NEW HORIZON
COLLEGE OF ENGINEERING

Department of Mechanical Engineering

Academic Year 2023-24

5TH and 6th Semester

Scheme and Syllabus

BATCH – 2021-2025

CREDITS: 160

NEW HORIZON COLLEGE OF ENGINEERING

VISION

To emerge as an institute of eminence in the fields of engineering, technology and management in serving the industry and the nation by empowering students with a high degree of technical, managerial and practical competence.

MISSION

- To strengthen the theoretical, practical and ethical dimensions of the learning process by fostering a culture of research and innovation among faculty members and students.
- To encourage long-term interaction between the academia and industry through their involvement in the design of curriculum and its hands-on implementation.
- To strengthen and mould students in professional, ethical, social and environmental dimensions by encouraging participation in co-curricular and extracurricular activities.

QUALITY POLICY

To provide educational services of the highest quality both curricular and co-curricular to enable students integrate skills and serve the industry and society equally well at global level

VALUES

- Academic Freedom
- Integrity
- Inclusiveness
- Innovation
- Professionalism
- Social Responsibility

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To create competent mechanical engineers capable of working in diversified disciplines for transformative impact on societal progressive development in the field of mechanical engineering through creative research and lifelong learning

MISSION

- To impart excellent education by providing the state of art research facilities in the field of mechanical engineering.
- To develop alliances with industries and other organizations for excellence in teaching learning process, research and consultancy projects.
- To enhance the knowledge of students in intellectual, entrepreneurial and ethical challenges through active participation by critical thinking.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

- **PEO 1**: The graduates will be able to apply the overall knowledge of Mechanical Engineering along with concepts of Mathematics, Science, Communication and Computing skills to understand specific problem areas and finding the optimal solutions for the same.

- **PEO 2**: The graduates will be able to implement ideas of Mechanical Engineering for the challenging tasks in the interdisciplinary areas like Electrical, Electronics, Computer Science, Civil, Bio-Technology and allied branches.

- **PEO 3**: The graduates will be widely talented in the fields of manufacturing, service and design industries, which will not only improve their employability but also aid in establishing the above said industries.

- **PEO 4**: The graduates will develop lifelong learning attitudes, ethics and values that will help their career employability and growth in engineering, academia, defence, state and central government sectors.

PEO TO MISSION STATEMENT MAPPING

Program Educational Objectives	M1	M2	M3
PEO 1	3	2	3
PEO 2	2	1	3
PEO 3	3	2	2
PEO 4	2	2	3

PROGRAM OUTCOMES (POs)

Graduate Attributes	PO #	Program Outcomes
Engineering knowledge	1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex mechanical engineering problems
Problem Analysis	2	Identify, formulate, review research literature, and analyze complex engineering problems in Mechanical Engineering reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
Design Development of Solutions	3	Design solutions for complex engineering problems and design system components or processes of Mechanical Engineering that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
Conduct Investigations of Complex Problems	4	Use research-based knowledge and research methods including design of experiments in Mechanical Engineering, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
Modern tool usage	5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities in Mechanical Engineering with an understanding of the limitations.
The Engineer and society	6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice in Mechanical Engineering.
Environment and Sustainability	7	Understand the impact of the professional engineering solutions of mechanical Engineering in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
Ethics	8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
Individual & team work	9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
Communication	10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
Project management and finance	11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, manage projects and in multidisciplinary environments.
Lifelong learning	12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

After successful completion of mechanical Engineering Program, the graduates will be able to:

PSO1	Specify, fabricate, test and operate various machines along with essential documentations.
PSO2	Analyze, design, develop and implement the concepts of mechanical systems and processes towards product development

V Semester Scheme													
S. No.	Course and Course Code		Course Title	BoS	Credit Distribution				Overall Credits	Contact Hours	Marks		
					L	T	P	S			CIE	SEE	Total
1	PCC	21MEE51	Machine Theory & Mechanism Design	ME	3	0	0	0	3	3	50	50	100
2	PCCL	21MEL51	Machine Theory & Mechanism Design Lab	ME	0	0	1	0	1	2	50	50	100
3	PCC	21MEE52	Computer Integrated Manufacturing	ME	3	0	0	0	3	3	50	50	100
4	PCCL	21MEL52	Computer Integrated Manufacturing Lab	ME	0	0	1	0	1	2	50	50	100
5	PCC	21MEE53	Machine Design	ME	3	0	0	0	3	3	50	50	100
6	PEC	21MEE54 X	Professional Elective Course-I	ME	3	0	0	0	3	3	50	50	100
7	AEC	21MEL55 X	Ability Enhancement Course-V	ME	0	0	1	0	1	2	50	50	100
8	MP	21MEE56	Mini Project	ME	0	0	1	0	1	2	50	50	100
9	AEC	21MEK57	Research Methodology and IPR	ME	1	0	0	0	1	2	50	50	100
10	UHV	21MEK58	Innovation and Design Thinking	ME	1	0	0	0	1	1	50	50	100
								Total	**18**	**23**	**500**	**500**	**1000**

NCMC	21NSS84	National Service Scheme (NSS)	NSS coordinator	All students have to register for any one of the courses namely National Service Scheme, Physical Education (PE) (Sports and Athletics) and Yoga with the concerned coordinator of the course during the first week of V semester. The activities shall be carried out from (for 4 semesters) between V semester to VIII semester. SEE in the above courses shall be conducted during VIII semester examinations and the accumulated CIE marks shall be added to the SEE marks. Successful completion of the registered course is mandatory for the award of the degree. The events shall to be reflected in the calendar prepared for the NSS, PE and Yoga activities.
	21PES84	Physical Education (PE) (Sports and Athletics)	Physical Education Director	
	21YOG84	Yoga	Yoga Teacher	

PCC: Professional Core Course, **PCCL**: Professional Core Course laboratory, **UHV**: Universal Human Value Course, **NCMC**: Non-Credit Mandatory Course, **AEC**: Ability Enhancement Course, **PEC**: Professional Elective Course, **PROJ**: Mini Project work **L:** Lecture, **T**: Tutorial, **P**: Practical **S: SDA**: Self Study for Skill Development, **CIE**: Continuous Internal Evaluation, **SEE**:Semester End Evaluation

Professional Elective Course-I			
21MEE541	Mechatronics	21MEE544	Statistics for Engineers
21MEE542	Non Destructive Testing	21MEE545	Electric Vehicles and Battery Management System
21MEE543	Industrial Waste Management		

Ability Enhancement Course-V			
21MEL551	Energy Engineering	21MEL554	Tools for Energy systems design and drafting
21MEL552	Sustainable energy systems design	21MEL555	Advanced Semiconductor Materials and its applications
21MEL553	Air Pollution Control		

Professional Elective Courses (PEC): A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in the Engineering and Technology curriculum. Multidisciplinary courses that are added supplement the latest trend and advanced technology in the selected stream of engineering.

Mini-project work: Mini Project is a laboratory-oriented/hands on course that will provide a platform to students to enhance their practical knowledge and skills by the development of small systems/applications etc. Based on the ability/abilities of the student/s and recommendations of the mentor. A student can do mini project as

(i) A group of 2 if mini project work is single discipline (applicable to all IT allied branches)

(ii) A group of 2- 4 if mini project work is single discipline (applicable to all Core Branches)

(iii) A group of 2 - 4 students if the Mini Project work is a multidisciplinary (Applicable to all Branches)

CIE procedure for Mini-project:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two faculty members of the Department, one of them being the Guide. The CIE marks awarded for the Mini-project work shall be based on the evaluation of the project report, project presentation skill, and question and answer session in the ratio of 50:25:25. The marks awarded for the project report shall be the same for all the batches mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group-wise at the college level with the participation of all the guides of the project.

The CIE marks awarded for the Mini-project, shall be based on the evaluation of the project report, project presentation skill, and question and answer session in the percentage ratio of 50:25:25. The marks awarded for the project report shall be the same for all the batch mates

Credit Definition: 1-hour Lecture (L) per week=1Credit 2-hoursTutorial(T) per week=1Credit 2-hours Practical / Drawing (P) per week=1Credit 2-hous Self Study for Skill Development (SDA) per week = 1 Credit	03-Credits courses are to be designed for 40 hours in Teaching-Learning Session 02- Credits courses are to be designed for 25 hours of Teaching-Learning Session 01-Credit courses are to be designed for 15 hours of Teaching-Learning Sessions

VI Semester Scheme													
S. No.	Course and Course Code		Course Title	BoS	Credit Distribution				Overall Credits	Contact Hours	Marks		
					L	T	P	S			CIE	SEE	Total
1	HSMC	21MEE61	Operation Research and Management	ME	3	0	0	0	3	3	50	50	100
2	PCC	21MEE62	Fundamentals of Heat Transfer	ME	3	0	0	0	3	3	50	50	100
3	PCCL	21MEL62	Fundamentals of Heat Transfer Lab	ME	0	0	1	0	1	2	50	50	100
4	PCC	21MEE63	Finite Element Methods	ME	3	0	0	0	3	3	50	50	100
5	PCCL	21MEL63	Finite Element Methods Lab	ME	0	0	1	0	1	2	50	50	100
6	PEC	21MEE64X	Professional Elective Course-II	ME	3	0	0	0	3	3	50	50	100
7	UHV	21MEK65	Social Connect and Responsibility	ME	0	0	1	0	1	2	50	-	50
8	INT	21MEE66	Innovation/Entrepreneurship/ Societal Internship	ME	0	0	3	0	3	0	50	50	100
9	MP	21MEE67	Mini project	ME	0	0	1	0	1	2	50	50	100
10	OEC	21NHOP6XX	Industrial Open Elective Course-I	Offering Dept.	3	0	0	0	3	3	50	50	100
Total									**22**	**23**	**500**	**450**	**950**

HSMC: Humanity and Social Science & Management Course, **PCC**: Professional Core Course, **PCCL**: Professional Core Course laboratory, **NCMC:** Non-Credit Mandatory Course, **AEC**: Ability Enhancement Course, **PEC**: Professional Elective Course, **OEC**: Open Elective Course, **PROJ**: Project work**, L:** Lecture, **T**: Tutorial, **P**: Practical **S: SDA**: Self Study for Skill Development, C**IE**: Continuous Internal Evaluation, **SEE**:Semester End Evaluation.

Industrial Open Elective Course (OEC): Credit for OEC is 03 (L: T: P: S) can be considered as (3: 0: 0 : 0). The teaching and learning of these Courses will be based on hands-on. The Course Assessment will be based on CIE and SEE in practical mode. This Courses will be offered by Centre of Excellence to students of all the branches. Registration to Industrial open electives shall be documented and monitored on college level.

Professional Elective Courses (PEC): A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in the Engineering and Technology curriculum. Multidisciplinary courses that are added supplement the latest trend and advanced technology in the selected stream of engineering.

21XXX61(HSMC)- This course must be pertaining to economics and management of the concerned degree program. The course syllabus should have both economics and management topics and the course title should bear the word Management.

For IT allied Branches: Software Product Management

For Core Branches: Engineering Economics and Management / Industrial Management / Construction Management /

Professional Elective Course-II			
21MEE641	EDA(Exploratory Data Analysis) using Modern Tools	21MEE644	Smart Materials and Intelligent system Design
21MEE642	Machine Learning for Mechanical Engineers	21MEE645	Bio Inspired Design and Innovation
21MEE643	Control Engineering		

Credit Definition: 1-hour Lecture (L) per week=1Credit 2-hoursTutorial(T) per week=1Credit 2-hours Practical / Drawing (P) per week=1Credit 2-hous Self Study for Skill Development (SDA) per week = 1 Credit	03-Credits courses are to be designed for 40 hours in Teaching-Learning Session 02- Credits courses are to be designed for 25 hours of Teaching-Learning Session 01-Credit courses are to be designed for 15 hours of Teaching-Learning Sessions

V Semester Syllabus

MACHINE THEORY AND MECHANISM DESIGN

Course Code	**21MEE51**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

21MEE51.1	Apply the concepts of kinematics and dynamics to analyze planar mechanisms
21MEE51.2	Understand the concept of mechanism to design different machine components.
21MEE51.3	Investigate the applications of Governors based on specific requirements and Analyze dynamic force of slider crank mechanism and design of flywheel
21MEE51.4	Analyze the Problems involving static and dynamic balancing and develop the solutions for the same using Graphical Method.
21MEE51.5	Apply the concept of Gyroscopic effect to Visualize the effect of Gyroscopic couple in Different Vehicles
21MEE51.6	Evaluate the fundamentals of gear and the prerequisites for gear design.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE51.1	3	2	-	2	-	-	-	-	-	-	-	-	-	3
21MEE51.2	2	2	2	3	-	-	-	-	-	-	-	-	-	3
21MEE51.3	3	2	2	2	-	-	-	-	-	-	-	-	-	3
21MEE51.4	3	2	2	2	-	-	-	-	-	-	-	-	-	3
21MEE51.5	2	3	2	3	-	-	-	-	-	-	-	-	-	3
21MEE51.6	3	2	2	3	-	-	-	-	-	-	-	-	-	3

MODULE-1	**INTRODUCTION AND MECHANISMS**	**21MEE51.1 21MEE51.2**	**8 Hours**

Introduction and Mechanisms: Definitions of Link, kinematic pairs, kinematic chain, mechanism, structure, degrees of freedom, Classification of pairs. Grashoff's Law, Grueler's Criterion, Inversions of four bar chain, single slider chain and double slider chain. Straight line mechanism- Peaucellier's mechanism, Intermittent mechanism- Geneva wheel mechanism, toggles mechanism. Ackerman steering gear mechanism.

