in organizations, impact of technology on society and business. Technology and competition. Product and process technology. Digital transformation and Industry 4.0 concepts – smart systems, automation, data-driven decision making and emerging technologies. Impact of emerging technologies across sectors.	8
II	Technology Acquisition and Technology Forecasting: Technology acquisition – need for technology acquisition, internal and external sources of technology, alternatives for acquiring new technologies, technology transfer mechanisms, make or buy decisions. Technology life cycle (S-curve concept). Technology forecasting – need and role of forecasting, characteristics and principles of technology forecasting, basic forecasting methods such as trend analysis, Delphi method and scenario planning (conceptual treatment). Technology generation and development and its importance in organizations.	9
III	Technology Strategy and Management: Need for technology strategy in engineering organizations. Technology adoption, diffusion, absorption and competitiveness. Elements of technology strategy. Role and benefits of technology absorption. Constraints in technology absorption in Indian industries. Technology capability building. Government initiatives supporting technological	9

	growth (Make in India, Startup India – overview). Sustainability and green manufacturing strategies.	
IV	Management of R&D and Innovation: Importance of Research and Development (R&D) in mechanical industries. Corporate research and product life cycle. Translation of R&D efforts into technology. Innovation – meaning and types (incremental, radical and disruptive innovation). Difference between invention and innovation. Framework for management of innovation. Organizational characteristics that facilitate innovation. Intellectual Property Rights – patents, trademarks and copyrights and their role in innovation management. Technology transfer in product development. Case discussions in automotive, space and manufacturing sectors.	10
V	Human Aspects in Technology Management: Integration of people and technology. Human factors in technology management – organizational and psychological aspects. Resistance to technological change. Skill development and re-skilling in Industry 4.0 environment. Human resource management issues in R&D and innovation. Ethical issues in technological decisions. Technology assessment and environmental impact analysis. Sustainability considerations in technological implementation.	9
	Total	45

VI) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40:60

Continuous Assessment	
Attendance	: 5 marks
Assignments	: 15 marks
Continuous Assessment Tests (2 Nos)	: 20 marks
Total Continuous Assessment	: 40 marks
End Semester Examination	: 60 marks
Total	: 100 marks

VII) CONTINUOUS ASSESMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

VII) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

S8: PROGRAMME ELECTIVE - V

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL45A	Aerospace Engineering	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW:

This course provides the fundamentals of aerospace engineering and an understanding of flight instruments. It equips students with the core aerospace disciplines required to design and analyze aerospace vehicles and systems.

ii) COURSE OUTCOMES

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

CO 1	Explain the characteristics and structure of the Earth's atmosphere.	Explain
CO 2	Apply airfoil theory to analyze two-dimensional, three-dimensional, and finite airfoils.	Apply
CO 3	Apply principles of flight dynamics to perform performance analysis of aircraft.	Apply
CO 4	Explain the working principles and applications of various flight instruments.	Explain
CO 5	Explain the fundamental concepts of aircraft stability and control, space travel and principles of wind tunnel testing.	Explain

iii) SYLLABUS

The characteristics of 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 horseshoe vortex system - 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 engines - 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

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.

iv) (a) TEXT BOOKS

- 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
- 4) Anderson, Bowden, Introduction to Flight, McGraw-Hill, 9th edition, 2022

(b) REFERENCES

- 1) Houghton and Brock, Aerodynamics for Engineering Student, Hodder & Stoughton,1977.
- 2) Rathakrishnan, Introduction to Aerospace Engineering, Wiley, First Edition, 2021
- 3) G P Sutton, Rocket Propulsion Elements, Wiley, 9th edition, 2017

V) 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 horseshoe vortex system - wing load distribution – aspect ratio, induced drag calculation of induced drag from momentum considerations. Skin friction and form drag - changes in finite wing plan shape.	9
III	Propellers – momentum and blade element theories – propeller coefficients and charts. Aircraft engines – Turbojet, Turbofan, Turboprop engines. 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	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 (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 - Earth orbiting and escape velocities for circular orbit.	9
	Total	45

VI) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40: 60

<u>Continuous Assessment</u>	
Attendance	: 5 marks
Assignments	: 15 marks
Continuous Assessment Tests (2 Nos)	: 20 marks
Total Continuous Assessment	: 40 marks
End Semester Examination	: 60 marks
Total	: 100 marks

VII) CONTINUOUS ASSESMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

VII) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL45B	Fundamentals of Unmanned Aerial Vehicles	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW

This course provides a comprehensive understanding of Unmanned Aerial Vehicles (UAVs). The course aims to equip students with the knowledge and skills needed to understand and engage with UAV technology in various fields. Students will explore the aerodynamics, propulsion systems, control mechanisms, and applications associated with UAVs, along with an awareness of emerging technologies and challenges.

ii) COURSE OUTCOMES

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

CO1	Explain the fundamentals of UAVs, classifications, and the basic atmospheric and aerodynamic concepts involved in flight.	Understand
CO2	Apply the principles of aerodynamics and atmospheric science to analyze UAV flight and performance.	Apply
CO3	Explain UAV subsystems, airframe configurations, propulsion mechanisms, and regulatory standards.	Understand
CO4	Explain deployment strategies, manufacturing techniques, and future developments in UAV technology.	Understand
CO5	Identify mission-specific requirements, optimize UAV systems, conduct energy efficiency studies, and perform simulation testing.	Apply

iii) SYLLABUS

Overview of UAV: Evolution, classifications, mission roles, and flight mechanics; study of aerodynamic principles, design parameters, wing types, and key terminology.

Analysis of aerofoil behaviour: Lift/drag, flow regimes, stability, and control; performance evaluation including endurance, range, payload, altitude and atmospheric effects.

Study of airframe design: Propulsion, control, and on board systems; introduction to UAV regulations, safety, and mission planning.

Study of UAV deployment: Airspace operations, fabrication methods, maintenance, and practical applications across multiple sectors.

Assessment of UAV energy efficiency: Optimization, and simulation testing; exploration of future trends, sustainability, and energy-efficient technologies.

iv) a) TEXTBOOKS

1. Introduction to Flight, John D. Anderson, McGraw-Hill Higher Education, 2015
2. Unmanned Aircraft Systems: UAVs Design Development and Deployment, Reg Austin, Wiley, 2008.
3. Aircraft Design : A Conceptual Approach , Daniel P. Raymer, American Institute of Aeronautics & Astronautics, 2018.

b) REFERENCES

1. Richard K. Barnhart, Stephen B. Hottman, Douglas M. Marshall, Eric Shappee, Introduction to Unmanned Aircraft Systems, CRC Press, Taylor and Francis, 2012.
2. Paul Gerin Fahlstrom, Thomas James Gleason, Introduction to UAV Systems, Fourth Edition, Wiley Publications, 2012.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to UAV Systems: Fundamentals and history of UAVs, classifications, mission types, and operational environments. Introduction to flight mechanics – forces on UAVs, atmosphere, and aerodynamic principles. Basic design parameters and performance metrics, Terminology. Wing nomenclature and types.	9
II	Aerodynamics and Flight Performance: Aerofoil characteristics, lift and drag estimation, Mach number, Reynolds number, stall, boundary layer, rotary-wing aerodynamics, stages of flight. Aircraft Polar, Boundary Layer, Total Air-Vehicle Drag. Stability and control concepts. Atmospheric effects on flight. UAV performance calculations – endurance, range, and payload effects.	10
III	UAV Subsystems and Configurations: Airframe design and materials. Propulsion systems. Control mechanisms and onboard systems – sensors, autopilot, communication, and navigation. Overview of UAV regulations and safety considerations. Mission Definition and Planning	9
IV	Deployment, Applications, and Manufacturing: UAV deployment strategies. Operation in different airspaces. Fabrication methods – composites, 3D printing, and modular designs. Maintenance and reliability studies. Applications in agriculture, defense, surveillance, and logistics.	9
V	Key Considerations and Performance Metrics. Design and operational effectiveness. UAV system optimization for mission requirements. Introduction to simulation testing and energy efficiency studies. Future developments and sustainability challenges in UAV technology.	8
	Total	45

vi) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40: 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	40 marks
End Semester Examination	:	60 marks
TOTAL	:	100 marks

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL45C	Non Destructive Testing	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW

The objective of this course is to impart students with the fundamentals and applications of various NDT techniques, the procedure followed in various NDT techniques, equipment required for the NDT techniques and the recent trends in NDT.

ii) COURSE OUTCOMES

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

	Course Outcomes	Learning Level
CO 1	Explain about the fundamental aspects of non-destructive testing and visual inspection method.	Understand
CO 2	Explain the principles and characteristics associated with liquid penetrant inspection (LPI) and magnetic particle inspection (MPI) and demonstrate various LPI, MPI methods.	Understand
CO 3	Demonstrate various ultrasonic testing methods and radiography techniques used in NDT focusing on its core principle and characteristics.	Understand
CO4	Explain about the fundamentals in eddy current testing and its application.	Understand
CO5	Choose an appropriate NDT method to identify defects for a given application.	Apply

iii) SYLLABUS

Introduction: Comparison between destructive test and NDT, Importance of NDT, Scope of NDT, difficulties of NDT

LPI and MPI principles, properties required for a good penetrants and developers - Types of penetrants and developers. Methods of magnetization, Principles of MPI.