Text Book	Text Book 1: 9.1 to 9.16
Case studies	To know the different mechanism and applications of it by building the models.

MODULE-2	**GOVERNORS AND FLYWHEEL**	**21MEE51.3**	**8 Hours**

Governors and flywheel: Introduction, types of governors, Centrifugal Governor, Watt Governor, Porter and Hartnell governor Stability, Sensitivity, , lift, Isochronous, Hunting, power& effort, and coefficient of insensitiveness Controlling force, Flywheel, Numericals.

Text Book	Text Book 1: 18.1-18.6.18.10,18.17
Assignment	Demonstration of various Governors in the Laboratory

MODULE-3	**BALANCING OF ROTATING MASSES**	**21MEE51.4**	**8 Hours**

Balancing of rotating masses: Static and Dynamic Balancing, Balancing of single rotating mass in a single plane. Balancing of several rotating mass in single plane and multiple planes. Numericals.

Text Book	Text Book 1: 21.1-21.6
Assignment	Demonstration of various rotating masses in same and different planes in the laboratory

MODULE-4	**GYROSCOPE**	**21MEE51.5**	**8Hours**

Introduction, Basic defnitions, Precessional angular motion, gyroscopic couple, Gyroscopic effect of a disc, ship, aero plane, two wheelers and four wheelers with vector diagrams,Numericals

Text Book	Text Book 1:14.1-14.9 Text Book 2: 10.1, 10.3, 10.5, 10.7
Assignment	Demonstration of Gyroscopic effect in the laboratory.

MODULE-5	**SPUR GEARS GEAR TRAINS**	**21MEE51.6**	**8 Hours**

Gear Terminology, Law of Gearing, Length of arc of contact, Minimum number of teeth on a gear to avoid interference and Minimum number of teeth on a pinion to avoid Interference ,Numericals
Gear Trains: Simple,Compound gear trainsfor speed reduction, Epicyclic gear trains ,Algebraic and Tabular methods for finding velocity ratio, Torque calculations

Applications	Practical applications of Different gears in an Automobile.
Text Book	Text Book 2: 12.1 to 12.10

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution		
		Test (s)	Qualitative Assessment (s)	MCQ's
		25	15	10
L1	Remember	5	-	-
L2	Understand	5	-	-
L3	Apply	5	5	5
L4	Analyze	5	5	5
L5	Evaluate	5	5	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources:

Text Books:

1) Theory of machines by RS Khurmi and JK Gupta S Chand Publishers, 34th Ed, ISBN: 9788121925372
2) Mechanism and Machine Theory by Ambedkar A G, Prentice Hall IndiaLearning Private Limited ISBN : 978-81-203-3134-1

Reference Books:

1) Theory of machines by Ballaney, Khanna Publishers, 25th Ed, ISBN-1397887409122X
2) Theory of machines by Sadhu Singh, Pearson Education India, 2006. ISBN,87581279.
3) Theory of machines by S.S. Rattan Tata McGraw Hill Publications,4th Ed,ISBN:9789351343479
4) Kinematics of machines by Srinath M.K., Skyward publishers, 20, ISBN-978-93-86442-00-01

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=EVqBzOGQlkI
- https://www.youtube.com/watch?v=GF5C8dH4f5o
- https://www.youtube.com/watch?v=0MeAZFFqmek&list=PLdLe0dTcWW-u_dCcNGoAK8fx2PiS5gkVu

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Visit to any Design company/aero/auto industry or any power plant
- Demonstration of various Mechanisms
- Demonstration of working of Gyroscope.
- Demonstration of Balancing of rotating masses
- Video demonstration of mechanisms using Adams.

- Contents related activities (Activity-based discussions)
  - For active participation of students, instruct the students to prepare models of various mechanism
  - Organizing Group wise discussions on issues

    Seminars

MACHINE THEORY & MECHANISM DESIGN LAB

Course Code	**21MEL51**	**CIE Marks**	**50**
L:T:P:S	**0:0:1:0**	**SEE Marks**	**50**
Hrs / Week	**2**	**Total Marks**	**100**
Credits	**01**	**Exam Hours**	**03**

Course outcomes:

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

21MEL51.1	Discuss the Inversions of mechanisms for different motion transfer scenarios
21MEL51.2	Determine the causes and solutions for Unbalance in rotary components of different machines.
21MEL51.3	Illustrate the inertial parameters and variables which affect the performance of Governors
21MEL51.4	Investigate the effects of Gyroscopic couple on different applications involving Prime movers.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEL51.1	3	3	3	1	3	-	-	-	-	-	-	-	2	3
21MEL51.2	2	2	3	3	3	-	-	-	-	-	-	-	2	3
21MEL51.3	2	3	2	3	-	-	-	-	-	-	-	-	2	3
21MEL51.4	2	2	2	2	-	-	-	-	-	-	-	-	2	3

Exp. No.	List of Experiments	Hours	COs
	Prerequisite Experiments/ Demo		
	• **Analysis of various mechanisms, Degrees of freedom.** • **Governors working principles** • **Gysrocopic effect of Automobile.**	2	NA
	PART-A		
1	Synthesis and simulation of 4 bar mechanism using multi-body dynamics software	2	21MEL51.1
2	Synthesis and simulation of Inversions of 4 bar mechanism using multi-body dynamics software	2	21MEL51.1
3	Synthesis and simulation of Slider crank Chain using multibody dynamics software	2	21MEL51.1
4	Synthesis and simulation of Inversions of Slider crank Chain using multi-body dynamics software.	2	21MEL51.1
5	Synthesis and simulation of Peaucellier's mechanism	2	21MEL51.2
6	Synthesis and simulation of Ackerman steering gear mechanism.	2	21MEL51.2
	PART-B		
7	Balancing of rotating masses in same plane using graphical Method in Solid edge.	2	21MEL51.2
8	Balancing of rotating masses in different planes using graphical method in solid edge	2	21MEL51.2
9	Determination of Sensitiveness and Controlling force of a Porter Governor	2	21MEL51.3
10	Demonstration on Practical applications of gyroscopic couple.	2	21MEL51.4
11	Demonstration on Practical applications of flywheel, gear train and cam follower	2	21MEL51.4

12	Balancing of reciprocating masses in different planes using graphical method in solid edge	2	21MEL51.4

PART-C

Beyond Syllabus Virtual Lab Content

(To be done during Lab but not to be included for CIE or SEE)

- https://www.youtube.com/watch?v=WPuR1AD_fuQ&t=392s
- https://www.youtube.com/watch?v=Y8lRgDefkXI
- https://www.youtube.com/watch?v=4sVNysRcbV8

CIE Assessment Pattern (50 Marks – Lab)

RBT Levels		Test (s)	Weekly Assessment
		20	30
L1	Remember	-	-
L2	Understand	5	5
L3	Apply	5	10
L4	Analyze	5	10
L5	Evaluate	5	5
L6	Create		

SEE Assessment Pattern (50 Marks – Lab)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	-
L2	Understand	10
L3	Apply	10
L4	Analyze	20
L5	Evaluate	10
L6	Create	-

Suggested Learning Resources:

Text Books:

1) Theory of machines by RS Khurmi and JK Gupta S Chand Publishers, 34th Ed, ISBN: 9788121925372
2) Mechanism and Machine Theory by Ambekar A G, Prentice Hall India Learning Private Limited ISBN : 978-81-203-3134-1

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1.Theory of machines by Ballaney, Khanna Publishers, 25th Ed, ISBN-1397887409122X
2. Theory of machines by Sadhu Singh, Pearson Education India, 2006. ISBN,87581279.
3. Theory of machines by S.S. Rattan Tata McGraw Hill Publications,4th Ed, ISBN:9789351343479

COMPUTER INTEGRATED MANUFACTURING

Course Code	**21MEE52**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

21MEE52.1	Understand the concepts of CIM and Automation.
21MEE52.2	Analyze the working of high volume production systems.
21MEE52.3	Understand the need of automated assembly systems.
21MEE52.4	Evaluate the automated material handling systems.
21MEE52.5	Interpret the requirement of process planning.
21MEE52.6	Apply the inspection techniques in automation.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE52.1	3	-	-	-	-	-	-	-	-	-	-	3	-	1
21MEE52.2	3	2	2	-	-	-	-	-	-	-	-	2	-	2
21MEE52.3	3	2	2	-	-	-	-	-	-	-	-	2	-	2
21MEE52.4	3	2	2	-	-	-	-	-	-	-	-	2	-	2
21MEE52.5	3	2	2	-	-	-	-	-	-	-	-	2	-	1
21MEE52.6	3	2	2	-	-	-	-	-	-	-	-	2	-	1

MODULE-1	**INTRODUCTION TO COMPUTER INTEGRATED MANUFACTURING AND AUTOMATION**	**21MEE52.1**	**8 Hours**

CIM, Computerized Elements of a CIM System, Evolution of Computer Integrated Manufacturing, Nature and Role of Elements of CIM system.
Automation, Types, Levels, Principles, Strategies, Advantages, Disadvantages, Information Processing Cycle, Production concepts.

Self-study / Case Study / Applications	Applications and implementation of automation in various industries.
Text Book	Text Book 1: 1.1, 1.2, 1.3, 1.4 Text Book 2: 1.1, 1.2 , 1.3

MODULE-2	**HIGH VOLUME PRODUCTION SYSTEMS**	**21MEE52.2**	**8 Hours**

Automated Production Lines, Automated Flow Line Symbols, Objectives, Configurations, Work Part Transport Methods, Work Part Transfer Mechanisms, Pallets, Buffer Storages, Control Functions.

Self-study / Case Study / Applications	Usage of pallets and work part holding devices in the production line.
Text Book	Text Book 2: 2.1, 2.2 , 2.3 , 2.4

MODULE-3	**AUTOMATED ASSEMBLY SYSTEMS AND MATERIAL HANDLING**	**21MEE52.3 21MEE52.4**	**8 Hours**

Design, Types, Parts Feeding Devices, Parts Delivery System, Material Handling, Automated Guided Vehicles, Types, Vehicle Guidance Technology, Routing, System Management, Safety, Automated Storage and Retrieval System.

Self-study / Case Study / Applications	Need for automated assembly and storage in various manufacturing industries.
Text Book	Text Book 1: 17.1 Text Book 2: 3.1, 3.2, 3.3, 3.4

MODULE-4	COMPUTERIZED MANUFACTURING SYSTEMS	21MEE52.5	8 Hours
Computer Aided Process Planning, Master Production Schedule, Material Requirement Planning, Fundamental Concepts, Capacity Planning, Outputs, Benefits, Manufacturing Resource Planning, Just-In-Time Production.			
Self-study / Case Study / Applications	Softwares used for Process Planning.		
Text Book	Text Book 1: 24.1, 24.2 Text Book 2: 6.1, 6.2, 6.3, 6.4		
MODULE-5	**AUTOMATED INSPECTION AND DATA CAPTURE**	**21MEE52.6**	**8 Hours**
Contact and Non-Contact Inspection, Co-ordinate Measuring Machine, Construction, Types, Operation, Machine Vision, Automatic Identification, Bar Code Technology, Radio Frequency Identification.			
Self-study / Case Study / Applications	Current inspection and data capture techniques used in the industry.		
Text Book	Text Book 1:22.1, 22.2		

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution		
		Test (s)	Qualitative Assessment (s)	MCQ's
		25	15	10
L1	Remember	5	-	-
L2	Understand	5	-	-
L3	Apply	5	5	5
L4	Analyze	5	5	5
L5	Evaluate	5	5	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources:

Text Books:

1) Mikell P. Groover,"Automation, Production Systems and Computer Integrated Manufacturing", PHI Learning Pvt. Ltd., 4th Edition, 2016, ISBN- 978-9332572492.
2) A.C. Niranjan,"Computer Integrated Manufacturing", Pooja Publications, 4th Edition, 2016.

Reference Books:

1) Bharat Vinjamuri ,"Computer Integrated Manufacturing" star publishers 3rd edition 2016.

Web links and Video Lectures (e-Resources):

- **https://www.techopedia.com/definition/30965/computer-integrated-manufacturing-cim**
- **https://archive.nptel.ac.in/noc/courses/noc21/SEM1/noc21-me65/**
- **https://www.slideshare.net/hareeshang/high-volume-production-systems-class-presentation**
- **https://www.systema.com/digital-transformation/automated-material-handling-systems**

- **https://en.wikipedia.org/wiki/Computer-aided_process_planning**

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Visit to any design department of manufacturing/automotive industry.
- Demonstration of lathe/milling/drilling/CNC operations.
- Video demonstration of latest trends in computer integrated manufacturing.
- Contents related activities (Activity-based discussions).
  - For active participation of students, instruct the students to prepare Flowcharts and Handouts.
  - Organizing Group wise discussions on issues.
  - Seminars.

COMPUTER INTEGRATED MANUFACTURING LAB

Course Code	**21MEL52**	**CIE Marks**	**50**
L:T:P:S	**0:0:1:0**	**SEE Marks**	**50**
Hrs / Week	**02**	**Total Marks**	**100**
Credits	**01**	**Exam Hours**	**03**

Course outcomes:

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

21MEL52.1	Understand the concept of CNC part programming.
21MEL52.2	Create a part program for CNC milling operation.
21MEL52.3	Create a part program for CNC turning operation.
21MEL52.4	Analyze the working of industrial CNC machines.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEL52.1	3	-	2	2	2	-	-	-	-	-	-	2	3	2
21MEL52.2	3	2	2	2	3	-	-	-	-	-	-	3	3	3
21MEL52.3	3	2	2	2	2	-	-	-	-	-	-	3	3	3
21MEL52.4	2	2	2	2	1	-	-	-	-	-	-	3	3	2

Exp. No.	List of Experiments	Hours	COs
	Prerequisite Experiments / Demo		
	• Introduction to programming, G codes and M codes. • Understanding of CNC programming. • Simulation of simple programs.	2	NA
	PART-A		
1	Create a part program for the given MILLING profile using Absolute programming method.	2	21MEL52.1 21MEL52.2 21MEL52.4
2	Create a part program for the given MILLING profile using Absolute programming method.	2	21MEL52.1 21MEL52.2 21MEL53.4
3	Create a part program for the given MILLING profile using Absolute programming method.	2	21MEL52.1 21MEL52.2 21MEL53.4
4	Create a part program for the given MILLING profile using Incremental programming method.	2	21MEL52.1 21MEL52.2 21MEL53.4
5	Create a part program for the given MILLING profile using Incremental programming method.	2	21MEL52.1 21MEL52.2 21MEL53.4
6	Create a part program for the given MILLING profile using Incremental programming method.	2	21MEL52.1 21MEL52.2 21MEL53.4
	PART-B		
7	Create a part program for the given TURNING profile having Box Turning Operation.	2	21MEL52.1 21MEL52.3 21MEL53.4

8	Create a part program for the given TURNING profile having Semi-Circular Turning Operation.	2	21MEL52.1 21MEL52.3 21MEL53.4
9	Create a part program for the given TURNING profile having Taper Turning Operation.	2	21MEL52.1 21MEL52.3 21MEL53.4
10	Create a part program for the given TURNING profile having Thread Cutting Operation.	2	21MEL52.1 21MEL52.3 21MEL53.4
11	Create a part program for the given TURNING profile having a Combination of Operations.	2	21MEL52.1 21MEL52.3 21MEL53.4
12	Create a part program for the given profile having Peck Drilling operations.	2	21MEL52.1 21MEL52.3 21MEL53.4

PART-C

Beyond Syllabus Virtual Lab Content

(To be done during Lab but not to be included for CIE or SEE)

http://vlabs.iitkgp.ernet.in/vlabs/rtvlab1/vmc.html

https://www.teksure.in/virtual_CNC_lathe_simulator.php

CIE Assessment Pattern (50 Marks – Lab)

RBT Levels		Test (s)	Weekly Assessment
		20	30
L1	Remember	-	
L2	Understand	5	5
L3	Apply	5	10
L4	Analyze	5	10
L5	Evaluate	5	5
L6	Create	-	-

SEE Assessment Pattern (50 Marks – Lab)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	05
L2	Understand	05
L3	Apply	10
L4	Analyze	10
L5	Evaluate	20
L6	Create	-

Suggested Learning Resources:

Reference Books:

1) Mikell P. Groover, "Automation, Production Systems and Computer Integrated Manufacturing", PHI Learning Pvt. Ltd., 4th Edition, 2016, ISBN- 978-9332572492.

2) A.C. Niranjan,"Computer Integrated Manufacturing", Pooja Publications, 4th Edition, 2016.

MACHINE DESIGN

Course Code	**21MEE53**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

21MEE53.1	Understand the concept of stresses, failure theories in a 2d and 3d plane by solving the numerical.
21MEE53.2	Determine and evaluate the stress in a machine element by considering stress concentration in curved beams.
21MEE53.3	Analyze the size of the threaded fastener by validating the selection of threaded fastener through design analysis.
21MEE53.4	Design the load carrying elements such as load carrying elements, such as ropes, chains, and screws.
21MEE53.5	Design the power transmission elements such as spur gear and bevel gear, by considering static, dynamic and wear load analysis.
21MEE53.6	Apply the design skills towards the engineering component design.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE53.1	3	-	-	-	-	-	-	-	-	-	-	2	-	3
21MEE53.2	3	-	-	-	-	-	-	-	-	-	-	2	-	3
21MEE53.3	3	3	3	-	-	-	-	-	-	-	-	2	-	3
21MEE53.4	3	3	3	-	-	-	-	-	-	-	-	2	-	3
21MEE53.5	3	3	3	-	-	-	-	-	-	-	-	2	-	3
21MEE53.6	3	3	3	-	-	-	-	-	-	-	-	2	-	3

MODULE-1	**STATIC, MODES AND THEORIES OF FAILURE**	**21MEE53.1 21MEE53.6**	**8 Hours**

Introduction to normal, shear, biaxial and tri axial stresses, Stress tensor, Codes and Standards (only theory) Numerical on Principal Stresses (2D only).
Static strength: Numerical on Axial load, Bending load and Torsion load.
Modes and Theories of Failure: Modes of Failure: Fatigue, creep, Ductile, Brittle, Wear, Corrosion. (theory), Definition of Maximum normal stress theory, Maximum shear stress theory, Distortion energy theory, Coulomb mohr theory. Numerical on Maximum normal stress theory, Maximum shear stress theory, Distortion energy theory.

Case Study / Applications	Investigation on the types of load application in a 2d elements (sheet metal)
Text Book:	Text Book 1: 4.1, 4.2, 4.3, 4.4, 4.5, 4.6 Text Book 1: 4.14, 4.15, 4.16, 4.17, 4.18

MODULE-2	**STRESS CONCENTRATION AND CURVED BEAMS**	**21MEE53.2 21MEE53.6**	**8 Hours**

Stress concentration: Determination of stress concentration factor
Curved Beams: Stresses in curved beams of standard cross sections used in crane hook, punching presses & clamps, closed rings and links.

Case Study / Applications	Application of stress concentration – Case study.
Text Book:	Text Book 1: 4.22 Text Book 1: 5.1, 5.2, 5.3

MODULE-3	**DESIGN OF THREADED FASTENERS, FATIGUE STRENGTH**	**21MEE53.3, 21MEE53.6**	**8 Hours**

Design of threaded fasteners: Stresses in threaded fasteners due to initial load and applied load, Numerical on axial load, eccentric load and shear load on threaded fasteners for circular and rectangular brackets Fatigue strength design: Introduction to S-N Diagram and Endurance limit, Fatigue strength under fluctuating stresses (soderberg& Goodman criteria), stresses due to combined loading and numerical.

Case Study / Applications	Case study: To identify the types of threaded fasteners used in IC engines
Text Book	Text Book 1: 7.1, 7.2, 7.7, 7.8, 7.10, 7.11, 7.12, 7.13, 7.14 Text Book 1: 5.15

MODULE-4	**DESIGN OF POWER SCREWS, ROPES, AND CHAINS**	**21MEE53.4, 21MEE53.6**	**8 Hours**

Design of power screws: Stresses in power screws, efficiency and self-locking.
Design of Ropes, Chains: Ropes and chains for different applications and numerical

Case Study / Applications	Determination of the screw diameters, pitch of power screws used in lathe machines and UTM
Text Book	Text Book 1: 6, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9 Text Book 1: 14.1, 14.2, 14.6, 14.7

MODULE-5	**DESIGN OF SPUR GEAR AND HELICAL GEAR**	**21MEE53.5, 21MEE53.6**	**8 Hours**

Design of spur gear and Bevel gear: Definitions, stresses in gear tooth, Lewis equation and form factor, Design for strength, Dynamic load and wear load. Helical Gears: Definitions, formative number of teeth, Design based on strength, dynamic and wear loads.

Case Study / Applications	Identification of the gear parameters physically by using gear tooth vernier
Text Book	Text Book 1: 17, 17.1, 17.2 to 17.22 Text Book 1: 19, 19.1, 19.2 to 19.7

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution		
		Test (s)	Qualitative Assessment (s)	MCQ's
		25	15	10
L1	Remember	5	-	-
L2	Understand	5	-	-
L3	Apply	5	5	5
L4	Analyze	5	5	5
L5	Evaluate	5	5	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources:

Text Books:

1. Shigley's Mechanical Engineering Design ,by Richard G Budynas and Keith J Nisbett,McGraw Hill International edition, 9 th Edition,ISBN:9780071077835
2. Design of Machine Elements, V. B Bhandari, Tata McGraw Hill Publishing Company Ltd., New Delhi,4th Ed. ISBN:9789339221126

Reference Books:

1.Machine Design, Robert L. Norton, Pearson Education . 5th edition,ISBN: 9780133356717
2. Design of Machine Elements, M. F. Spotts, T. E. Shoup, L. E. Hornberger, S. R. Jayram and C. V. Venkatesh, Pearson Education, 8th edition.
3. Schaum's Outline of Machine Design , Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., New Delhi, Special Indian Edition, 1st edition,ISBN:9780070634589.

Web links and Video Lectures (e-Resources):

- **https://archive.nptel.ac.in/courses/112/105/112105125/**
- **http://www.nptelvideos.com/course.php?id=791**
- **https://www.coursera.org/learn/machine-design1**

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Visit to any manufacturing/aero/auto industry or any power plant
- Demonstration of lathe/milling/drilling/CNC operations
- Demonstration of working of IC engine/refrigerator
- Demonstration of metal joining process
- Video demonstration of latest trends in mobility/robotics
- Demonstration of power transmission systems.
- Contents related activities (Activity-based discussions)
  - For active participation of students, instruct the students to prepare Flowcharts and Handouts
  - Organizing Group wise discussions on issues
  - Seminars

MECHATRONICS

Course Code	**21MEE541**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

21MEE541.1	Understand the basics of mechatronics and sensors
21MEE541.2	Apply the concept of signal conditioning and data acquisition system in mechatronics system design
21MEE541.3	Analyze the working of electro mechanical drives
21MEE541.4	Understand the elements of microprocessor and its programming
21MEE541.5	Illustrate the working of automotive mechatronic systems
21MEE541.6	Apply the mechatronic approach for different systems

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE541.1	3	2	2	-	-	-	-	-	-	-	-	2	2	3
21MEE541.2	3	2	2	-	-	-	-	-	-	-	-	2	2	3
21MEE541.3	3	2	2	-	-	-	-	-	-	-	-	2	2	3
21MEE541.4	3	2	2	-	-	-	-	-	-	-	-	2	2	3
21MEE541.5	3	2	2	-	-	-	-	-	-	-	-	2	2	3
21MEE541.6	3	2	2	-	-	-	-	-	-	-	-	2	2	3

MODULE-1	**INTRODUCTION TO MECHATRONICS SYSTEMS:**	**21MEE541.1**	**8 Hours**

Definitions, multi-disciplinary scenario, origin of mechatronics, engineering system, mechatronics system, Measurement and its elements, control systems open loop and closed loop control system, their elements and functions, Microprocessor based controllers. Program logic controller (PLC). Review of sensors and transducers, classification of sensors and transducers, light sensors, proximity sensors, hall effect sensors, optical encoders

Self-study / Case Study / Applications	Self-study of vision sensors
Text Book	Text Book 1: 1.1 to 1.14, 2.1 to 2.8, 2.15

MODULE-2	**SIGNAL CONDITIONING AND ELECTRO MECHANICAL DRIVES**	**21MEE541.2 21MEE541.3**	**8 Hours**

Signal Conditioning: Introduction to signal conditioning, necessity, methods, amplifying signals using OP amps, Protection, Filtering, Digital signals, Analog to digital conversion, multiplexers, Data acquisition systems, Control and data acquisition (SCADA)

Electro Mechanical Drives: Relays and Solenoids, Stepper Motors, DC brushed motors, DC brushless motors, DC servo motors

Self-study / Case Study / Applications	Case study on the type of motors used in industrial robots.
Text Book	Text Book 1: 3.3, 3.5, 3.6 to 3.10 Text Book 2: 3.1 to 3.9, 7.1 to 7.7

MODULE-3	MICROPROCESSOR & MICROCONTROLLERS:	21MEE541.4	8 Hours
Introduction to microprocessors, Microcontrollers, Difference between Microprocessor and Microcontrollers, INTEL 8085 Microprocessor architecture and terminology, INTEL 8085-Data and Address buses, Instruction set of 8085, Instruction flow cycle, Programming the 8085, Assembly language programming.			
Self-study / Case Study / Applications	Explore the latest advancements in microprocessor		
Text Book	Text Book 1: 5.1 to 5.3, 6.5 to 6.7, 7.1 to 7.3 Text Book 2: 15.1 to 15.5		
MODULE-4	**AUTOMOTIVE MECHATRONIC SYSTEMS**	**21MEE541.5**	**8 Hours**
Engine Management Systems (EMS), EMS sensors, Traction control system, electronic brake force distribution, electronic stability control, Anti-Lock braking system, Tire pressure monitoring system, Active suspension system, Air bags, Seat belt tensioners, Adaptive headlamps, Central locking, Telematics.			
Self-study / Case Study / Applications	Case study of comparison of EMS of different vehicles		
Text Book	Text Book 2: 10.1, 10.3, 10.5, 10.7		
MODULE-5	**CASE STUDIES OF MECHATRONIC SYSTEM:**	**21MEE541.6**	**8 Hours**
Traditional and mechatronic approach examples and case studies of Auto focus Camera, Mechatronics control in automated manufacturing, pick and place robot, ph control system, De-icing temperature control system, Thermal fatigue test, Automatic washing machine, CNC machines, etc.,			
Self-study/ Case Study / Applications	Case studies of various mechatronic systems		
Text Book	Text Book 2: 22.1 to 22.3 Text Book 3: 8.1 to 8.3		

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution	
		Test (s)	NPTEL
		25	25
L1	Remember	5	-
L2	Understand	5	5
L3	Apply	5	10
L4	Analyze	5	10
L5	Evaluate	5	-
L6	Create	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	20
L3	Apply	10
L4	Analyze	10
L5	Evaluate	--
L6	Create	--

Suggested Learning Resources:

Text Books:

1) Mechatronics and Microprocessors, K. P. Ramchandran, G. K. Vijay Raghavan, M.S. Balasundran, Wiley, 1st Ed, 2009.