Ultrasonic testing: principle, types of waves, frequency, velocity, wavelength, reflection, divergence, attenuation, mode conversion in ultrasonic UT testing methods

Radiography: Principle, electromagnetic radiation sources: X-ray source, production of X-rays, high energy X-ray source, gamma ray source - Properties of X-rays and gamma rays

Eddy current testing: Principle, physics aspects of ECT like conductivity, permeability, resistivity, inductance, inductive reactance, impedance.

iv) a) TEXTBOOKS

1. Baldev Raj, Practical Non – Destructive Testing, Narosa Publishing House ,1997
2. J. Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGraw-Hill Education, 2nd edition (2017).

b) REFERENCES

1. Hull B. and V.John, Non-Destructive Testing, Macmillan,1988
2. Krautkramer, Josef and Hebert Krautkramer, Ultrasonic Testing of Materials, Springer-Verlag, 1990

v) COURSE PLAN

Module	Contents	Hours
I	Introduction to NDT, Comparison between destructive test and NDT, Importance of NDT, Scope of NDT, difficulties of NDT, future progress in NDT, economics aspects of NDT. Visual Inspection - tools, applications and limitations -Fundamentals of visual testing: vision, lighting, material attributes, environmental factors. visual perception, direct and indirect methods mirrors, magnifiers, boroscopes, fibrosopes, closed circuit television, light sources, special lighting, a systems, computer enhanced system	8
II	Liquid Penetrant Inspection: principles, properties required for a good penetrants and developers - Types of penetrants and developers, advantages and limitations of various methods of LPI – LPI technique/ test procedure, interpretation and evaluation of penetrant test indications, false indication. Magnetic Particle Inspection (MPI)- Principles of MPI, basic physics of magnetism, permeability, flux density, cohesive force, magnetizing force, retentivity, residual magnetism. Methods of magnetization, magnetization techniques such as head shot technique, cold shot technique, central conductor testing, magnetization using products using yokes, direct and indirect method of magnetization, continuous testing of MPI, residual technique of MPI, system sensitivity	10
III	Ultrasonic Testing (UT): principle, types of waves, frequency, velocity, wavelength, reflection, divergence, attenuation, mode conversion in ultrasonic UT testing methods, contact testing and immersion testing, normal beam and straight beam testing, angle beam testing, dual crystal probe, ultrasonic testing techniques, resonance testing, through transmission technique, pulse echo testing technique, Reference blocks with artificially created defects, calibration of equipment, A,B,C Scan, TOFD	9
IV	Radiography Testing (RT): Principle, electromagnetic radiation sources: X-ray source, production of X-rays, high energy X-ray source, gamma ray source - Properties of X-rays and gamma rays, Inspection techniques like SWSI, DWSI, DWDI, panoramic exposure, real time radiography, films used in industrial radiography, types of film, speed of films, qualities of film, screens used in radiography, quality of a good radiograph, film processing, interpretation, evaluation of test results, safety aspects required in radiography	9
V	Eddy Current Testing (ECT) - Principle, physics aspects of ECT like conductivity, permeability, resistivity, inductance, inductive reactance, impedance, Field factor and lift of effect, edge effect, end effect, impedance plane diagram in brief, depth of penetration of ECT, relation between frequency and depth of penetration in ECT, equipment and accessories, various application of ECT such as conductivity measurement, hardness	9

	measurement, defect detection, coating thickness measurement.	
	Total	45

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	40 marks
End Semester Examination	:	60 marks
TOTAL	:	100 marks

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
23MEL45D	ACOUSTICS AND NOISE CONTROL	PEC	2	1	0	3	2023

i) COURSE OVERVIEW:

The course explores the fundamental principles of acoustics, providing an understanding of various acoustic measurement instruments and emphasizing the importance of noise control. It also discusses regulations and standards related to noise exposure.

ii) COURSE OUTCOMES

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

CO 1	Explain various acoustic terminologies and understand the physics of acoustic wave propagation	Understand
CO 2	Explain reflection and transmission coefficients in sound transmission through different media and understand the concept of standing waves	Understand
CO 3	Explain the mechanism of hearing, concept of noise, various noise criteria and standards	Understand
CO 4	Explain different noise measures and noise measurement devices	Understand
CO 5	Apply noise control measures to different machines and devices	Apply

iii) SYLLABUS

Basic acoustic principles- sound pressure, particle velocity, acoustic wave equation, plane acoustic waves and harmonic solutions. Frequency, wavelength, acoustic impedance, sound power, sound intensity, energy density and the decibel scale, including the relationship between sound pressure, intensity and power.

Sound propagation and radiation – spherical waves, simple and hemispherical sources, radiating piston, pressure and intensity distribution, beam width and directivity index. Sound transmission – transmission through single and multiple media, reflection at plane surfaces, transmission loss and standing waves.

Human hearing and noise effects – structure and function of the ear, hearing thresholds, loudness, sound adaptation, human response to sound, speech interference level, perceived noise level, phon and sone scales, and hearing loss.

Noise criteria and standards – noise exposure regulations, noise criteria and guidelines for designing quieter equipment. Noise measurement – microphones, sound level meters, sound intensity probes, dosimeters, noise analyzers and spectrum analysis, including measurements in anechoic and reverberation chambers.

Noise control – principles of noise control at the source, during transmission and at the receiver, acoustic insulation, acoustic materials, mufflers, plenum chambers and advanced acoustic absorbers. Noise control in machinery such as pumps, rotating machines and reciprocating machines.

iv) a) TEXTBOOKS

1. Kinsler and frey – Fundamentals of Acoustics John Wiley & Sons Inc,1999
2. I. L. Ver, L. L. Beranek– Noise and Vibration Control Engineering: Principles and Applications,2005
3. Irwin,J.David – Industrial noise and vibration,Prentice Hall,1979

b) REFERENCES

1. Malcom J Crocker , Handbook of noise and vibration control, John Wiley & Sons, Inc.2007
2. Heinrich Kuttruff, Acoustics an introduction, Taylor & Francis 2006
3. David-A Bies. Collin H Hansen, Engineering Noise control- Theory and Practice, Fourth edition, Spon press, London,CRC Press,2009
4. Michael Moser, Engineering Acoustics, Springer,2004

v) COURSEPLAN

Module	Contents	Hours
I	Introduction – Basic acoustic principles, sound pressure, acoustic velocity, particle velocity, acoustic wave equation, Plane acoustic wave, harmonic solution. Frequency, wavelength, acoustic impedance, sound power, sound intensity, Energy density, Decibel scale – relationship between pressure, intensity and power	8
II	Spherical waves – radiation – simple source – hemispherical source- radiating piston –pressure intensity distribution – Beam width and directivity index Transmission through one, two and three media – Transmission through pipes – branched and unbranched, resonators – Transmission loss- reflection at plane surface, standing waves, standing wave apparatus.	8
III	Ear's structure and function, Hearing Thresholds, Loudness of Sound, and Sound Adaptation, Human reaction to sound – definitions of speech interference level, perceived noise level, phon and sone, hearing loss. Noise criteria and standards – noise and number index guidelines for designing quieter equipments	9
IV	Noise measurement- microphones, sound level meters, sound intensity probes, dosimeters, noise analyzer and graphic level recorder, spectrum Analysis, Measurement in anechoic and reverberation chambers.	10
V	Principles of noise control, control at source, during transmission and at receiver-protection of receiver, Acoustic insulation – acoustic materials – acoustic filter and mufflers – plenum chamber, advanced acoustic absorbers. Active noise control and adaptive noise cancellation systems Principles of noise control in machinery such as pumps, rotating and reciprocating machines, electric and hybrid machines.etc	10
	Total	45

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	40 marks
End Semester Examination	:	60 marks
TOTAL	:	100 marks

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL45E	Composite Materials	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW:

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

ii) COURSE OUTCOMES

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

CO 1	Explain about composites, various matrices and reinforcements used in composites.	Understand
CO 2	Explain the types of fibers/ whiskers used in composites, structure, properties and applications, manufacturing process.	Understand
CO 3	Explain polymer matrix composites, classification, properties, characteristics and applications, manufacturing methods.	Understand
CO 4	Elaborate the classification, properties, characteristics, applications, and manufacturing methods, alloys of metal and ceramic matrix composites, including their potential roles as matrices in composite materials.	Understand
CO 5	Apply micromechanical failure criteria to predict failure of composite lamina under given loading conditions.	Apply

iii) SYLLABUS

Composite: Introduction, definition, characteristics, functions, classification of composites
Fibers: Introduction, types of fibers, natural fibers, glass fiber fabrication, structure, properties and applications, boron fiber fabrication, structure, properties and applications, carbon fiber, ExPan carbon fiber, ex cellulose carbon fiber, Ex-Pitch carbon, carbon fiber structure, properties.
Polymer matrix composites (PMC), Metal matrix composites (MMC) : classification of metals, intermetallic, **Ceramic matrix composites (CMC) :** classification of ceramics and their potential role as matrices, properties, characteristics and applications of ceramics as matrix materials, conventional techniques.

iv) a) TEXTBOOKS

- 1) K. K. Chawla, Composite Materials : Science and Engineering, Springer, 3e, 2013.
- 2) P.K.Mallicak, Fiber-reinforced composites , Monal Deklar Inc., New York, 1988.
- 3) Reddy J N (Ed.), Mechanics of Composite Materials; Selected Works of Nicholas J. Pagano, Springer, 1994.
- 4) Robert M. Jones, Mechanics of Composite Materials, CRC Press, 1998.

b) REFERENCES

- 1) F.L.Matthews & R.D.Rawlings, Composite Materials, Engineering and Sciences, Chapman & hall, London, 1994.
- 2) Hand Book of Composites, George Lubin. Van Nostrand, Reinhold Co. 1982.
- 3) Michael Hyer, Stress Analysis of Fiber - Reinforced Composite Materials , McGraw Hill Education, 1998.