2) Mechatronics, W. Bolton, Longman, 6 th Ed, Pearson Publications, ISBN10: 1292076682

3)) "Mechatronics System Design", Devdas shetty, Richard A. Kolkm PWS Publishing Company, 2 nd Ed, ISBN-13: 978-1439061985

Reference Books:

1) Mechatronics-Principles Concepts and Applications Nitaigour Premchand Mahalik Tata McGraw Hill 1stEdition, 2003
2) 1 Mechatronics HMT Ltd Tata Mc Graw Hill 1st Edition, 2000 ISBN:978007 46364353
3) 3 Introduction to Mechatronics and Measurement Systems David G. Aldatore, Michael B. Histand McGraw-Hill Inc USA, 2003

Web links and Video Lectures (e-Resources):

- **https://nptel.ac.in/courses/112107298**
- **https://nptel.ac.in/courses/112103174**
- **https://www.youtube.com/playlist?list=PLLy_2iUCG87BNHXRb6L2pWEpMcLoFaY_U**
- **https://www.youtube.com/@HowToMechatronics**

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Visit to any manufacturing/electronic component/automobile industry
- Video demonstration of latest trends in mechatronics
- Contents related activities (Activity-based discussions)
  - For active participation of students, instruct the students to prepare Flowcharts and Handouts
  - Organizing Group wise discussions on issues
  - Seminars

NON-DESTRUCTIVE TESTING

Course Code	**21MEE542**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**3**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

21MEE542.1	Understand the important role in quality control and flaw detection for industries.
21MEE542.2	Identify the various NDT techniques in use.
21MEE542.3	Analyze the structural health monitoring covering wide range of industries.
21MEE542.4	Determine the basic understanding the NDT principles.
21MEE542.5	Investigate the fundamental science behind the commonly used NDT methods.
21MEE542.6	Design and analysis the process details of NDT methods.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE542.1	3	3	2	3	3	-	-	-	-	-	-	3	3	-
21MEE542.2	3	3	2	3	3	-	-	-	-	-	-	3	-	3
21MEE542.3	3	3	2	3	2	-	-	-	-	-	-	2	3	-
21MEE542.4	3	3	2	3	3	-	-	-	-	-	-	3	-	3
21MEE542.5	2	2	2	2	2	-	-	-	-	-	-	2	-	3
21MEE542.6	2	2	2	2	1	-	-	-	-	-	-	2	-	3

MODULE-1	**INTRODUCTION AND SURFACE NDT TECHNIQUES**	**21MEE542.1 21MEE542.2**	**8 Hours**

Procedure, testing and evaluation, Visual examination. Dye penetrant testing, principle, Types and methods of application, Developer. Magnetic particle testing, theory and methods of magnetism,, Field indicators, Particle application.

Self-study / Case Study / Applications	Nondestructive Testing and traditional areas of industrial applications.
Text Book	Text Book 2: 1.5, 1.7, 4.129, 5.142

MODULE-2	**RADIOGRAPHIC TESTING**	**21MEE542.2 21MEE542.3 21MEE542.4**	**8 Hours**

Radiography principle, X-ray films, exposure, radiographic imaging, inspection standards and techniques, Radiography applications, limitations and safety.

Self-study / Case Study / Applications	Radiographic testing industrial applications.
Text Book	Text Book 1: 9.1, 9.2, 9.4, 9.5, 9.10

MODULE-3	**EDDY CURRENT TESTING**	**21MEE542.2 21MEE542.3 21MEE542.4**	**8 Hours**

Principle, depth of penetration, eddy current response, eddy current instrumentation, probe Configuration, applications and limitations.

Self-study / Case Study / Applications	Eddy current testing and Ultrasonic testing case studies.
Text Book	Text Book 2: 6.173, 6.177, 6.184

MODULE-4	**ULTRASONIC TESTING AND ACOUSTIC EMISSION TESTING**	**21MEE542.4 21MEE542.5 21MEE542.6**	**8 Hours**

Properties of sound beam, ultrasonic transducers, inspection methods, flaw characterization technique, immersion testing. Theory of AE sources and Waves, Equipment, Signal Features, Data display, source location.

Self-study / Case Study / Applications	Applications of ultrasonic testing and Acoustic emission testing.
Text Book	Text Book 1: 11.1, 11.2, 11.7, 2.1, 2.2, 2.3, 2.6, 2.7

MODULE-5	**EMERGING NDT TECHNIQUES**	**21MEE542.4 21MEE542.5 21MEE542.6**	**8 Hours**

Leak testing, Holography, Thermography, Magnetic resonance Imaging, Magnetic Barkhausen Effect, In-situ metallography.

Self-study / Case Study / Applications	Emerging NDT techniques industrial applications and case studies of the same.
Text Book	Text Book 1: 5.1, 5.2, 5.4, 9.22

CIE Assessment Pattern (50 Marks – Theory) –

RBT Levels		Marks Distribution	
		Test (s)	NPTEL
		25	25
L1	Remember	5	-
L2	Understand	5	5
L3	Apply	5	10
L4	Analyze	5	10
L5	Evaluate	5	-
L6	Create	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	-

Suggested Learning Resources:

Text Books:

1) Introduction to Nondestructive Testing, Paul E Mix, Publisher: John Wiley, ISBN: 9780471420293, 0471420298,

2) Nondestructive Testing, Louis Cartz, ASM International, ISBN-13, ISBN: 978-0-87170-517-4

Reference Books:

1) Practical Non- Destructive Testing, Baldev Raj , Narosa, 2013, ISBN-13-978-8173197970
2) Nondestructive Evaluation and Quality Control, ASM Handbook, Vol. 17. ISBN-13, 978-0871700230
3) Non-Destructive Testing Technique, Laodeno Rem N, Yoshida Kenichi, Publisher: LAP Lambert Academic Publishing, ISBN-13: 978-3659335587.
4) Non Destructive Evolution and Quality Control - volume 17 of metals hand book 9 edition Asia internal. ISBN-13: 978-3659336592.
5) Non Destructive Testing and evaluation of materials-J Prasad and C G K Nair, McGraw hill ISBN: 978-0070707030.

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=U8mInQlwwN8
- https://www.youtube.com/watch?v=jv4bA5UexjU
- **https://www.youtube.com/watch?v=_CkK90CVARM**
- **https://www.youtube.com/watch?v=uzogGRDSmMA**
- **https://www.youtube.com/watch?v=uqdW25EpzXw**
- **https://www.youtube.com/watch?v=UjvUyXGAjoo**

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Visit to any manufacturing/aero/auto industry
- Video demonstration of latest trends in Nondestructive Testing
- Contents related activities (Activity-based discussions)
  - For active participation of students, instruct the students to conduct Nondestructive Testing
  - Organizing Group wise discussions on Nondestructive Testing issues
  - Seminars

INDUSTRIAL WASTE MANAGEMENT

Course Code	**21MEE543**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**3**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

21MEE543.1	Understand characteristics of waste produced.
21MEE543.2	Identify the waste for Recycle, reuse and byproduct recovery.
21MEE543.3	Analyze the waste with respect to quality and quantity.
21MEE543.4	Determine treatment methods for socially vital issues with critical thought.
21MEE543.5	Investigate the hazardous waste management through research and experiential learning.
21MEE543.6	Design and analysis of the waste management through research and experiential learning

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE543.1	3	1	1	-	-	-	-	-	-	-	-	1	-	2
21MEE543.2	3	1	1	-	-	-	-	-	-	-	-	2	-	2
21MEE543.3	3	1	1	-	-	-	-	-	-	-	-	2	-	2
21MEE543.4	3	3	3	-	-	-	-	-	-	-	-	2	-	2
21MEE543.5	3	3	3	-	-	-	-	-	-	-	-	2	-	2
21MEE543.6	3	3	3	-	-	-	-	-	-	-	-	2	-	2

MODULE-1	**INTRODUCTION**	**21MEE543.1**	**7 Hours**

Types of industries and industrial pollution – Characteristics of industrial wastes – Population equivalent – Bioassay studies – effects of industrial effluents on streams, sewer, land, sewage treatment plants and human health – Environmental legislations related to prevention and control of industrial effluents and hazardous wastes.

Self-study / Case Study / Applications	Investigate the Challenges of Industrial waste on the environment.
Text Book	Text Book 1: 1.1-1.10

MODULE-2	**CLEANER PRODUCTION**	**21MEE543.2**	**8 Hours**

Waste management Approach – Waste Audit – Volume and strength reduction – Material and process modifications – Recycle, reuse and by product recovery – Applications.

Self-study / Case Study / Applications	Investigate the quantity and quality of the industrial waste produced.
Text Book	Text Book 1: 2.1-2.10

MODULE-3	**POLLUTION FROM MAJOR INDUSTRIES**	**21MEE543.3**	**10 Hours**

Sources, Characteristics, waste treatment flow sheets for selected industries such as Textiles, Tanneries, Pharmaceuticals, Electroplating industries, Dairy, Sugar, Paper, distilleries, Steel plants, Refineries, fertilizer, thermal power plants – Wastewater reclamation concepts.

Self-study / Case Study / Applications	Explore the characteristics of the industrial waste.		
Text Book	Text Book 1: 3.1-3.10		
MODULE-4	**TREATMENT TECHNOLOGIES**	**21MEE543.4,6**	**12 Hours**
Equalisation – Neutralisation – Removal of suspended and dissolved organic solids - Chemical oxidation – Adsorption - Removal of dissolved inorganics – Combined treatment of industrial and municipal wastes – Residue management – Dewatering - Disposal			
Self-study / Case Study / Applications	Scrutinize the Different types of Optimization techniques.		
Text Book	Text Book 1: 4.1-4.15		
MODULE-5	**HAZARDOUS WASTE MANAGEMENT**	**21MEE543.5,6**	**8 Hours**
Hazardous wastes - Physico chemical treatment – solidification – incineration – Secured land fills			
Self-study / Case Study / Applications	Survey on Industrial waste, treatment and case studies of the same.		
Text Book	Text Book 1:5.1-5.15		

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution	
		Test (s)	NPTEL
		25	25
L1	Remember	5	-
L2	Understand	5	5
L3	Apply	5	10
L4	Analyze	5	10
L5	Evaluate	5	-
L6	Create	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources:

TEXTBOOKS

1. M.N.Rao & A.K.Dutta, "Waste water Treatment", Oxford - IBH Publication, 1995.
2. W .W. Eckenfelder Jr., "Industrial Water Pollution Control", McGraw-Hill Book Company, New Delhi, 2000.

Reference Books:

1. T.T.Shen, "Industrial Pollution Prevention", Springer, 1999.
2. R.L.Stephenson and J.B.Blackburn, Jr., "Industrial Waste water Systems Hand book", Lewis Publisher, New Yark, 1998
3. H.M.Freeman, "Industrial Pollution Prevention Hand Book", McGraw-Hill Inc., New Delhi, 1995.
4. Bishop, P.L., "Pollution Prevention: Fundamental & Practice", McGraw-Hill, 2000.

Web links and Video Lectures (e-Resources):

- https://shorturl.at/tLST3
- https://www.youtube.com/watch?v=aS-U8xsvZ-4
  https://www.youtube.com/watch?v=HBkwTyBI75M
- https://archive.nptel.ac.in/courses/105/105/105105160/
- https://nsf-gov-resources.nsf.gov/2023-03/Bio-inspired%20Design%20Workshop%20Report_2232327_October%202022_Final.508.pdf

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Visit to any manufacturing/aero/auto industry/process industry/any power plant
- Demonstration of waste produce though in the manufacturing or process industry.
- Video demonstration of latest waste treatment methods
- Contents related activities (Activity-based discussions)
  - For active participation of students, instruct the students to prepare Flowcharts and Handouts
  - Organizing Group wise discussions on issues
  - Seminars

STATISTICS FOR ENGINEERS

Course Code	**21MEE544**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

21MEE544.1	Compute the descriptive statistics using numerical and graphical techniques.
21MEE544.2	Develop the basic concepts of random variables and find an approximate distribution for analyzing data specific to an experiment.
21MEE544.3	Apply statistical methods like correlation, regression analysis in analysing, interpreting experimental data
21MEE544.4	Develop appropriate decision making using statistical inference that is the central to experimental research.
21MEE544.5	Use statistical methodology and tools in reliability engineering problems
21MEE544.6	Apply R programming concepts for statistical data

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE544.1	3	2	2	-	-	-	-	-	-	-	1	-	-	3
21MEE544.2	3	2	2	-	-	-	-	-	-	-	1	-	-	3
21MEE544.3	2	2	2	2	1	-	-	-	-	-	1	-	-	3
21MEE544.4	3	2	2	-	-	-	-	-	-	-	1	-	-	3
21MEE544.5	3	2	2	2		-	-	-	-	-	1	-	-	3
21MEE544.6	3	2	2	2	2	-	-	-	-	-	1	-	-	3

MODULE-1	**INTRODUCTION TO STATISTICS**	**21MEE544.1**	**8 Hours**

Introduction to Statistics and Data Analysis – Measures of Central Tendency – Measures of Variability – [Moments -Skewness-Kurtosis (Concepts Only)]

Self-study	Explore the Challenges of current system variability parameter.
Text Book	Text Book 1: 1.1-1.7, 2.1-2.6,

MODULE-2	**Random Variables**	**21MEE544.2**	**8 Hours**

Introduction – Random Variables – Probability Mass Function, Distribution and Density Functions – Joint Probability Distribution and Joint Density Functions – Marginal, Conditional Distributions and Density Functions – Mathematical Expectation and its Properties – Covariance – Moment Generating Function – Characteristic Function.

Self-study	Desirable identification of systems with covariance and joint probability distribution.
Text Book	Text Book 1: 2.1-2.8

MODULE-3	**Correlation and Regression**	**21MEE544.3, 21MEE544.4**	**8 Hours**

Correlation and Regression – Rank Correlation – Partial and Multiple Correlation – Multiple Regression

Self-study	Explore the problems with capabilities of correlation and regression.
Text Book	Text Book 1: 11.1-11.13

MODULE-4	**Hypothesis Testing – I**	**21MEE544.5**	**8 Hours**

Testing of Hypothesis – Introduction – Types of Errors – Critical Region – Procedure of Testing Hypothesis – Large Sample Tests – Z-Test for Single Proportion, Difference of Proportions, Single Mean and Difference of Means

Case Study	Identify hypothesis with typical errors
Text Book	Text Book 2:11.1-11.8

MODULE-5	**Hypothesis Testing – II**	**21MEE544.6**	**8 Hours**

Small Sample Tests – Student's t-Test – F-Test – Chi-Square Test – Goodness of Fit – Independence of Attributes – Design of Experiments – Analysis of Variance – One and Two Way Classifications - CRD-RBD- LSD

Case Study	Identify hypothesis with variance(DOE)
Text Book	Text Book 2: 13.1-13.6

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution	
		Test (s)	NPTEL
		25	25
L1	Remember	5	-
L2	Understand	5	5
L3	Apply	5	10
L4	Analyze	5	10
L5	Evaluate	5	-
L6	Create	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources:

Text Books:

1)Probability and Statistics for engineers and scientists, R.E.Walpole, R.H.Myers, S.L.Mayers and K.Ye, 9th Edition, Pearson Education (2012).

2) Applied Statistics and Probability for Engineers, Douglas C. Montgomery, George C. Runger, 6th Edition, John Wiley & Sons (2016).

Reference Books:

1) Reliability Engineering, E.Balagurusamy, Tata McGraw Hill, Tenth reprint 2017.
2) Probability and Statistics, J.L.Devore, 8th Edition, Brooks/Cole, Cengage Learning (2012).
3) Probability and Statistics for Engineers, R.A.Johnson, Miller Freund's, 8th edition, Prentice Hall India (2011)

Web links and Video Lectures (e-Resources):

- **https://onlinecourses.nptel.ac.in/noc21_ma74/preview**
- **https://nptel.ac.in/courses/110107114**
- **https://onlinecourses.nptel.ac.in/noc23_ge25/preview**

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- NPTEL certifications.
- Contents related activities (Activity-based discussions)
  - For active participation of students, instruct the students to enroll various Nptel courses
  - Organizing Group wise solutions for issues

ELECTRIC VEHICLES AND BATTERY MANAGEMENT SYSTEM

Course Code	**21MEE545**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

21MEE545.1	Understand Basic of hybrid and electric vehicles
21MEE545.2	Identify Different energy storage devices
21MEE545.3	Evaluate different Characteristics of Fuel Cells
21MEE545.4	Analyze the Performance of electric vehicles
21MEE545.5	Apply Concepts of hybrid electric drive train to design various components of hybrid electric vehicles with environment conceren.
21MEE545.6	Analyze the thermal management in batteries and Classify Electric motors and controllers

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE545.1	3	2	-	-	-	-	-	-	-	-	-	-	-	3
21MEE545.2	3	2	1	-	-	-	-	-	-	-	-	-	-	3
21MEE545.3	3	2	2	-	-	-	-	-	-	-	-	-	-	3
21MEE545.4	3	2	1	-	-	-	-	-	-	-	-	-	-	3
21MEE545.5	3	2	2	-	-	-	2	-	-	-	-	-	-	3
21MEE545.6	3	2	1	-	-	-	-	-	-	-	-	-	-	3

MODULE-1	**Introduction to need for Alternative System**	**21MEE545.1**	**8 Hours**

Introduction to need for Alternative System: History of electric and hybrid vehicles. Need of electric and hybrid vehicles – comparative study of diesel, petrol, electric and hybrid vehicles. Limitations of electric vehicles. Specification of different electric and hybrid vehicles.

Self-study / Case Study / Applications	Investigate the challenges of electric and hybrid vehicles. Compare with traditional areas of automobile engineering.
Text Book	Text Books 1.1, 1.2, 1.3

MODULE-2	**Energy Storage Devices and Fuel Cells**	**21MEE545.2**	**8 Hours**

Energy Storage Devices and Fuel Cells: Electromechanical batteries- types of batteries –lead acid batteries, nickel based batteries, lithium based batteries, electrochemical reactions, thermodynamic voltage, specific energy, specific power, energy efficiency and ultra-capacitors. Fuel Cell- Fuel cell characteristics- Fuel cell types-Hydrogen fuel cell- Connecting cell in series- water management in the PEM fuel cell- Thermal Management of the PEM fuel cell

Self-study / Case Study / Applications	Investigate life and reliability of energy storage devices and fuel cells in EV and their applications.
Text Book	Text Books 2.1, 2.2, 2.3

MODULE-3	**Electric Vehicles**	**21MEE545.4**	**8 Hours**

Electric Vehicles: Electric vehicle layout, performance of electric vehicles – traction motor characteristics, tractive effort, transmission requirements, vehicle performance, energy consumption, advantage and limitations, specifications, system components, electronic control system, safety and

challenges in electric vehicles.

Self-study / Case Study / Applications	Explore the performance of electric vehicles.
Text Book	Text Books 4.4, 4.2, 4.3

MODULE-4	**Hybrid Vehicles**	**21MEE545.5**	**8 Hours**

Hybrid Vehicles: Concepts of hybrid electric drive train, types, architecture of series and parallel hybrid electric drive train, merits and demerits, hybrid electric drive train design, mild and full hybrids, plug-in hybrid electric vehicles and range extended hybrid electric vehicles.

Self-study / Case Study / Applications	Investigate the hybrid electric vehicle drive train design.
Text Book	Text Books 5.1, 5.2, 5.3, 5.4

MODULE-5	**Battery Management System, Propulsion Motors and Controllers:**	**21MEE545.6**	**8 Hours**

Battery Pack: selection of battery for EVs and HEVs, traction battery pack design, requirement of battery monitoring, state of charge, energy and power estimation methods, battery cell equalization, thermal control, protection interface, battery thermal management system.
Battery Management System: definition, parts, power module, battery, DC/DC converter, load, communication channel, battery pack safety, battery standards and tests.
Propulsion Motors and Controllers: Types of electric motors – working principle of AC and DC motors.

Self-study / Case Study / Applications	Case study on thermal management of batteries.
Text Book	Text Books 7.1, 7.2, 7.3, 10.1, 10.2,10.3

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution	
		Test (s)	NPTEL
		25	25
L1	Remember	5	-
L2	Understand	5	5
L3	Apply	5	10
L4	Analyze	5	10
L5	Evaluate	5	-
L6	Create	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources:

Text Books:

1) Jack Erjavec and Jeff Arias, "Hybrid, Electric and Fuel Cell Vehicles", Cengage Learning, 2012.
2) Jack Erjavec and Jeff Arias, "Alternative Fuel Technology – Electric, Hybrid and Fuel Cell Vehicles", Cengage Learning Pvt. Ltd., New Delhi, 2007
3) Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2009.

Reference Books:

1) Wei Liu, "Hybrid Electric Vehicle System Modeling and Control", General Motors, USA, John Wiley and Sons, Inc., 2017.
2) Teresa Donateo, "Hybrid Electric Vehicles", ExLi4EvA, 2017.
3) Gianfranco Pistoia Consultant, "Electric and Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure and the Market", Rome, Italy, Elsevier Publications, 2017.

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/108/103/108103009/
- https://www.youtube.com/watch?v=7WNIDLFX7Xk
- https://www.youtube.com/watch?v=iihYXx79QiE
- https://www.youtube.com/watch?v=cS5tkvbC4ts
- https://new.nsf.gov/news/retired-electric-vehicle-batteries-could-be-used

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Visit to any manufacturing/electric vehicle industry
- Demonstration of EV, motors, and batteries
- Video demonstration of latest trends in electric vehicles and hybrid electric vehicles
- Video demonstration of latest trends in battery management systems
- Contents related activities (Activity-based discussions)
  - For active participation of students, instruct the students to prepare Flowcharts and Handouts
  - Organizing Group wise discussions on issues
  - Seminars

ENERGY ENGINEERING

Course Code	**21MEL551**	**CIE Marks**	**50**
L:T:P:S	**0:0:1:0**	**SEE Marks**	**50**
Hrs / Week	**02**	**Total Marks**	**100**
Credits	**01**	**Exam Hours**	**03**

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

21MEL551.1	Understand the basic concepts of Energy Engineering.
21MEL551.2	Apply the properties of solid ,liquid and gaseous fuels to control the emission.
21MEL551.3	Develop the skills to analyse ,implement and manage sustainable Energy systems
21MEL551.4	Analyze the engineering principles for the effective management of Renewable Energy systems.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEL551.1	3	2	-	-	-	-	-	-	-	-	-	2	3	-
21MEL551.2	3	2	-	1	-	-	3	-	-	-	-	2	2	3
21MEL551.3	3	3	3	2	1	-	-	-	-	-	-	2	3	3
21MEL551.4	3	3	3	2	1	-	-	-	-	-	-	2	3	-

Exp. No.	List of Experiments	Hours	COs
	Prerequisite Experiments/ Demo		
	NA	2	NA
	PART-A		
1	Study of energy resources.	2	21MEL551.1
2	Demonstration of World energy use and reserves of energy resources	2	21MEL551.1
3	Determination of calorific value of solid fuels- coal	2	21MEL551.2
4	Determination of calorific value of gaseous fuels.	2	21MEL551.2
5	Determination of cloud point , pour point and flash point of the given 2T oil .	2	21MEL551.2
6	Determination of spray pattern for the given fuel		
	PART-B		
7	Energy audit of the class rooms of sardar vallabhbhai patel block- NHCE	2	21MEL551.3
8	Performance analysis of 25kW Solar photovoltaic power plant.	2	21MEL551.3
9	Study on the performance of Hybrid (Wind-Solar) energy plant.	2	21MEL551.3
10	Performance analysis of Hydraulic turbines- Kaplan turbine	2	21MEL551.4
11	Demonstration of Geothermal Energy resource	2	21MEL551.4
12	Demonstration of solar radiation at ground level	2	21MEL551.4

CIE Assessment Pattern (50 Marks – Lab)

RBT Levels		Test (s)	Weekly Assessment
		20	30
L1	**Remember**	-	-
L2	**Understand**	5	5
L3	**Apply**	5	10
L4	**Analyze**	5	10
L5	**Evaluate**	5	5
L6	**Create**		-

SEE Assessment Pattern (50 Marks – Lab)

RBT Levels		Exam Marks Distribution (50)
L1	**Remember**	**05**
L2	**Understand**	**05**
L3	**Apply**	**10**
L4	**Analyze**	**20**
L5	**Evaluate**	**10**
L6	**Create**	**-**

Suggested Learning Resources:

Reference Books:

1) G.D Rai ,Non-Conventional Energy Sources Khanna Publishers (2003)
2) S.P Sukhatme and J.K Nayak, Solar Energy : Principles of Thermal Collection and storage. McGraw-Hill(2009)
3) A. Duffie and W.A. Beckmann, Solar Engineering of Thermal Processes-John Wiley (1980).
4) B H Khan ,Non-Conventional Energy Sources ,McGraw-Hill(2017)