v) COURSE PLAN

Module	Contents	No.of hours
I	Composite : Introduction, definition, characteristics, functions. Classification of composites based on structure and matrix: History, industrial scene and applications. Smart composites, advantages and limitations. Interfaces: wettability and bonding interface in composites. Types of bonding at interface.	9
II	Fibers : Introduction, types of fibers, natural fibers. Fiberization, stabilization, carbonization, graphitization, glass fiber Fabrication, structure, properties and applications. Boron fiber fabrication, structure, properties and applications. Carbon fiber, Ex-Pan carbon fiber, Ex-Pitch carbon, Ex cellulose carbon fiber Aramid fiber fabrication, structure, properties and applications. Whiskers: characteristics, properties and applications.	9
III	Polymer matrix composites (PMC) : thermoset, thermoplastic and Elastomeric polymers. Properties, characteristics and applications as matrix materials. Processing of polymer matrix composites: hand methods, Lay up method, spray up method. Moulding methods, pressure bagging and bag moulding methods, Autoclave-based processing with prepregs. Pultrusion and filament winding process.	9
IV	Metal matrix composites (MMC) : Classification of metals, intermetallic, alloys and their potential role as matrices in composites. Properties, characteristics and applications of metals as matrix material. Production techniques: powder metallurgy, diffusion bonding, melt stirring. Squeeze Casting, liquid infiltration under pressure, in situ process.	9
V	Ceramic matrix composites (CMC) : Classification of ceramics and their potential role as matrices. Properties, characteristics and applications of ceramics as matrix materials. Conventional techniques : cold pressing and sintering, hot pressing, Reaction bonding, liquid infiltration, pultrusion. Lanxide process, in situ chemical technique, sol-gel technique Micromechanics of composites: maximum stress and strain criterion Application and derivation of maximum stress and maximum strain failure criteria to predict failure in composite lamina under given loading conditions., Tsai-Hill and Tsai-Wu failure criterion.	9
Total Hours :		45

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

<hr/> Continuous Assessment <hr/>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	40 marks
End Semester Examination	:	60 marks
TOTAL	:	100 marks

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

S8: PROGRAMME ELECTIVE VI

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL46A	Refrigeration and Air Conditioning	PEC	2	1	0	0	3	2023

i) **COURSE OVERVIEW:**

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

ii) **COURSE OUTCOMES**

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

CO 1	Explain the basic concepts and applications related to refrigeration and analyze the performance of ideal refrigeration cycles.	Understand
CO 2	Apply the thermodynamic principles to analyze the vapour compression refrigeration systems for improving the system performance.	Apply
CO 3	Explain the concept and working of vapour absorption and steam refrigeration systems.	Understand
CO 4	Explain and select appropriate refrigerants and system components for different applications.	Understand
CO 5	Estimate the properties of moist air using psychrometric principles and the cooling load and capacity requirement of AC machine.	Evaluate

iii) **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 for 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. Refrigerants and their properties, selection of refrigerants for different applications. Refrigerant leakage and detection – charging of refrigerant.

Air conditioning: Psychrometric properties, psychrometers, psychrometric chart. Psychrometric processes– Numerical examples.

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

iv) (a) **TEXT BOOKS**

1) Refrigeration and Air Conditioning, Arora C.P, Tata McGraw hill. 2017.

2) A Course in Refrigeration and air conditioning Arora S. C. and S. Domkundwar,

Dhanpat Rai and Company. 2022.

- 3) A Text Book of Refrigeration and air conditioning – R.K .Rajput, Kataria Publications, 2013.
- 4) Heating, Ventilating, and Air Conditioning: Analysis and Design, Faye C. McQuiston, Jerald D. Parker, Jeffrey D. Spitler, John Wiley and sons. New York. 2004.

(b) DATA BOOKS

- 1) Refrigeration tables and charts including air conditioning data, C P Kothandaraman, New Age International. 2018.
- 2) Refrigeration and air conditioning data book, Domkundwar and Domkundwar, Dhanpat Rai & Co. 2016.

(c) REFERENCES

- 1) ASHRAE Handbook 201(Volume 1,2,3).
- 2) Principles of heating ventilation and air conditioning in building, John Dixon, Delmar learning. 2013.
- 3) Analysis and design of heating ventilation and air conditioning system, Herbert W Sanferd and Adam F Spach, CRC press -Taylor and Francis. 2019.

V) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Refrigeration, 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- superheating, under cooling, Liquid suction heat exchanger, actual cycle. Multi pressure systems - multi compressor 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 fields of application. 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, Psychrometric chart. Psychrometric 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.	9

	Introduction to Air-conditioning, Applications of Air-conditioning. 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.	
	Total	45

VI) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40 : 60

Continuous Assessment	
Attendance	: 5 marks
Assignments	: 15 marks
Continuous Assessment Tests (2 Nos)	: 20 marks
Total Continuous Assessment	: 40 marks
End Semester Examination	: 60 marks
Total	: 100 marks

VII) CONTINUOUS ASSESMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

VIII) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL43X	ADVANCED METAL JOINING TECHNIQUES	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW

The objective of this course is to focus on modern and high-performance joining processes used in aerospace, automotive, nuclear, marine, and advanced manufacturing industries. The course introduces the classification and weldability aspects of advanced joining methods, followed by an in-depth study of solid-state welding, high-energy beam welding, and special welding processes. The course also covers alternative and emerging techniques. Students will gain the ability to analyze and select the appropriate advanced joining techniques for modern engineering applications.

ii) COURSE OUTCOMES

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

	Course Outcomes	Learning Level
CO 1	Explain the principles, mechanisms, and process parameters of solid-state welding techniques and the fundamentals of adhesive bonding.	Understand
CO 2	Explain the working principles, equipment, and applications of explosive welding, friction welding and friction stir welding.	Understand
CO 3	Explain the principles, process parameters, and weld joint designs associated with ultrasonic welding.	Understand
CO4	Apply the working principles, process parameters, and operational characteristics of high-energy beam welding processes such as EBW, LBW, and PAW.	Apply
CO5	Outline the alternative and emerging joining techniques including MIAB, underwater welding, brazing, micro-joining, and nano-joining for modern engineering applications	Understand

iii) SYLLABUS

Solid State Welding: Principle and mechanism of solid-state welding, techniques, process parameters and applications of diffusion welding, Adhesive Bonding: Principle – types of adhesives, bonding methods – applications

Explosive welding: principle and theory, equipment used, Process parameters and characteristics, weld joint design.

Friction and Friction stir welding: principle and theory – Process parameters and applications, Tools, and Metal flow.

Ultrasonic Welding: principle, theory, and types –Welding environment, equipment used- Process parameters and characteristics, weld joint design and applications. **Electron Beam Welding (EBW)** - principle and theory, Welding environment, equipment used- Process parameters and characteristics, **Laser Beam Welding (LBW)** – Principle and theory, types

of lasers, Simple problems on EBW and LBW, **Plasma Arc Welding (PAW)** –Theory – transferred arc and non-transferred arc techniques, equipment.

Alternative and Emerging Joining Techniques: Magnetically Impelled Arc Butt (MIAB)– principle and applications. **Under water welding** – wet-land dry under water welding- set-up for underwater welding systems. **Brazing** – Principle – processes involved – torch brazing, furnace brazing, vacuum brazing, induction brazing. **Micro-joining and nano-joining:** Introduction, theory, and applications.

iv) a) TEXTBOOKS

1. Advanced welding Processes, J. Norrish, Woodhead, publishing 2006.
2. Welding Processes and Technology, Parmar R. S Khanna, Publishers 1998.

b) REFERENCES

1. Principles of Welding, R. W. Messler, John Wiley and Sons 1999.
2. Metal Joining Manual, Schwartz M. M, McGraw-Hill Inc. 1979.
3. Micro-joining and Nano-joining, Y. N. Zhou, Woodhead publishing 2008.
4. Fundamentals of Metal Joining: Processes, Mechanisms and Performance, D. K. Dwivedi, Springer, 2021.

v) COURSE PLAN

Module	Contents	Hours
I	Introduction & Classification of Advanced Joining, Weldability. Solid State Welding: Principle and mechanism of solid-state welding, techniques, process parameters and applications of diffusion welding, cold pressure welding. Adhesive Bonding: Principle – types of adhesives, bonding methods – applications.	9
II	Explosive welding: principle and theory, equipment used, Process parameters and characteristics, weld joint design, Applications, advantages, and limitations. Friction and Friction stir welding: principle and theory – Process parameters and applications, Tools, and Metal flow.	9
III	Ultrasonic Welding: principle, theory, and types –Welding environment, equipment used- Process parameters and characteristics, weld joint design and applications.	8
IV	Electron Beam Welding (EBW) - principle and theory, Welding environment, equipment used- Process parameters and characteristics, advantages, and limitations. Laser Beam Welding (LBW) – Principle and theory, types of lasers, Process parameters and characteristics, Applications, advantages, and limitations. Simple problems on EBW and LBW, Plasma Arc Welding (PAW) –Theory – transferred arc and non-transferred arc techniques, equipment – applications.	10
V	Alternative and Emerging Joining Techniques: Magnetically Impelled Arc Butt (MIAB)– principle and applications. Under water welding – wet and dry	9

	under water welding- set-up for underwater welding systems. Brazing – Principle – processes involved – torch brazing, vacuum brazing, induction brazing – advantages and applications. Micro-joining and nano-joining: Introduction, theory, and applications.	
	Total	45

vi) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40: 60

Continuous Assessment	
Attendance	: 5 marks
Assignments	: 15 marks
Assessment through Tests	: 20 marks
Total Continuous Assessment	: 40 marks
End Semester Examination	: 60 marks
TOTAL	: 100 marks

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL46C	Numerical Methods in Engineering	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW:

The goal of the course is to provide the students with a solid foundation of the theory of Numerical Techniques, thus equipping them to solve mathematical models of engineering systems. Focus is on computational implementation of numerical methods.

ii) COURSE OUTCOMES

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

CO 1	Solve a system of equations using numerical techniques.	Apply
CO 2	Apply linear and nonlinear regression techniques to fit curves to data and implement least-squares-based solutions.	Apply
CO 3	Apply numerical differentiation and integration methods whenever and wherever routine methods are not applicable.	Apply
CO 4	Solve numerically the ordinary differential equations using different methods.	Apply
CO 5	Solve numerically the partial differential equations using different methods.	Apply

iii) SYLLABUS

Introduction to computational methods for engineering problem formulation, significant figures, accuracy, precision, error analysis, and Taylor series expansion. Numerical solution of algebraic and nonlinear equations. **Curve fitting** and regression analysis including linear, multiple linear, polynomial, and nonlinear regression. **Numerical differentiation and integration** using finite difference formulas, Newton's methods, Trapezoidal and Simpson's rules, and Gauss quadrature. **Numerical solution of ordinary differential equations** using Taylor, Euler, and fourth-order Runge-Kutta methods for single and simultaneous equations. **Solution of partial differential equations** using finite difference methods for elliptic, parabolic, and hyperbolic equations, including interpolation. Case studies to be implemented using computational tools such as MATLAB, Python, Scilab, or C++.

iv) a) TEXTBOOKS

- 1) Chapra S C and Canale R P, "Numerical Methods for Engineers", McGraw Hill, 2016.

b) REFERENCES

- 1) Joe D Hoffman, Numerical Methods for Engineers and Scientists, Second Edition, Marcel Dekker (2001).