SUSTAINABLE ENERGY SYSTEMS DESIGN

Course Code	**21MEL552**	**CIE Marks**	**50**
L:T:P:S	**0:0:1:0**	**SEE Marks**	**50**
Hrs / Week	**02**	**Total Marks**	**100**
Credits	**01**	**Exam Hours**	**03**

Course outcomes:

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

21MEL552.1	Understand the depth of knowledge in the area of Energy Engineering and Management.
21MEL552.2	Apply independent research and knowledge for the benefit of mankind
21MEL552.3	Analyze the engineering principles for the effective management of Energy systems.
21MEL552.4	Evaluate the scientific principles for the effective management of Energy systems.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEL552.1	3	2	2	-	-	-	-	-	-	-	-	2	3	3
21MEL552.2	3	2	2	-	-	-	-	-	-	-	-	2	2	3
21MEL552.3	3	3	2	2	-	-	-	-	-	-	-	2	3	2
21MEL552.4	3	3	2	2	-	-	-	-	-	-	-	2	3	3

Exp. No.	List of Experiments	Hours	COs
	Prerequisite Experiments / Programs / Demo		
	• Demonstration on solar basic concepts	2	NA
	PART-A		
1	Study of energy resources	2	21MEL552.1
2	Study of energy cycle of the earth	2	21MEL552.2
3	Predicting renewable energy resources and their importance.	2	21MEL552.2
4	Demonstration of World energy use and reserves of energy resources	2	21MEL552.3
5	Demonstration of extra-terrestrial solar radiation	2	21MEL552.3
6	Demonstration of radiation at ground level	2	21MEL552.3
	PART-B		
7	Energy analysis on Solar collectors	2	21MEL552.4
8	Energy analysis on Solar cells	2	21MEL552.4
9	Demonstration of Biomass Conversion - Biogas Production	2	21MEL552.4
10	Demonstration of Pyrolysis and Gasification	2	21MEL552.4
11	Study of Wind energy Conversion, Classification and Types	2	21MEL552.4
12	Demonstration of Geothermal Energy resource types and Applications	2	21MEL552.4

PART-C

https://vlab.amrita.edu/?sub=77&brch=297 - Wind energy Labs

https://vlab.amrita.edu/?sub=77&brch=298 - Solar energy Labs

CIE Assessment Pattern (50 Marks – Lab)

RBT Levels		Test (s)	Weekly Assessment
		20	30
L1	Remember	-	-
L2	Understand	5	5
L3	Apply	5	10
L4	Analyze	5	10
L5	Evaluate	5	5
L6	Create		-

SEE Assessment Pattern (50 Marks – Lab)

RBT Levels		Exam Marks Distribution (50)
L1	**Remember**	
L2	**Understand**	**10**
L3	**Apply**	**10**
L4	**Analyze**	**20**
L5	**Evaluate**	**10**
L6	**Create**	

Suggested Learning Resources:

Reference Books:

1) Non-Conventional Energy Sources G.D Rai Khanna Publishers 2003
2) T.N.Veziroglu, Alternative Energy Sources,Vol 5 and 6,McGraw- Hil (1978).
3) A. Duffie and W.A. Beckmann, Solar Engineering of Thermal Processes-John Wiley (1980).
4) F.Kreith and J.F. Kreider, Principles of Solar Engineering, McGraw-Hill (1978).

AIR POLLUTION CONTROL

Course Code	**21MEL553**	**CIE Marks**	**50**
L:T:P:S	**0:0:1:0**	**SEE Marks**	**50**
Hrs / Week	**02**	**Total Marks**	**100**
Credits	**01**	**Exam Hours**	**03**

Course outcomes:

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

21MEL553.1	Evaluate the concentration of pollutants in ambient air and monitor ambient noise
21MEL553.2	Evaluate the concentration of pollutants from vehicle tailpipe emissions.
21MEL553.3	Study and analyse the effect of pollutants on human health
21MEL553.4	Estimate meteorological parameters and draw wind rose diagram

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEL553.1	3	2	-	-	1	-	1	-	-	-	-	2	1	2
21MEL553.2	3	2	-	-	1	-	1	-	-	-	-	2	1	2
21MEL553.3	3	2	-	-	1	-	1	-	-	-	-	2	-	2
21MEL553.4	3	2	-	-	1	-	1	-	-	-	-	2	-	2

Exp. No. / Pgm. No.	List of Experiments / Programs	Hours	COs
	Prerequisite Experiments / Programs / Demo		
	NIL	2	NA
	PART-A		
1	Sampling of PM10 in ambient air and the determination of its concentration using Gravimetric method	2	21MEL553.1
2	Sampling of PM2.5 in ambient air and the determination of its concentration using Gravimetric method	2	21MEL553.1
3	Measurement of Sulphur dioxide (SO2) concentration in the ambient air using Improved West and Gaeke method	2	21MEL553.1
4	Measurement of Nitrogen dioxide (NOX) concentration in the ambient air using Improved West and Gaeke method	2	21MEL553.1
5	Measurement of Nitrogen dioxide (NOX) concentration in the ambient air	2	21MEL553.1
6	calculate emission rates (ER) for different exhaust gases emitting from vehicular tailpipe	2	21MEL553.2
	PART-B		
7	calculate the air change rate (ACH) of indoor environment air and deposition rate of particulate concentration of different sizes	2	21MEL553.1
8	Estimation of respiratory deposition doses (RDD) to the human beings under different conditions.	2	21MEL553.3
9	Measurement of meteorological parameters (wind velocity, wind direction, humidity, temperature, solar insolation, rainfall) and drawing wind rose diagram.	2	21MEL553.4
10	Ambient noise monitoring.	2	21MEL553.1

11	estimate the atmospheric stability within the atmospheric boundary layer of the study area	2	21MEL553.1
12	Measurement of VOC using Gas chromatography – Flame Ionization Detector	2	21MEL553.1

PART-C

Case Studies: Madhura refinery and it's impact on Taj Mahal, Bhopal gas tragedy, Chernobyl disaster and HPCL Visakha refinery, changes in raw materials, alternative technology for minimization of pollutants.

CIE Assessment Pattern (50 Marks – Lab)

RBT Levels		Test (s)	Weekly Assessment
		20	30
L1	Remember	-	-
L2	Understand	5	5
L3	Apply	5	10
L4	Analyze	5	10
L5	Evaluate	5	5
L6	Create	-	-

SEE Assessment Pattern (50 Marks – Lab)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	-
L2	Understand	10
L3	Apply	10
L4	Analyze	20
L5	Evaluate	10
L6	Create	

Suggested Learning Resources:

Reference Books:

1) Textbook of Air pollution and its control, S.C Bhatia, Atlantic Publishers and distributors (p) ltd., 2007
2) Air Pollution, M N Rao, H V N Rao, McGraw Hill Education (India) Private ltd., 2013
3) Air Pollution and control Technologies, Anjaneyulu, Allied Publishers (P) Ltd., India, 2002
1) 4) Sewage Disposal and Air Pollution Engineering, Santosh Kumar Garg, Khanna Publishers, 2012.

TOOLS FOR ENERGY SYSTEM DESIGN AND DRAFTING

Course Code	**21MEL554**	**CIE Marks**	**50**
L:T:P:S	**0:0:1:0**	**SEE Marks**	**50**
Hrs / Week	**02**	**Total Marks**	**100**
Credits	**01**	**Exam Hours**	**03**

Course outcomes:

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

21MEL554.1	Understand the Indian Standards in modelling practices.
21MEL554.2	Apply energy concepts on simple mechanical elements (2D).
21MEL554.3	Analyze the flow concepts on practical applications (3D) using CBE comfort tool.
21MEL554.4	Design the concepts on creating simple mechanical members.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEL554.1	3	2	2	-	-	-	-	-	-	-	-	2	-	2
21MEL554.2	3	3	3	1	2	-	-	-	-	-	-	2	-	2
21MEL554.3	3	3	3	3	2	-	-	-	-	-	-	2	-	2
21MEL554.4	3	3	3	3	2	-	-	-	-	-	-	2	-	2

Exp. No. / Pgm. No.	List of Experiments / Programs	Hours	COs
	Prerequisite Experiments / Programs / Demo		
	• Computer Aided Engineering • Computer Aided Machine Drawing	2	NA
	PART-A		
1	Introduction to modelling software	2	21MEL554.1
2	Introduction to the different commands used in CATIA	2	21MEL554.1
3	Design of modelling solid and hallow mechanical elements	2	21MEL554.1
4	Introduction to 2D Energy tool	2	21MEL554.1
5	Experimentation on application of 2D energy tool to solid and hallow mechanical elements	2	21MEL554.2
6	Experimentation on the behavior of thermo mechanical structures.	2	21MEL554.2
	PART-B		
7	Introduction to Predicted mean vote (PMV) and standard effective temperature (SET)	2	21MEL554.2
8	Experimentation on CBE Thermal Comfort Tool in the study of thermal comfort in buildings	2	21MEL554.2
9	Experimentation on modelling the comfort effects of short-wave solar radiation indoors	2	21MEL554.3
10	Introduction to Google sketcher and its uses	2	21MEL554.3
11	Design of modelling solid mechanical elements using sketcher.	2	21MEL554.4
12	Design of modelling hallow mechanical elements using sketcher.		21MEL554.4

PART-C

- https://comfort.cbe.berkeley.edu/EN
- https://github.com/ElsevierSoftwareX/SOFTX_2020_242

CIE Assessment Pattern (50 Marks – Lab)

RBT Levels		Test (s)	Weekly Assessment
		20	30
L1	Remember	-	-
L2	Understand	5	5
L3	Apply	5	10
L4	Analyze	5	10
L5	Evaluate	5	5
L6	Create	-	-

SEE Assessment Pattern (50 Marks – Lab)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	-
L2	Understand	10
L3	Apply	10
L4	Analyze	20
L5	Evaluate	10
L6	Create	

Suggested Learning Resources:

Reference Books:

1)Arens, E., T. Hoyt, X. Zhou, L. Huang, H. Zhang and S. Schiavon. 2015. Modeling the comfort effects of shortwave solar radiation indoors. Building and Environment 88, 3-9.

2) Shyy, W., Thakur, S. S. , Ouyang, H., Liu, J., and Blosch, E., 1997, Computational Techniques for Complex Transport Phenomena, Cambridge University Press, Cambridge.

ADVANCED SEMICONDUCTOR MATERIALS AND ITS APPLICATIONS

Course Code	**21MEL555**	**CIE Marks**	**50**
L:T:P:S	**1:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**02**	**Total Marks**	**100**
Credits	**01**	**Exam Hours**	**03**

Course outcomes:

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

21MEL555.1	Understand the basic concepts of semiconductor, its materials and classification.
21MEL555.2	Analyze the properties and characteristics of semiconductor materials through a set of characterization techniques
21MEL555.3	Apply the latest developments and advancements in semiconductor technology to design semiconductor products.
21MEL555.4	Evaluate the applications of various semiconductor devices

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEL555.1	3	1	1	-	-	-	-	-	-	-	-	2	3	3
21MEL555.2	3	3	3	2	2	-	-	-	-	-	-	2	3	3
21MEL555.3	3	2	2	1	1	-	-	-	-	-	-	2	3	3
21MEL555.4	3	3	2	2	-	-	-	-	-	-	-	2	3	3

Exp. No.	List of Experiments	Hours	COs
	Prerequisite Experiments / Programs / Demo		
	• Demonstration on working of PV cells	2	NA
	PART-A		
1	Study the performance characteristics of monocrystalline PV cells	2	21MEL555.1
2	Study the performance characteristics of polycrystalline PV cells	2	21MEL555.1
3	Study the doping characteristics of pentavalent and trivalent PV cells	2	21MEL555.2
4	Study the synthesis of chemical vapour deposition for the integration of chips	2	21MEL555.2
5	Performance and synthesis of Perovskite solar cells	2	21MEL555.2
6	Study the performance of MEMS devices	2	21MEL555.3
	PART-B		
7	Study on the coating thickness of the semiconductor materials	2	21MEL555.3
8	Study the fabrication mechanisms of MOSFETS	2	21MEL555.3
9	Study the applications of semiconductors in medical field	2	21MEL555.4
10	Study the applications of semiconductors in space technology	2	21MEL555.4
11	Study the characteristics of Zener diode	2	21MEL555.2
12	Study the characteristics of PN junction diode	2	21MEL555.2

PART-C

- https://youtu.be/QpSr2OQdCfQ?si=y7PSyOLbMdLbK_km
- https://youtu.be/pk0XAUpZVMQ?si=LiEJGrgy3X5AhUy2
- https://youtu.be/_t1G-qTL8UU?si=dqi90-yiZxaydppA

CIE Assessment Pattern (50 Marks – Lab)

RBT Levels		Test (s)	Weekly Assessment
		20	30
L1	Remember	-	-
L2	Understand	5	5
L3	Apply	5	10
L4	Analyze	5	10
L5	Evaluate	5	5
L6	Create	-	-

SEE Assessment Pattern (50 Marks – Lab)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	-
L2	Understand	10
L3	Apply	10
L4	Analyze	20
L5	Evaluate	10
L6	Create	-

Suggested Learning Resources:

Text Books:

1. SupriyoDatta, Quantum Transport Atom to Transistor, Cambridge University Press, 2005
2. A.K. Maini, All in One Electronics Simplified, Khanna Publishing House, Delhi,2010

Reference Books:

1. J. P. Colinge and C. A. Colinge, "Physics Of Semiconductor Devices", Kluwer Academic Publishers

B. G. Streetman and S. Banerjee Solid state electronics devices, 5th Edition, PHI.

MINI PROJECT

Course Code	**21MEE56**	**CIE Marks**	**50**
L: T:P:S	**0:0:1:0**	**SEE Marks**	**50**
Hrs / Week	**02**	**Total Marks**	**100**
Credits	**01**	**Exam Hours**	**03**

Course outcomes:

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

21MEE56.1	Identify an open ended problem in area of mechanical engineering
21MEE56.2	Identify the methods and materials required for the project work
21MEE56.3	Apply the theoretical concepts to solve industrial problems with teamwork and multidisciplinary approach.
21MEE56.4	Formulate and implement innovative ideas for social and environmental benefit
21MEE56.5	Analyze the results to come out with concrete solutions
21MEE56.6	Demonstrate professionalism with ethics; present effective communication skills and relate engineering issues to broader societal context

Mini Project Roadmap: Guiding Principles for Mini Project Success

Project Overview:

- Clearly define the project's scope, objectives, and expected outcomes.
- Provide a brief description of the problem the project aims to solve or the functionality it should implement.