- 2) Santhosh K. Gupta, "Numerical Methods for Engineers", New Age International publishers, 2005.
- 3) S. P. Venkateshan, Prasanna Swaminathan, Computational Methods in Engineering, Ane Books (2014).
- 4) Gilbert Strang, Computational Science and Engineering, Wellesley Cambridge Press (2007).

v) COURSEPLAN

Module	Contents	No.of hours
I	Introduction to Computational methods , system of equations Revision - Formulation of engineering problems and solutions using computational methods; significant figures, accuracy, precision, round off error, truncation error, Taylor series expansion of a polynomial. Roots of equation - Bisection, Newton- Raphson, and Bairstow methods. Linear algebraic equations - Gauss Elimination method, LU decomposition. Non- linear equation- Gauss-Jordan method, Newton-Raphson for simultaneous equations. Case studies with computer programs (Matlab/Python/Scilab/C++/Fortran/other).	9
II	Curve fitting - Linear regression- linearization of non linear relation, linear least squares, multiple linear regression. Nonlinear regression-polynomial regression, Gauss- Newton method. Case studies with computer programs (Matlab/Python/Scilab/C++/Fortran/other).	9
III	Numerical differentiation and integration - Derivatives- Newton's forward, backward, divided difference and Sterling formula. Integration -Trapezoidal rule, Simpsons one third, Simpsons three eighth, Gauss quadrature-two & three point. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).	9
IV	Numerical solutions to ordinary differential equations - Taylor's method, Euler's method, Runge-Kutta method fourth order, simultaneous first order, Case studies with computer programs (Matlab/Python/Scilab/ C++/Fortran/other).	9
V	Solution of partial differential equation & Interpolation. Solution of partial differential equation -Difference equations, Elliptic equation- Laplace equation, Poisson equation, Liebmann's iterative methods, Parabolic equation- Bender-Schmidt method, simple implicit, Crank Nicolson scheme, Solution of hyperbolic equation. Case studies with computer programs (Matlab/Python/Scilab/ C++/Fortran/other).	9
	Total hours:	45

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	40 marks
End Semester Examination	:	60 marks
TOTAL	:	100 marks

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL46D	OPTIMIZATION TECHNIQUES IN ENGINEERING	PEC	2	1	0	0	3	2023

1) Course Objectives:

To provide the basic knowledge of optimization techniques and optimal output and to apply design optimization for achieving best result compared with conventional design.

2) Course Outcomes:

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

CO 1	Explain the fundamentals and formulation of optimization problems	Understand
CO 2	Apply single-variable optimization techniques	Apply
CO 3	Solve unconstrained and constrained optimization problems	Apply
CO4	Apply optimization techniques in mechanical engineering applications	Apply
CO 5	Solve optimization results using basic computational tools	Apply

3) Syllabus:

Fundamentals of optimization and its significance in mechanical engineering, problem on formulation through design variables, objective functions, and constraints, **classification of optimization problems**, concepts of maxima and minima, concavity and convexity, and basic Taylor series understanding. **Single-variable optimization methods**, mechanical system design, manufacturing and production optimization, basic multi-objective concepts, **and introductory use of MATLAB**, supported by engineering multivariable unconstrained techniques using gradient-based and direct search methods, **and constrained optimization using Lagrange multipliers**, KKT conditions, and penalty methods. **Applications focus on Mechanical engineering - oriented numerical examples and case studies.**

4)

a) Textbooks

- i. Singiresu.S.Rao., "Engineering Optimization Theory and Practice" New Age International (P) Limited, Publishers 1996.
- ii. Johnson Ray.C., "Optimum design of mechanical elements" Wiley, John & Sons, 1990

b) Reference

- iii. Ravindran, Ragsdell, Reklaitis, *Engineering Optimization*, Wiley
- iv. Saravanan.R, “Manufacturing Optimization through intelligent techniques”, Taylor and Francis Publications, CRC Press. 2006.

5) Course Plan:

Module	Contents	No. of hours
I	Introduction to optimization and its importance in mechanical engineering. Elements of an optimization problem: design variables, objective function, constraints. Classification of optimization problems: single and multi-variable, constrained and unconstrained. Maxima and minima of single-variable functions. Basic concept of concavity and convexity. Taylor’s series expansion (single variable – conceptual understanding).	9
II	Optimality criteria for single-variable optimization. Exhaustive search method. Dichotomous search method. Fibonacci search method. Golden section search method. Introduction to Newton–Raphson method. Comparison of single-variable search techniques.	9
III	Optimality conditions for multivariable functions. Concept of gradient and Hessian matrix. Method of steepest descent. Introduction to conjugate gradient method. Direct search methods: Simplex (Nelder–Mead) method. Engineering-oriented numerical examples.	9
IV	Formulation of constrained optimization problems. Equality constrained optimization. Method of Lagrange multipliers. Inequality constraints (conceptual understanding). Introduction to Kuhn–Tucker (KKT) conditions. Penalty function method. Simple numerical problems relevant to mechanical engineering.	9
V	Optimization in mechanical system design. Manufacturing process optimization. Introduction to production planning and control. Basic concept of multi-objective optimization. Introduction to MATLAB for optimization (demonstration level). Case studies from mechanical engineering applications.	9
	Total hours	45

6) Assessment Pattern :

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	40 marks
End Semester Examination	:	60 marks
TOTAL	:	100 marks

7) Continuous assessment test :

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

8) End Semester Examination

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23MEL46E	Pressure Vessels Design	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW

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

ii COURSE OUTCOMES

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

CO1	Explain the design considerations of pressure vessels.	Understand
CO2	Make use of relevant stress analysis techniques to solve practical problems related to thin pressure vessel design.	Apply
CO3	Apply the design methodologies to design and analyze thick-walled pressure vessels in adherence to relevant industry standards and codes.	Apply
CO4	Apply design concepts in the design of shell and supports of vertical and horizontal pressure vessels	Apply
CO5	Solve problems involving the thickness and stiffener support requirements of cylinders under buckling loads	Apply

iii) SYLLABUS

Fundamentals of Thin Pressure Vessel Design: : Membrane stresses in general axisymmetric shell under internal Pressure. Stresses and dilation in various kinds of components. Bending plates.

Thick Pressure Vessel Analysis and Construction: Stresses in thick walled cylinders – Lamé’s equation - Shrink fit Stresses in built up cylinders in Built up cylinders. Auto-frettage in cylinders. Thermal stresses and significance. **Design of Vertical Pressure Vessels:** Design of tall vertical shell structures and its supports. Application of relevant standards and codes.

Design of Horizontal Pressure Vessels: Design of horizontal vessels. Analysis and design of supports. Application of relevant standards and codes. **Buckling Analysis and Stability:** Derivation of critical buckling pressure under external pressure, Pipe sizing and stiffener support design, Combined circumferential and axial buckling design.

iv) a) TEXTBOOKS

1. Harvey, J. F. (2018). Theory and Design of Pressure Vessels. CBS Publishers and Distributors.
2. Brownell, L. E., & Young, E. H. (1959). Process Equipment Design. John Wiley and Sons.

3. Chattopadhyay, S. (2004). Pressure Vessels: Design and Practice. CRC Press.

b) REFERENCES

1. Bednar, H. H. (1986). Pressure Vessels Design Handbook (2nd ed.). Van Nostrand Reinhold Company.
2. American Society of Mechanical Engineers (ASME). (2025). ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1, 2, and 3. ASME.
3. Moss, D., & Basic, M. (2013). Pressure Vessel Design Manual (4th ed.). Gulf Professional Publishing.

v) COURSE PLAN

Module	Contents	No. of hours
I	Fundamentals of Thin Pressure Vessel Design: Membrane stresses in axisymmetric shells under internal pressure. Stress and dilation analysis of common thin-walled components (spherical, cylindrical, conical). Introduction to bending plates and their application in vessel design.	9
II	Thick Pressure Vessel Analysis and Construction: Derivation and application of Lamé's equations for thick-walled cylinders. Shrink fit and stress analysis in built-up cylinders. Autofrettage techniques and their impact on stress distribution. Introduction to the significance of thermal stresses in pressure vessels.	9
III	Design of Vertical Pressure Vessels: Design considerations for tall vertical shell structures. Analysis and design of supports for vertical vessels. Application of relevant standards and codes for vertical vessel design.	11
IV	Design of Horizontal Pressure Vessels: Design of shell structures for horizontal vessels. Analysis and design of supports for horizontal vessels. Familiarization with industry standards and codes for horizontal vessel design.	7
V	Buckling Analysis and Stability: Derivation of critical buckling pressure for vessels under external pressure. Pipe sizing and stiffener support design for buckling prevention. Analysis of combined circumferential and axial buckling in pressure vessels.	9
	Total	45

vi) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40 : 60

Continuous Assessment

Attendance : 5 marks

Assignments : 15 marks

Assessment through Tests : 20 marks

Total Continuous Assessment : 40 marks**End Semester Examination : 60 marks****TOTAL : 100 marks**

viii CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEJ48A, 23MEJ48B	PROJECT	PWS	0	0	10	0	5	2023

i. COURSE OVERVIEW The aim of this course is to apply engineering knowledge in solving practical problems, to foster innovation in design of products, processes or systems, and to develop creative thinking in finding viable solutions to engineering problems. The course is mainly intended to evoke the innovation and invention skills of 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. There are two options to conduct the course:

Option 1:

- This option is recommended for students who are expected to undertake an internship in either 7th or 8th semester as per the department guidelines.
- The project shall be completed within a single semester, either in the 7th or the 8th semester.
- In the event that a student fails to undertake an internship in one of the semesters, the student shall be required to complete one more project during the next semester.
- The final project evaluation shall be conducted at the end of the semester.