Project Milestones:

- Set clear project milestones and deadlines for various phases, such as planning, design, implementation, testing, and presentation.

Project Requirements:

- List the specific features or functionality that students need to implement in their projects.
- Clearly state any constraints or limitations they should be aware of during development.

Testing and Quality Assurance:

- Incorporate testing practices into their development process.
- Specify the types of testing (e.g., unit testing, integration testing)

Collaboration and Communication:

- If the project involves teamwork, outline expectations for collaboration, including communication channels and responsibilities within the team.

Documentation:

- Emphasize the importance of thorough documentation throughout the project.
- Require students to maintain documentation for code, design, and usage instructions.

Presentation:

- Require students to present their projects to the class, explaining their design choices, challenges faced, and how they overcame them.

CIE Assessment Pattern (50 Marks – Reviews as per the rubric statements defined)

RBT Levels		**Exam Marks Distribution (50)**
L1	**Remember**	**-**
L2	**Understand**	**-**
L3	**Apply**	20
L4	**Analyze**	10
L5	**Evaluate**	10
L6	**Create**	10

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	**Remember**	**-**
L2	**Understand**	**-**
L3	**Apply**	20
L4	**Analyze**	10
L5	**Evaluate**	10
L6	**Create**	10

RESEARCH METHODOLOGY AND IPR

Course Code	**21MEK57**	**CIE Marks**	**50**
L:T:P:S	**1:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**02**	**Total Marks**	**100**
Credits	**01**	**Exam Hours**	**02**

Course outcomes:

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

21MEK57.1	Characterize the significance and suitability of research for various engineering applications
21MEK57.2	Demonstrate the various processing techniques of research
21MEK57.3	Appraise the research in the development of engineering materials, process and tools
21MEK57.4	Identify criteria to fit own intellectual work in particular form of IPRs
21MEK57.5	Apply statutory provisions to protect particular form of research
21MEK57.6	Develop the art of scholarly writing and evaluate its quality

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEK57.1	3	3	3	-	-	-	-	3	3	3	2	3		2
21MEK57.2	3	3	3	2	2	-	-	3	3	3	2	3		2
21MEK57.3	3	3	3	2	2	-	-	3	3	3	2	3		2
21MEK57.4	3	3	-	-	-	-	-	3	3	3	2	3		2
21MEK57.5	3	-	-	-	-	-	-	3	3	3	2	3		2
21MEK57.6	3	3	3	2	2	-	-	3	3	3	2	3		2

MODULE-1	**RESEARCH FORMULATION AND DESIGN**	**21MEK57.1, 21MEK57.2**	**3 Hours**

Definition and objective of research, types of research, steps in research process, research design, concept and types of research design, defining and formulating the research problems, importance of literature review-primary and secondary sources, reviews, monographs, patent, research database, web sources, identifying gap areas from the literature and research data base, surveying synthesis, Interpretation.

Self-study / Case Study / Applications	Investigate the Challenges in Research and its uses.
Text Book	Text Book 1: Ch. 1, 2& 6

MODULE-2	**SAMPLING & DATA INTERPRETATION**	**21MEK57.2, 21MEK57.3**	**3 Hours**

Mathematical tools for analysis, statistical analysis of data, regression analysis, correlation, concept of best fit and exact fit, exact fit, theory, examples from linear regression with one and more unknowns.

Self-study / Case Study / Applications	Apply the mathematical tool and analysis for research work to be validate.
Text Book	Text Book 1: Ch. 4& 7

MODULE-3	**PATENT RIGHTS AND IPR**	**21MEK57.3, 21MEK57.4**	**3 Hours**

Patents and its basics, process of filing patent at national and international level, Introduction and significance of intellectual property rights, commercialization, royalty, copyright, trade related aspects of IPR, Administration of patent system in India, licensing and transfer of technology, case studies.

Self-study / Case Study / Applications	Explore the research work into publishing a patent.		
Text Book	Text Book 2: Ch. 1 & 2/ IPR India website		
MODULE-4	**RESEARCH AND PUBLICATIONETHICS**	**21MEK57.4, 21MEK57.5**	**3 Hours**
Research and Integrity, Scientific mis conduct: Falsification, Fabrication and Plagiarism (FFP), Conflict of research, Predatory publishers and Journals, Open access publication, citation and acknowledgement, reproducibility and accountability, software tools for similarity check			
Self-study / Case Study / Applications	Publish a journal paper using the research work.		
Text Book	Text Book 1: Ch. 14 & 15		
MODULE-5	**REPORT WRITING**	**21MEK57.5, 21MEK57.6**	**3 Hours**
Structure and components of research report, types of report, layout of research report, mechanism of writing a research report, referencing in academic writing, Abstracting, Bibliography			
Self-study / Case Study / Applications	Publish a journal paper using the research work.		
Text Book	Text Book 1: Ch. 14		

CIE Assessment Pattern (50 Marks – Theory) –

RBT Levels		Marks Distribution		
		Test (s)	Qualitative Assessment (s)	MCQ's
		25	15	10
L1	Remember	5	-	-
L2	Understand	5	-	-
L3	Apply	5	5	5
L4	Analyze	5	5	5
L5	Evaluate	5	5	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources:

Text Books:

1) Kothari, C.R., "Research Methodology: Methods and Techniques". New Age International, 2018, ISBN-13: 978-8122436235
2) Ramakrishna Chintakunta, A Text book of Intellectual Property rights, Blue Hill Publication, ASIN: B09T6YDB5N, 2022

Reference Books:

1) Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K, An introduction toResearch Methodology, RBSA Publishers. 2015, ISBN-13:978-8176111652

2) Ranjith Kumar, Research methodology, Saga publications,4th edition, 2014, ISBN-13- 978-9351501336Anderson, T. W., "An Introduction to Multivariate Statistical Analysis", Wiley Eastern Pvt., Ltd., New Delhi, 2011, ISBN-13: 978-8126524488
3) Montgomary, Douglas C. &Runger, George C. (2016) 6/e, Applied Statistics & probability for Engineers (Wiley India) ISBN-13: 978-1118539712
4) Montgomary, Douglas C. (2012) 8th edition, Design and Analysis of Experiments (Wiley India) ISBN: 978-1-118-14692-7
5) Sinha, S.C. and Dhiman, A.K., 2012. Research Methodology, EssEss Publications. 2 volumes. ISBN : 81-7000-324-5, 81-7000-334-2

Web links and Video Lectures (e-Resources):

- https://study.sagepub.com/kumar5e
- https://www.youtube.com/watch?v=GSeeyJVD0JU
- https://study.sagepub.com/benzo/student-resources/chapter-12/weblinks

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Demonstration on paper writing
- Contents related activities (Activity-based discussions)
  - For active participation of students, instruct the students to prepare Flowcharts and Handouts Seminars

INNOVATION AND DESIGN THINKING

Course Code	**21MEK58**	**CIE Marks**	**50**
L:T:P:S	**1:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**01**	**Total Marks**	**100**
Credits	**01**	**Exam Hours**	**02**

Course outcomes:

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

21MEK58.1	Articulate a comprehensive understanding of the concept of Design Thinking
21MEK58.2	Apply Design Thinking methodologies to solve complex and ambiguous problems effectively
21MEK58.3	Utilize design thinking tools for creative solutions
21MEK58.4	Implement design thinking in IT that showcase the ability to drive meaningful innovation
21MEK58.5	Develop strategic innovation for Business Model Design
21MEK58.6	Create the stages of the Design Thinking process

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEK58.1	3	-	-	-	-	-	-	-	3	3	-	3	-	3
21MEK58.2	3	3	2	-	-	-	-	-	3	3	-	3	-	3
21MEK58.3	3	3	2	-	2	-	-	-	3	3	-	3	-	3
21MEK58.4	3	3	2	2	2	-	-	-	3	3	-	3	-	3
21MEK58.5	3	3	2	2	-	-	-	-	3	3	-	3	-	3
21MEK58.6	3	3	2	2	2	1	1	1	3	3	1	3	-	3

MODULE-1	**UNDERSTANDING DESIGN THINKING**	**21MEK58.1 21MEK58.2**	**3 Hours**

Definition, Origin and features of Design Thinking, Design thinker in organization, Principles and stages of Design thinking. Design Shared model in team-based design, Theory and practice in Design thinking. Collaborative design thinking. Live examples of MVP or Prototyping

Self-study / Case Study / Applications	Introduction about the design thinking Theory and practice through presentation MVP and Prototyping through live examples and videos

MODULE-2	**TOOLS FOR DESIGN THINKING**	**21MEK58.3**	**3 Hours**

Visualization, Journey mapping, Value Chain Analysis, The mind map, Rapid Concept development, Assumption testing, Prototype, Co creation, Learning launches and Storytelling.

Self-study / Case Study / Applications	Case studies on design thinking for real-time interaction and analysis Simulation exercises for collaborated enabled design thinking Live examples on the success of collaborated design thinking

MODULE-3	**DESIGN THINKING IN IT**	**21MEK58.4**	**3 Hours**

Business process modelling (BPM). Agile in Virtual collaboration environment. Scenario based Prototyping. Case studies on Design thinking

Self-study / Case Study / Applications	Case studies on design thinking and business acceptance of the design Simulation on the role of virtual eco-system for collaborated prototyping

MODULE-4	**DESIGN THINKING FOR STRATEGIC INNOVATION**	**21MEK58.5**	**3 Hours**

Strategic management and Innovation management, Types of Innovations, Features and Scope of strategic innovations, Design thinking and strategic innovation, Practices of integrating Design thinking in Strategic Innovation.

Self-study / Case Study / Applications	Business model examples of successful designs Presentation by the students on the success of design Live project on design thinking in a group of 4 students		
MODULE-5	**DESIGN THINKING WORK SHOP**	**21MEK58.6**	**3 Hours**
Focus, Need and stages of Design thinking workshop. Empathize, Design, Ideate, Prototype and Test			
Self-study / Case Study / Applications	8 hours design thinking workshop from the expect and then presentation by the students on the learning from the workshop		

CIE Assessment Pattern (50 Marks – Theory) –

RBT Levels		Marks Distribution		
		Test (s)(15)	Assignment (10)	Seminar/ Activity (25)
		15	10	25
L1	Remember	3	-	-
L2	Understand	8	-	5
L3	Apply	4	5	5
L4	Analyze	-	5	8
L5	Evaluate	-	-	7
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	25
L3	Apply	15
L4	Analyze	--
L5	Evaluate	--
L6	Create	--

Suggested Learning Resources:

1. Christian Mueller-Roterberg, Handbook of Design Thinking - Tips & Tools for how to design thinking.
2. John.R.Karsnitz, Stephen O'Brien and John P. Hutchinson, "Engineering Design",Cengage learning (International edition) Second Edition, 2013.
3. Roger Martin, "The Design of Business: Why Design Thinking is the Next Competitive Advantage",Harvard Business Press, 2009.
4. Hasso Plattner, Christoph Meinel and Larry Leifer (eds), "Design Thinking: Understand – Improve - Apply", Springer, 2011
5. Yousef Haik and Tamer M.Shahin, "Engineering Design Process", CengageLearning, SecondEdition, 2011.
6. Book - Solving Problems with Design Thinking - Ten Stories of What Works (Columbia BusinessSchool Publishing) Hardcover – 20 Sep 2013 by Jeanne Liedtka (Author), Andrew King (Author), Kevin Bennett (Author)

Web links and Video Lectures (e-Resources):

- **https://www.ibm.com/design/thinking/**
- **https://www.ideou.com/pages/design-thinking**
- **https://www.youtube.com/watch?v=3RemkU4BH8U**

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Video demonstration of latest trends in mobility/robotics
- Contents related activities (Activity-based discussions)
- For active participation of students, instruct the students to prepare Flowcharts and

Handouts

- Organizing Group wise discussions on issues
- Seminars

VI Semester Syllabus

OPERATION RESEARCH AND MANAGEMENT

Course Code	**21MEE61**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

21MEE61.1	Apply basic principles of project management for real time projects.
21MEE61.2	Understand entrepreneurship as an individual or as a group by creating awareness on its needs and roles with respect to growth of economic development
21MEE61.3	Develop solutions for barriers in small scale industries.
21MEE61.4	Estimating the interest rates, cash flows and costing materials, production and overheads
21MEE61.5	Analyse the sequence of jobs on various machines.
21MEE61.6	Identify the significance of Game theory and determine the optimal solution.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE61.1	3	2	2	-	-	-	-	-	-	-	-	2	-	2
21MEE61.2	3	1	-	-	-	-	-	-	-	-	-	2	-	2
21MEE61.3	3	3	2	2	-	-	-	-	-	-	-	2	-	2
21MEE61.4	3	3	3	3	-	-	-	-	-	-	-	2	-	2
21MEE61.5	3	3	3	2	-	-	-	-	-	-	-	2	-	2
21MEE61.6	3	2	1	-	-	-	-	-	-	-	-	2	-	2

MODULE-1	**Basics of Project Management**	**21MEE61.1**	**8 Hours**

Introduction, Definition of project, characteristics of projects, types of projects, need for project management, phases of project life cycle management, impact of delays in project completions, roles and responsibilities of project leader.