Option 2:

The project is conducted in **two phases**:

- This option is applicable for students not opting for internships.
- Phase I (7th semester): Completion of 50% of the project work.
- Phase II (8th semester): Remaining 50% of the work to be completed.
- The final project evaluation shall be conducted at the end of the 7th and 8th semester.

- **Desirable:** The project outcome should be published in a peer-reviewed journal or presented at a conference, or a patent application should be filed.

It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies.

ii. COURSE OUTCOMES After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Apply multidisciplinary knowledge to model and solve real world problems.	Apply
CO 2	Apply innovative and creative problem-solving to develop sustainable and socially relevant products, processes, or technologies.	Create
CO 3	Exhibit effective teamwork and leadership skills in diverse environments, with the ability to comprehend and carry out designated responsibilities.	Apply
CO 4	Execute tasks by planning effectively and utilizing available resources to meet deadlines, while adhering to ethical and professional standards.	Apply
CO 5	Effectively document, present, and communicate technical and scientific outcomes in professional written and verbal formats.	Apply

iii. Evaluation Guidelines & Rubrics

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

- Project progress evaluation by guide: **20** Marks.
- Two interim evaluations by the Evaluation Committee: **30** Marks (15 marks for each evaluation).
- Final evaluation by the Final Evaluation committee: **30** Marks
- Quality of the report evaluated by the evaluation committee: **20** Marks

Interim Evaluation:

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

Final Evaluation:

The final evaluation committee comprises of Project coordinator, domain expert from the Department and expert from Industry/research/academic Institute / senior faculty from a sister department.

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23MEI48A	INTERNSHIP	PWS	0	0	-	0	5	2023

i) COURSE OBJECTIVES

The internship is an integral component of the undergraduate programme aimed at providing students with immersive learning through practical exposure in industry, research organizations, or academic institutions.

BENEFITS OF INTERNSHIP

Benefits to Students

- Provides practical exposure to real-world industrial and organizational environments, enabling the application of theoretical knowledge gained in classrooms.
- Enhances professional competencies such as communication, teamwork, time management, interpersonal skills, and workplace ethics.
- Facilitates the development of technical and domain-specific skills, thereby strengthening overall professional readiness.
- Assists students in assessing their career interests and determining the suitability of a particular industry or profession.
- Improves employability by strengthening profiles for placements, higher education, and potential recruitment by the host organization.
- Encourages professional networking and relationship - building with industry experts and peers.
- Offers an opportunity to evaluate the organization and work culture before committing to full-time employment.

Benefits to the Institute

- Strengthens industry - academia collaboration.
- Facilitates smoother and more effective placement processes.
- Enhances institutional credibility and brand value.
- Supports student engagement and retention.
- Enables curriculum updates based on industry and student feedback.
- Improves the overall teaching - learning process through industry relevance.

Benefits to the Industry

- Provides access to a pool of motivated, job-ready students who can contribute immediately.
- Offers a cost-effective mechanism to evaluate and recruit potential employees.
- Enables the availability of a flexible workforce for temporary, project-based, or seasonal requirements.
- Brings fresh perspectives and innovative approaches to problem-solving.
- Enhances organizational visibility and employer branding within academic institutions.
- Strengthens corporate image by contributing to education and skill development.

TYPES OF INTERNSHIPS

- Industry Internship with/without Stipend
- Government / PSU Internship (BARC/Railway/ISRO etc.)
- Internship with prominent education/ Research Institutes
- Internship with Incubation centres /Start-ups

ii) COURSE OVERVIEW

Students can undertake an internship at an industry, research organization, or a reputed academic institution with prior approval of the respective Head of the Department. Each student shall be assigned a faculty guide/supervisor for monitoring and evaluation. The internship shall be relevant to the student's stream of study and can be carried out in Semester **VII** or Semester **VIII**, as specified by the Department, for a minimum duration of **three months**.

A student shall be permitted to undertake the internship only after the respective semester registration. During the internship period, any other courses or academic activities shall be pursued in online mode or as specified by the Department, to ensure timely fulfillment of all academic requirements.

On successful completion of the internship, students are expected to demonstrate improved technical competence, professional conduct, and the ability to address practical problems in their chosen field.

iii) COURSE OUTCOMES

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

CO1	Apply theoretical knowledge and engineering principles to practical problems encountered in professional practice.	Apply
CO2	Demonstrate technical competence and understanding of tools, techniques, and processes relevant to the chosen field of specialization.	Apply
CO3	Analyse social, environmental, economic, safety, and administrative factors influencing industrial operations and decision-making processes.	Analyze
CO4	Communicate effectively through technical reports, presentations, and professional interactions in an industrial or research environment.	Apply
CO5	Apply professional ethics, teamwork, and adaptability while performing assigned tasks in a multidisciplinary work setting.	Apply

iv) GUIDELINES FOR STUDENTS

- Duration of internship is three to six months (One semester).
- Students may undertake mini projects, case studies, or related technical tasks during the internship with the prior approval of the competent authority at the host organisation.
- Students shall strictly adhere to the rules, regulations, code of conduct, and working hours prescribed by the host organisation.

- Prior permission shall be obtained from the host organisation before using or reproducing any data, documents, drawings, photographs, or proprietary information for academic purposes.
- Students shall follow all ethical practices, confidentiality requirements, and Standard Operating Procedures (SOPs) of the host organisation.
- Students shall comply with all health, safety, and environmental guidelines prescribed by the host organisation during the internship period.
- Students shall maintain regular contact with the assigned faculty guide/supervisor and submit weekly progress updates on the work carried out.
- Each student shall maintain a diary/logbook recording daily activities, learning outcomes, and progress throughout the internship period.
- On completion of the internship, students shall submit the following documents to the Department:
 - ✓ Internship report detailing the work carried out and learning outcomes
 - ✓ Internship Completion Certificate issued by the host organisation
 - ✓ Feedback from the employer
 - ✓ Proof of stipend received, if applicable

v) **ASSESSMENT PATTERN**

The marks awarded for the Internship will be based on the following:

- (i) Evaluation done by the industry,
- (ii) Student's diary,
- (iii) Internship report, and
- (iv) Internship viva voce.

Continuous Assessment		
Student's diary/ Daily Log	:	25 marks
Evaluation done by the industry	:	25 marks
Total Continuous Assessment	:	50 marks
Summative Assessment		
Internship Report	:	25 Marks
Internship Viva Voce	:	25 marks
Total Summative Assessment	:	50 marks
TOTAL	:	100 marks

Student's Diary/ Daily Log

The purpose of maintaining a daily diary is to cultivate systematic documentation habits and to encourage students to record observations, impressions, information gathered and suggestions, if any, during the internship period. The diary shall contain a day-to-day record of activities, learning experiences, technical details, and relevant sketches or drawings related to the work carried out. The daily diary shall be signed regularly by the industry supervisor and shall be verified and ratified by the faculty guide during the interim review.

The interim review shall be conducted midway through the internship by the Internship Review Committee, comprising the internship coordinator, faculty supervisor, and a senior faculty member of the Department. The review may be conducted in online or offline mode, based on the feasibility of the student's physical presence on campus.

Internship Report

On completion of the internship, each student shall prepare and submit a comprehensive internship report to the faculty supervisor. The report shall present a systematic account of the activities undertaken, observations made and knowledge gained during the training period. Students may consult the industry supervisor during the preparation of the final report, subject to compliance with the confidentiality policies and norms of the host organisation. The completed report shall be duly certified and signed by the Industry Supervisor, Faculty guide and the Head of the Department.

The internship report shall be evaluated based on the following criteria:

- Originality and technical content
- Adequacy, clarity and relevance of the written presentation
- Organization, format, use of drawings, sketches, language and overall style
- Variety and relevance of learning experiences documented
- Demonstration of practical applications and linkage with theoretical concepts covered in the curriculum

Evaluation done by the industry

The performance of the student during the internship shall be evaluated by the industry supervisor or the person-in-charge using a prescribed evaluation format provided by the institution. The evaluation shall cover key parameters such as professional behaviour, technical competence, learning ability, initiative, quality of work, communication skills, teamwork, discipline, time management, and overall professional attitude.

The faculty guide shall share the evaluation format with the host organisation and coordinate the assessment process. The completed evaluation form shall be duly signed and sealed by the industry supervisor and submitted to the Department as part of the internship assessment records.

Internship Viva Voce

The viva voce examination shall be conducted by the Internship Review Committee. The committee shall assess the student's understanding of the internship work, technical competence, learning outcomes, and professional orientation.

Item ME:BS 9.05

ME:BS 9.05	Considering the fourth year syllabi of the Honours courses offered by the Department of Mechanical Engineering - 2023 scheme
Background	<p>College has implemented the new B.Tech curriculum (2023 scheme) under autonomy in AY 2023-2024, with due approvals from the respective BoS, Academic Council and the Governing Body of the College. The students of the Department of Mechanical Engineering are provided with a facility to attain “B.Tech Honours” degree by earning additional credits.</p> <p>The proposed fourth year syllabi offered as Honours for B.Tech Programme of MED (2023 scheme) is presented for your kind consideration.</p>
Decision required	<p>BoS may examine the proposed fourth year syllabi for Honours courses (2023 scheme) for B.Tech programme in Mechanical Engineering and may give the recommendations to the Academic Council for granting approval.</p>
Annexure	<p>Proposed syllabi of fourth year courses for B.Tech Honours (2023 scheme) in Mechanical Engineering is attached as annexure to this item.</p>

B.Tech HONORS

<u>Semester</u>	<u>Basket 1: Power Plant and Energy Engineering</u>				<u>Basket 2: Manufacturing Engineering</u>			
	Course Code	Course Name	L-T-P-J	Credit	Course Code	Course Name	L-T-P-J	Credit
4	23MEL2HB	Thermal and Nuclear Power Plants	2-1-0-0	3	23MEL2HD	Additive Manufacturing	2-1-0-0	3
5	23MEL3HA	Emerging Technologies in Renewable Energy Sources	2-1-0-0	3	23MEL3HC	Theory of Metal Forming	2-1-0-0	3
6	23MEL3HB	Equipment Design for Thermal Systems	2-1-0-0	3	23MEL3HD	Reliability Engineering	2-1-0-0	3
7	23MEL4HA	Environmental and Safety Engineering	2-1-0-0	3	23MEL4HC	Manufacturing Automation	2-1-0-0	3
8	23MEJ4HB	Mini Project	0-0-6-0	3	23MEJ4HD	Mini Project	0-0-6-0	3

<u>Semester</u>	<u>Basket 3: Machine Design</u>				<u>Basket 4: Sports Engineering and Management</u>			
	Course Code	Course Name	L-T-P-J	Credit	Course Code	Course Name	L-T-P-J	Credit
4	23MEL2HF	Continuum Mechanics	2-1-0-0	3	23MEL2HH	Sports Psychology	2-1-0-0	3
5	23MEL3HE	Advanced Design Synthesis	2-1-0-0	3	23MEL3HG	Sports Analytics	2-1-0-0	3
6	23MEL3HF	Design of Pressure Vessels	2-1-0-0	3	23MEL3HH	Sports Engineering	2-1-0-0	3
7	23MEL4HE	Advanced Theory of Vibrations	2-1-0-0	3	23MEL4HG	Sports Product Design	2-1-0-0	3
8	23MEJ4HF	Mini Project	0-0-6-0	3	23MEJ4HH	Mini Project	0-0-6-0	3

S7 HONOURS
2023 SCHEME

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL4HA	Environmental and Safety Engineering	VAC	2	1	0	0	3	2023

i) COURSE OVERVIEW:

This course is designed to provide undergraduate students with a foundational understanding of environmental protection, pollution control, and industrial safety. It examines the environmental impacts of pollutants, waste management techniques, industrial safety practices, and hazard control measures. Emphasizing the significance of sustainable practices and safety in industrial environments, the course equips students with practical knowledge in managing environmental risks, ensuring compliance with environmental standards, and promoting a culture of safety within industrial settings.

ii) COURSE OUTCOMES

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

CO 1	Explain the types and sources of effluents generated from various power plants.	Understand
CO 2	Explain the principles of waste minimization, recovery, and resource conservation.	Understand
CO 3	Identify appropriate pollution control equipment and methods for air, water, and solid effluents in power plants.	Apply
CO 4	Evaluate the impact of power plant effluents on air, water, soil, and biodiversity through case-based analysis.	Apply
CO 5	Analyze fire hazards and propose fire safety plans for power plant environments.	Apply

iii) SYLLABUS

Air Pollution: Standards, Effects of Air Pollutants on Materials, Vegetation and Health Origin and Fate of Pollutants (Carbon monoxide, Hazardous Air Pollutants, Lead, Nitrogen Dioxide, Photochemical Oxidants, Sulphur Oxides, Particulates) Acid Rain, Ozone depletion & Greenhouse effect.

Waste Water Treatment : Waste water Microbiology, Characteristics of Waste Water, Municipal and Industrial waste water treatment, Unit operation of Pretreatment, Primary Treatment, Unit processes of Secondary treatment, disinfections, Land treatment, Sludge treatment and disposal.

Solid Waste Management: Waste characteristics, Disposal by Sanitary landfill, thermal conversion; combustion or incineration system, Pyrolysis, Gasification, Pelletization. Waste to Energy, Resource conservation and recovery, Biological processing of Solid wastes.

Hazardous Wastes Management : Characteristics of Hazardous Waste, Management of Hazardous Waste; Chemical. Oxidation, vitrification, Hazardous wastes landfills, Radioactive waste; Detection and analysis, classification and disposal of Radioactive Wastes, Fly ash characteristics and disposal, Site remediation techniques.

Effluents from power plants and Impact on environment : pollutants and pollution standards – Methods of Pollution control. Impact of pollutants on environment: Air, water, soil and noise pollution. Climate change contribution and biodiversity loss.

Industrial Safety: Accidents (Causes & Factors, Cost of Accidents, Accident Prevention, Investigation of Accidents, Reporting and Recording Systems for Accidents. First Aid (Basics of First Aid, How injuries are caused in lifting, falls etc.)

Fire Fighting: Fundamentals of Fire, Fire Fighting Equipments and Systems, Fire Extinguishing Methods, Demonstration of various Fire

Industrial Hazards Prevention: Protective Clothing and Equipment, Safe Working Practices in Power Plant, Permit to work system, Safety in Movement and storage of Materials, House Keeping, Safety Rules.

iv) (a) TEXT BOOKS

- 1) Sangeeta Raut & Sudip Kumar Sen C. (2017). Environmental Engineering & Safety Scientific Publishers.
- 2) Dr. Trinath Biswal, B. K. Nanda. (2019). Environmental Engineering & Safety. B.K.Publications Pvt. Ltd.
- 3) Dr. D.D. Misra. (2023). Environmental Engineering & Safety, University Book House (Pvt.) Ltd.

(b) REFERENCES

- 1) Sincero, Arcadio P. (Arcadio Pacquiao), J. M. (1996). Environmental engineering : a design approach. Upper Saddle River, N.J. : Prentice Hall.
- 2) P Aarne Vesilind, J. Jeffrey Peirce, Ruth F. Weiner. (2013), Environmental Engineering, 2th Edition. Elsevier.

V) COURSE PLAN

Module	Contents	No. of hours
I	Air Pollution Standards; Effects of Air Pollutants on Materials, Vegetation and Health Origin and Fate of Pollutants (Carbon monoxide, Hazardous Air Pollutants, Lead, Nitrogen Dioxide, Photochemical Oxidants, Sulphur Oxides, Particulates) Acid Rain, Ozone depletion & Greenhouse effect. Waste Water Treatment : Waste water Microbiology, Characteristics of Waste Water, Municipal and Industrial waste water treatment, Unit operation of Pretreatment, Primary Treatment, Unit processes of Secondary treatment, disinfections, Land treatment, Sludge treatment and disposal.	9
II	Solid Waste Management: Waste characteristics, Disposal by Sanitary landfill, thermal conversion; combustion or incineration system, Pyrolysis, Gasification, Pelletization. Waste to Energy, Resource conservation and recovery, Biological processing of Solid wastes. Hazardous Wastes Management : Characteristics of Hazardous Waste, Management of Hazardous Waste; Chemical. Oxidation, vitrification, Hazardous wastes landfills, Radioactive waste; Detection and analysis, classification and disposal of Radioactive Wastes, Fly ash characteristics and disposal, Site remediation techniques.	9
III	Effluents from power plants and Impact on environment – pollutants and pollution standards – Methods of Pollution control. Impact of pollutants on environment:	9

	Air, water, soil and noise pollution. Climate change contribution and biodiversity loss.	
IV	Industrial Safety: Accidents (Causes & Factors, Cost of Accidents, Accident Prevention, Investigation of Accidents, Reporting and Recording Systems for Accidents. First Aid (Basics of First Aid, How injuries are caused in lifting, falls etc.) Fire Fighting: Fundamentals of Fire, Fire Fighting Equipments and Systems, Fire Extinguishing Methods, Demonstration of various Fire	9
V	Industrial Hazards, Protective Clothing and Equipment, Safe Working Practices in Power Plant, Permit to work system, Safety in Movement and storage of Materials, House Keeping, Safety Rules.	9
	Total	45

VI) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40 : 60

Continuous Assessment	
Attendance	: 5 marks
Assignments	: 15 marks
Continuous Assessment Tests (2 Nos)	: 20 marks
Total Continuous Assessment	: 40 marks
End Semester Examination	: 60 marks
Total	: 100 marks

VII) CONTINUOUS ASSESMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

VIII) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL4HC	Manufacturing Automation	VAC	2	1	0	0	3	2023

i) COURSE OVERVIEW

The objective of this course is to impart knowledge of non-conventional (non-traditional) machining principles and techniques, highlighting where conventional methods are inadequate. The course covers mechanical, chemical, electrochemical, thermal, and hybrid machining processes. Emphasis is placed on industrial need, process selection, advantages, limitations, emerging technologies, and nano-finishing applications.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:		
	Course Outcomes	Learning Level
CO 1	Explain automation and explain the benefits, limitations, and economic considerations of automation in manufacturing systems.	Understand
CO 2	Explain types of automation (fixed, programmable, and flexible), automation strategies, and their applications in manufacturing industries.	Understand
CO 3	Apply basic automation system architecture concepts to select suitable automation solutions for manufacturing workflows and flow lines.	Apply
CO 4	Apply sequence control concepts using PLCs and relay ladder logic (RLL) for simple industrial automation and material handling tasks.	Apply
CO 5	Explain automated manufacturing systems involving work flow, material transport mechanisms, buffer storage, and actuation systems.	Understand

iii) SYLLABUS

Introduction to Manufacturing Automation – Definition of automation. Pros and cons of automation. Benefits of automation. Reasons for automating manufacturing operations. Types of automation: fixed automation, programmable automation, and flexible automation – features, comparison, and industrial examples. Automation strategies in manufacturing systems.

Automation System Architecture – Architecture of industrial automation systems: sensors, measurement systems, controllers, actuators, material handling systems, and communication interfaces. Role of automation hierarchy in manufacturing plants.

Measurement and Data Acquisition Systems – Characteristics of measurement systems. Static and dynamic characteristics. Introduction to industrial sensors. Data acquisition systems – signal conditioning, sampling, A/D and D/A conversion, and industrial data acquisition concepts.

Control and Sequence Automation – Introduction to automatic control in manufacturing systems. Basic feedback control concepts. PID control – concept and industrial relevance (no advanced mathematical treatment). Introduction to sequence control. PLC fundamentals, scan cycle, relay ladder logic (RLL), basic PLC programming elements. Structured design approach to sequence control. PLC hardware environment.

Automated Manufacturing Flow Lines and Material Handling – Automated flow lines – objectives, applications, and benefits. General forms of work flow and criteria for selection. Methods of work part transport: continuous, intermittent, and asynchronous systems – types, features, and selection criteria. Transfer mechanisms – linear transfer mechanisms and rotary transfer mechanisms with industrial examples. Buffer storage – purpose, types, and role in automated systems.

Industrial Actuation and Integration – Flow control valves. Basics of hydraulic and pneumatic control systems used in automation. Introduction to variable speed drives for energy savings. Introduction to CNC machines as automated manufacturing systems. Fieldbus networks and higher-level automation systems – overview and industrial relevance.

iv) a) TEXTBOOKS

1. Mukhopadhyay, S., Sen, S., & Deb, A. K., Industrial Instrumentation, Control and Automation, Jaico Publishing House, 2013.
2. Groover, M. P., Automation, Production Systems, and Computer-Integrated Manufacturing, Pearson Education.

b) REFERENCES

1. Krishnan, R., Electric Motor Drives: Modeling, Analysis, and Control, Prentice Hall India, 2002.
2. Merritt, H. E., Hydraulic Control Systems, Wiley, 1991.
3. Bolton, W., Programmable Logic Controllers, Elsevier / Newnes.
4. Kalpakjian, S. & Schmid, S., Manufacturing Engineering and Technology, Pearson Education.

c) NPTEL courses

1. https://onlinecourses.nptel.ac.in/noc26_me39/preview
2. https://onlinecourses.nptel.ac.in/noc26_ee47/preview

v) COURSE PLAN

Module	Contents	Hours
I	Introduction to automation: definition, pros & cons, benefits, reasons for automating. Types of automation: fixed, programmable, flexible – features and examples. Automation strategies.	8
II	Architecture of industrial automation systems. Sensors, controllers, actuators, automation hierarchy. Measurement system characteristics. Data acquisition systems – fundamentals.	8

III	Introduction to automatic control for manufacturing systems. Feedback control concepts. PID control – industrial relevance. Introduction to sequence control, PLCs, scan cycle, RLL, basic PLC programming.	11
IV	Automated flow lines – objectives and applications. Work flow forms and selection criteria. Work part transport methods: continuous, intermittent, asynchronous. Transfer mechanisms – linear and rotary. Buffer storage	10
V	Industrial actuation systems – basics of hydraulics and pneumatics. Variable speed drives and energy savings. Introduction to CNC machines. Overview of Fieldbus and higher-level automation systems.	8
	Total	45

vi) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40: 60

Continuous Assessment	
Attendance	: 5 marks
Assignments	: 15 marks
Assessment through Tests	: 20 marks
Total Continuous Assessment	: 40 marks
End Semester Examination	: 60 marks
TOTAL	: 100 marks

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL4HE	ADVANCED THEORY OF VIBRATIONS	VAC	2	1	0	0	3	2023

1) Course Objectives:

The objective of this course is

- To understand the principles of vibration theory
- To introduce techniques for solving vibration problems.

2) Course Outcomes:

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

#	Description	Level
CO1	Solve equation of motion of free and forced single degree of freedom vibration systems.	Apply
CO2	Solve matrix eigenvalue problem in multidegree of freedom systems	Apply
CO3	Solve numerical methods to compute natural frequencies and mode shapes of multidegree of freedom systems.	Apply
CO4	Analyze the free vibration characteristics of continuous systems	Apply

3) Syllabus:

Free and forced vibrations, rotating and reciprocating unbalance, base excitation, whirling of shafts, impulse and arbitrary excitation, convolution integral, vibration measurement. Normal modes and natural frequencies, principal coordinates, coordinate coupling, dynamic vibration absorbers. Lagrange's equations; matrix formulation, eigenvalues and eigenvectors; orthogonality of eigenvectors, modal analysis. Dunkerley's method, Rayleigh's method, Holzer method. Transverse vibration of strings, longitudinal and torsional vibration of rods, Euler equation for beams, Rayleigh-Ritz method, assumed modes and Galerkin method.

4) References:

- Leonard Meirovitch, Elements of Vibrations Analysis, Tata McGraw Hill - 2007
- Thomson W.T, Theory of Vibration with Applications, Pearson Education; 5 Edition, 2008.
- C Sujatha, Vibration, Acoustics and Strain Measurement: Theory and Experiments, Springer Nature; 2023.
- S.S Rao, Mechanical Vibrations, Pearson Education India; Sixth edition, 2018.
- Den Hartog, J P, Mechanical Vibrations, McGrawHill, 1956.

4) Course Plan:

Module	Contents	Hours
I	Vibration of single degree of freedom systems – free and forced vibrations – rotating and reciprocating unbalance, base excitation, whirling of shafts.	9
II	Impulse excitation- Response to arbitrary excitation – convolution integral. Vibration Measurement-Transducers, Vibration Pickups, Vibration Exciters. Two degree of freedom systems – normal modes and natural frequencies.	9
III	Principal co-ordinates –co-ordinate coupling - dynamic vibration absorbers - Numerical problems Multi degree of freedom systems – Lagrange’s equation. Matrix Formulation- Eigenvalue problem.	9
IV	Eigen values and Eigen vectors- Orthogonality of eigen vectors – Mode summation- Modal analysis. Approximate numerical methods- Dunkerley’s method- Rayleigh’s method- Holzer method.	9
V	Vibration of continuous system-Transverse vibration of strings- Longitudinal vibration of Rods. Torsional vibration of Rods- Euler Equation for beams. Rayleigh-Ritz method, Assumed modes and Galerkin method.	9
Total hours		45

5) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment

Attendance : 5 marks

Assignments : 15 marks

Assessment through Tests : 20 marks

Total Continuous Assessment : 40 marks

End Semester Examination : 60 marks

TOTAL : 100 marks

6) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

7) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23MEL4HG	Sports Product Design	VAC	2	1	0	0	3	2023

i) COURSE OVERVIEW

This course will help understand the world of Sports Product Design in depth through various examples, principles of innovation, current technologies, and real-life case studies.

ii) COURSE OUTCOMES

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

	Course Outcomes	Learning Level
CO 1	Explain engineering principles in sports product design and innovation.	Understand
CO 2	Apply the integration of biomechanics, materials, ergonomics, and sustainability.	Apply
CO 3	Develop industry-relevant design and prototyping skills.	Apply
CO 4	Explain promote innovation in sports equipment and wearable products.	Understand
CO5	Explain the concepts of sustainability, ethics, safety standards, and industry practices in sports product design.	Understand

ii) SYLLABUS

Introduction to Sports Product Design: Overview of sports product design and innovation, Classification of sports products: equipment, apparel, footwear, wearables, Role of engineering in sports performance and safety, Design thinking process in sports products.

Biomechanics, Ergonomics, and Human Factors: Fundamentals of sports biomechanics, Forces, motion, and energy transfer in sports movements, Ergonomic principles in sports equipment design, Body–equipment interaction, Injury mechanisms and preventive design.

Data Capturing Techniques in sports science: Introduction to Wearable Technologies, Type of devices, Information processing Decision making using data analysis on performance, injury, engagement, tools used for data collection – cameras, sensors, GPS

trackers etc. Case examples.

Sports Engineering design: Introduction to Sports Product designs and Human-Centered Design in Sport, Design Tools and Techniques, Materials in Sports Products, Basics of Sports Science- Anatomy and physiology related to sports performance. Kinematics and kinetics in sports movements.

Sustainability, Ethics, Safety Standards & Industry Practices in Sports: Concepts of sustainability and circular economy in sports products, Inclusivity and accessibility in sports product design, Data ethics and privacy in wearable sports technologies, international safety standards: ISO, ASTM, EN standards, BIS (India) standards for sports goods, Certification, quality assurance, and product testing methods.

iv) TEXTBOOKS

1. Jenkins, M. (2022). *Materials in Sports Equipment*. Cambridge: Woodhead Publishing.
2. McGinnis, P.M. (2021). *Biomechanics of Sport and Exercise*. Champaign, IL: Human Kinetics.
3. Cross, N. (2019). *Design Thinking: Understanding How Designers Think and Work*. London: Bloomsbury Publishing.
4. Yoxall, A., & Luxmoore, J. (2022). *Sports Product Design: Design for Performance*. London: Routledge.

b) REFERENCES

1. Bartlett, R. (2018). *Introduction to Sports Biomechanics: Analysing Human Movement Patterns*. London: Routledge.
2. Nigg, B.M., & Herzog, W. (2019). *Biomechanics of the Musculo-skeletal System*. Chichester: Wiley.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Sports Product Design: Overview of sports product design and innovation, Classification of sports products: equipment, apparel, footwear, wearables, Role of engineering in sports performance and safety, Design thinking process in sports products.	8
II	Biomechanics, Ergonomics, and Human Factors: Fundamentals of sports biomechanics, Forces, motion, and energy transfer in sports movements, Ergonomic principles in sports equipment design, Body–equipment interaction, Injury mechanisms and preventive design. Case studies: footwear, helmets, rackets, protective gear	9
III	Materials, Manufacturing, and Prototyping: Materials used in sports products: polymers, composites, metals, smart materials, Material selection based on performance and durability, Manufacturing processes: injection molding, additive manufacturing, CNC, Rapid prototyping and 3D printing in sports design. (Propose Sample solution -	10

	Modelling/simulation/sketching)	
IV	Smart Sports Products, Data Integration, and Innovation: Smart sports products and wearable technologies, Sensors, IoT, and data-driven design Integration of AI and analytics in sports products, Design for user experience (UX) and aesthetics, Product lifecycle management and commercialization.	9
V	Sustainability, Ethics, Safety Standards & Industry Practices in Sports: Concepts of sustainability and circular economy in sports products, Environmental impact of sports equipment, apparel, and footwear, Ethical responsibilities of sports product designers and engineers, Inclusivity and accessibility in sports product design, Data ethics and privacy in wearable sports technologies, international safety standards: ISO, ASTM, EN standards, BIS (India) standards for sports goods, Certification, quality assurance, and product testing methods.	9
	TOTAL	45

vi) CONTINUOUS ASSESMENT EVALUATION PATTERN

Attendance	: 5 marks
Continuous Assessment Tests (2 Nos)	: 20 marks
Assignments/Project/Case study etc.	: 15 marks
Total	: 40 marks

vii) CONTINUOUS ASSESMENT EXAMINATION PATTERN

Two tests of 30 marks each (2.5 modules to be covered in each exam)

Duration – **1.5 hours**

viii) END SEMESTER EXAMINATION

Total - **60 marks.**

Duration – **3 hours**

23MEJ4HB/ 23MEJ4HD/ 23MEJ4HF/ 23MEJ4HH	MINI PROJECT	Category	L	T	P	J	Credit	Year of Introduction
		VAC	0	0	6	0	3	2023

i) COURSE OVERVIEW:

The main objective of this course is to apply fundamental concepts learned in the respective Honour streams of Engineering through practical implementation. The course provides students with exposure to the development of application-oriented software, hardware solutions, or software simulations in their chosen field. Working in small teams under faculty supervision, students identify a relevant problem, perform literature review, plan and execute the project, and present the outcomes through a working model or prototype. The mini project enhances problem-solving ability, teamwork, project planning, and technical communication skills, and serves as a foundation for future research or major project work.

ii) COURSE OUTCOMES:

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

CO1	Identify engineering problems that are socially relevant, technically feasible, and economically viable.	Apply
CO2	Make use of relevant literature and existing engineering principles to explore and analyze potential solutions.	Apply
CO3	Develop a suitable design or methodology using modern tools while adhering to professional ethics.	Apply
CO4	Evaluate the performance or feasibility of the proposed solution using theoretical or experimental validation.	Evaluate
CO5	Apply effective communication techniques to prepare technical reports, presentations, and demonstrations.	Apply
CO 6	Plan and execute project activities and coordinate effectively within a team to meet objectives and deadlines.	Apply

iii) COURSE PLAN / GUIDELINES:

In this course, each group consisting of a maximum of 4 members is expected to design and develop a moderately complex software/hardware system relevant to their domain with practical applications. The basic concept of product design may be taken into consideration. Students should identify a topic of interest in consultation with the Project guide assigned and Project coordinator in charge of the course. They should review the literature from latest

journals, relevant conferences and gather information pertaining to the chosen topic. Later the group should state the objectives and develop a methodology to achieve the objectives and then carry out the design/fabrication or develop codes/programs to achieve the objectives. Finally the team should demonstrate the novelty of the project through the working results and outputs. The progress of the mini project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department/Project Coordinator in charge. A project report is required at the end of the semester which will be evaluated and approved by the department. Innovative design concepts, reliability considerations, aesthetics/ergonomic aspects taken care of in the project shall be given due considerations. A zeroth review may be conducted to finalize the topic and plan in the beginning. Two continuous reviews will assess progress and implementation.

iv) EVALUATION SCHEME

The Mini Project shall be evaluated through a comprehensive assessment framework designed to monitor continuous progress, technical competence, and quality of documentation. The evaluation carries a total of 100 marks, with a minimum pass requirement of 50 marks, and is conducted through multiple stages involving the project guide and an evaluation committee. Continuous assessment includes project progress evaluation by the guide, two interim evaluations by the Evaluation Committee to assess problem formulation, design, and implementation progress, and a final evaluation to judge the level of completion, functionality, demonstration, technical understanding, and viva-voce performance. In addition, the quality of the project report is assessed for technical depth, clarity, organization, and adherence to prescribed standards. The Evaluation Committee comprises the Head of the Department or a senior faculty member, the Mini Project Coordinator, and the Project Supervisor, ensuring a fair and holistic evaluation of the mini project.

v) EVALUATION PATTERN AND MARK DISTRIBUTION

Project progress evaluation by Guide	: 20 marks
Interim Evaluation – I	: 15 marks
Interim Evaluation – II	: 15 marks
Final Evaluation by Evaluation Committee:	30 marks
Quality of Project Report	: 20 marks
Total	: 100 marks

B.Tech MINORS

Semester	BASKET I				BASKET II				BASKET III			
	Supply Chain and Logistics				Unmanned Aerial Vehicle (UAV)				Computational Design Engineering			
	Course code	Course Name	L-T-P-J	Credits	Course code	Course Name	L-T-P-J	Credits	Course code	Course Name	L-T-P-J	Credits
S3	23MEL2MA	Supply chain and Logistics Management	3-0-0-0	3	23MEL2MC	Introduction to Unmanned Aerial Vehicles	2-1-0-0	3	23MEL2ME	Computer Aided Design	2-0-1-0	3
S4	23MEL2MB	Emerging Technologies in SCM	2-1-0-0	3	23MEL2MD	Elements of UAV system	2-1-0-0	3	23MEL2MF	Finite Element Methods	2-0-1-0	3
S5	23MEL3MA	Green Logistics and operations management	2-1-0-0	3	23MEL3MC	Design and Simulation of UAV	2-1-0-0	3	23MEL3ME	Computational Mechanics	2-1-0-0	3
S6	23MEL3MB	Digital Manufacturing Transformation	2-1-0-0	3	23MEL3MD	Fabrication and Testing of UAV	2-1-0-0	3	23MEL3MF	Optimization Techniques	2-1-0-0	3
S7/S8	23MEJ4MA	Mini Project	0-0-6-0	3	23MEJ4MC	Mini Project	0-0-6-0	3	23MEJ4ME	Mini Project	0-0-6-0	3

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23MEJ4MA 23MEJ4MC 23MEJ4ME	MINIPROJECT	VAC	0	0	6	0	3	2023

i) COURSE OVERVIEW

The course encourages students to apply the concepts, methods, and tools learned to solve real-world or socially relevant problems. The course also emphasizes innovation, and critical thinking, encouraging students to explore new ideas and technologies. The mini project topic selected will be assigned to 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. It helps students develop skills in teamwork, project planning, technical documentation, and communication.

ii) COURSE OUTCOMES

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

CO 1	Identify real life engineering problems that are socially relevant, technically feasible and economically viable.	Apply
CO 2	Design proper scientific methodology to successfully complete the project	Apply
CO 3	Develop solutions to socially relevant practical problems by applying suitable scientific tools	Apply
CO 4	Evaluate the performance of the developed solution using suitable data analysis, validation techniques, and engineering judgement.	Evaluate
CO 5	Prepare a technical report and present the project outcomes effectively using appropriate engineering and communication tools	Apply
CO6	Build the culture of working effectively in a team, upholding professional and ethical responsibilities	Apply

iii) COURSE PLAN

In this course, each group consisting of three/four members is expected to identify a topic of interest in consultation with Faculty-in-charge of mini project, review the literature and gather information pertaining to the chosen topic, state the objectives and develop a methodology to achieve the objectives. Execute experimental procedure,

design/fabrication or develop codes/programs or conduct case studies to achieve the objectives. Demonstrate the novelty of the project through the results and outcomes.

The progress of the mini project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department. A project report is submitted by each student at the end of the semester.

iv) ASSESSMENT PATTERN

The final evaluation will be conducted as an internal evaluation based on the level of objectives achieved, the report and a viva-voce examination, conducted by a 3-member committee appointed by Head of the Department offering minor. The committee members shall be HoD or a senior faculty member, Mini project coordinator and project supervisor. The Committee will evaluate the level of completion and demonstration of functionality/specifications, presentation, oral examination, working knowledge and involvement. The progress of the mini project is evaluated through a minimum of TWO reviews. At the time of the 1st review, students are expected to propose a methodology to achieve the objectives after completing a thorough literature study of the existing systems under their chosen area. In the 2nd review students are expected to highlight the implementation details of the proposed solution.

V) Mark Distribution:

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

- Project progress evaluation by guide : 20 Marks.
- Two interim evaluations by the Evaluation Committee : 30 Marks (15 marks for each evaluation).
- Final evaluation by the Final Evaluation committee : 30 Marks
- Quality of the report evaluated by the evaluation committee: 20 Marks