Self-study / Case Study / Applications	Create project management plan by taking any real time project as example.
Text Book	Text Book 1: 1.1, 1.1, 1.8, 1.9, 1.10, 1.18, 1.16.

MODULE-2	**ENTREPRENEUR AND SSI**	**21MEE61.2 21MEE61.3**	**8 Hours**

Meaning of Entrepreneur, Functions of an Entrepreneur, Types of Entrepreneur, Stages in entrepreneurial process; Role of entrepreneurs in Economic Development. Entrepreneurship in India; women entrepreneurs, Entrepreneurship - its Barriers,

SSI Impact of Liberalization, Privatization, Globalization on SSI Effect of WTO/GATT Supporting Agencies of Government for SSI, Meaning, Nature of support. Objectives; Functions; Types of Help.

Self-study / Case Study / Applications	List out some of the Small Scale Industries which are mainly focused on women empowerment.
Text Book	Text Book 1: 2.2, 2.3, 2.4 to 2.15

MODULE-3	**INTEREST, CASH FLOW, ESTIMATION AND COSTING**	**21MEE61.4**	**8 Hours**

Law of demand and supply, Law of returns, Interest and Interest factors: Interest rate, Simple interest, Compound interest, Cash - flow diagrams, Personal loans and EMI Payment, Exercises and Discussion. Components of costs such as Direct Material Costs, Direct Labor Costs, Fixed Over-Heads, Factory cost, Administrative Over-Heads, First cost, Marginal cost, Selling price, Estimation for simple components.

Text Book	Text Book 2: 2.1 to 2.10		
MODULE-4	**SEQUENCING**	**21MEE61.5**	**8 Hours**

Basic assumptions, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule- 'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing 2 jobs on 'm' machines using graphical method.

Self-study / Case Study / Applications	Case study on sequencing by taking any real time examples.
Text Book	Text Book 3 : Chapter 11

MODULE-5	**GAMETHEORY**	**21MEE61.6**	**8 Hours**

Formulation of games, Two person-Zero sum game, games with and without saddle point, Graphical solution (2x n, m x 2 game), dominance property.

Self-study / Case Study / Applications	Case study on game theory by taking any real time examples.
Text Book	Text Book 3: Chapter 14

CIE Assessment Pattern (50 Marks – Theory) –

RBT Levels		Marks Distribution		
		Test (s)	Qualitative Assessment (s)	MCQ's
		25	15	10
L1	Remember	5	-	-
L2	Understand	5	-	-
L3	Apply	5	5	5
L4	Analyze	5	5	5
L5	Evaluate	5	5	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources:

Text Books:

1.Contemporary Project Management, Timothy J Kloppenborg, Cengage Learning, 2 nd Edition, ISBN: 97881315187

1. Operations Research: An Introduction, H A Taha,Pearson; 10th edition (17 January2017), ISBN-13: 978-1292165547
2. Engineering Economy, Thuesen H.G. PHI , 2002

3.Operation Research, S D Sharma, KedarNathRamNath publication, 2014 edition,ISBN-13: 1234567142552

Reference Books

1. Engineering Economy, Riggs J.L., 4 TH ed. , McGraw Hill, 2002
2. Project Management a System approach to Planning Scheduling & Controlling, Harold Kerzner, CBS Publishers and Distributors.2nd Ed., ISBN: 9788123908670

Web links and Video Lectures (e-Resources):

- **https://onlinecourses.nptel.ac.in/noc22_ge24/preview**
- **https://projectmanagement.berkeley.edu/project-managemenet-course/**
- https://www.youtube.com/watch?v=cwxXY9Qe8ss
- **https://www.youtube.com/watch?v=V2GvQXvjhLA**
- **https://nsf-gov-resources.nsf.gov/2023-03/Bio-inspired%20Design%20Workshop%20Report_2232327_October%202022_Final.508.pdf**

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Visit to any manufacturing/aero/auto industry or any power plant
- Demonstration of project management by taking any real time examples
- Demonstration of implementation of game theory in industries.
- Demonstration of application of sequencing in the industries
- Motivational videos from a women entrepreneurs.
- Contents related activities (Activity-based discussions)
  - For active participation of students, instruct the students to prepare Flowcharts and Handouts
  - Organizing Group wise discussions on issues
  - Seminars

FUNDAMENTALS OF HEAT TRANSFER

Course Code	**21MEE62**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

21MEE62.1	Apply heat transfer principles to design and evaluate the performance of thermal systems in order to minimize the heat loss
21MEE62.2	Formulate the steady state conduction equations for one dimensional heat transfer systems like Fins, Lumped systems and develop the solution for the temperature distributions within the body.
21MEE62.3	Apply the concepts of radiation shield system in preventing harmful radiations in power plants.
21MEE62.4	Develop the enhanced thermal systems as a team by minimizing the constraints which enables the student to have continuous learning
21MEE62.5	Analyze the complex engineering problems in convection heat transfer and also use computational tools to design heat exchangers.
21MEE62.6	Design the eco friendly Condensing and heat exchange equipment's so as to optimize the heat flow.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE62.1	3	2	2	2	-	-	-	-	-	-	-	-	-	3
21MEE62.2	3	3	3	2	-	-	-	-	-	-	-	-	-	2
21MEE62.3	3	2	2	2	-	1	2	-	-	-	-	2	-	3
21MEE62.4	3	2	2	-	-	-	-	-	-	-	-	-	-	3
21MEE62.5	3	3	2	-	2	-	-	-	-	-	-	-	-	3
21MEE62.6	3	2	2	-	-	-	2	-	-	-	-	-	-	3

MODULE-1	**INTRODUCTION TO HEAT TRANSFER CONCEPTS**	**20MEE61.1 20MEE61.6**	**8 Hours**

Introduction to Concepts And Definitions: Modes of heat transfer; Basic laws governing conduction, convection, and radiation heat transfer; Boundary conditions of 1st, 2nd and 3rd kind (Numerical Problems). Derivation of general three-dimensional conduction equation in Cartesian coordinate and its special cases, discussion on 3-D conduction in cylindrical and spherical coordinate systems (No derivation). One dimensional conduction equation in rectangular, cylindrical and spherical coordinates for plane and composite walls (No Derivations only Numerical Problems). Thermal contact resistance (Numerical Problems). Introduction to Insulating materials, types and selecting criteria of insulating material, R value of insulation. Critical thickness of insulation without heat generation (Numerical Problems

Applications	Investigate the Practical Applications of Laws of Heat Transfer.
Text Book	Text Book 1: 1.1, 1.2, 1.3, 1.4,2.1,2.2,2.5,2.6 Text Book 2: 1.1, 1.2, 2.1,2.2,

MODULE-2	**TRANSIENT CONDUCTION AND HEAT TRANSFER IN EXTENDED SURFACES**	**20MEE61.2 20MEE61.6**	**8 Hours**

Transient Conduction: Lumped system analysis, Use of Transient temperature charts (Heisler's charts) for transient conduction in slab, long cylinder and sphere; use of transient temperature charts for transient conduction in semi- infinite solids. Numerical Problems.

Heat transfer in extended surfaces: Heat transfer in extended surfaces of uniform rectangular cross-section without heat generation, Long fin, and short fin with insulated tip and without insulated tip and fin connected between two heat sources. Fin efficiency and effectiveness. Numerical Problems

Case Study	Case study on Analysis of Transient Heat conduction in different Geometries.
Text Book	Text Book 1: 2.10,2.10.1,2.10.2,4.2,4.5Text Book 2: 1.1, 1.2, 1.3

MODULE-3	**FREE CONVECTIONS FORCED CONVECTIONS**	**20MEE61.3,**	**8 Hours**

		20MEE61.5, 20MEE61.6	

Free or Natural convection: Application of dimensional analysis for free convection, use of correlations of free convection in vertical, horizontal and inclined flat plates, vertical and horizontal cylinders and spheres, Numerical problems.
Forced Convections: Applications of dimensional analysis for forced convection, Use of various correlations for hydrodynamically and thermally developed, flows inside a duct, use of correlations for flow over a flat plate, over a cylinder and sphere. Numerical problems

Applications	Investigate the Application of dimensional analysis for free convection and forced convection.
Text Book	Text Book 1: 6.6, 7.1, 7.2 , 7.3 ,8.1,8.5,8.8 Text Book 2: 2.1, 2.3, 2.4, 2.5, 2.6

MODULE-4	**RADIATION HEAT TRANSFER**	**20MEE61.2 20MEE61.6**	**8 Hours**

Radiation Heat Transfer: Thermal radiation; definitions of various terms used in radiation heat transfer. Basic Laws: Stefan-Boltzmann law, Kirchoff's law, Planck's law and Wein's displacement law, Lambert's law. Radiation heat exchange between two parallel infinite black surfaces, between two parallel infinite gray surfaces; effect of radiation shield; intensity of radiation and solid angle; Numerical problems

Case Study	Case study on radiation heat transfer in Furnaces
Text Book	Text Book 1: 11.1,11.2,11.3,11.4,11.5,11.6,11.7,11.8,11.9 Text Book 2: 5.1, 5.3, 5.5, 5.7

MODULE-5	**HEAT EXCHANGERS, CONDENSATION AND BOILING**	**20MEE61.4 20MEE61.6**	**8 Hours**

Heat Exchangers: Classification of heat exchangers; Temperature profiles of Heat exchangers. Overall heat transfer coefficient, fouling and fouling factor; LMTD, Effectiveness-NTU methods of analysis of heat exchangers. Numerical problems. Introduction to the concepts of Micro, Nano and PCB type heat exchangers.
Condensation And Boiling: Types of condensation (discussion only) Nusselt's theory for laminar condensation on a vertical flat surface; use of correlations for condensation on vertical flat surfaces, horizontal tube and horizontal tube banks; Reynolds number for condensate flow; regimes of pool boiling, pool boiling correlations. Numerical problems

Case Study	Case study on Design of Heat Exchangers
Text Book	Text Book 1: 10.1,10.2,10.310.4,10.5, 9.1,9.2,9.3 Text Book 2: 8.1, 8.3, 8.4, 8.5, 8.6

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		**Marks Distribution**		
		Test (s)	**Qualitative Assessment (s)**	**MCQ's**
		25	**15**	**10**
L1	**Remember**	5	-	-
L2	**Understand**	5	-	-
L3	**Apply**	5	5	5
L4	**Analyze**	5	5	5
L5	**Evaluate**	5	5	-
L6	**Create**	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		**Exam Marks Distribution (50)**
L1	**Remember**	**10**
L2	**Understand**	**10**
L3	**Apply**	**10**

L4	**Analyze**	**10**
L5	**Evaluate**	**10**
L6	**Create**	**--**

Suggested Learning Resources:

Text Books:

1) Heat & Mass transfer, R.K Rajaput, S Chand and Co Ltd, 5th Ed,2012. ISBN: 81-219-2617-3
2) Engineering Heat and Mass transfer, Mahesh M. Rathore, Lakshmi Publication Pvt Ltd 3rd Edition, 2016, ISBN: 978-81-318-0613-5

Reference Books:

1) Heat transfer, a practical approach, Yunus A- Cengel Tata McGraw Hill,5th Ed, ISBN: 9789339223199
2) Principles of heat transfer, Kreith Thomas Learning ,7th Ed, ISBN-13: 978-0495657704
3) Fundamentals of heat and mass transfer, Frank P. Incropera and David P. Dewitt, John Wiley and sons, 7th Ed, ISBN : 978-1-118-37924-0
4) Heat transfer-A basic approach, Ozisik, Tata McGraw Hill 2002.

Web links and Video Lectures (e-Resources):

- **https://onlinecourses.nptel.ac.in/noc20_ch21/preview**
- **https://www.youtube.com/watch?v=lvyCe0UaqJY**
- **https://www.udemy.com/course/fundamentals-of-heat-masstransfer-basic-to-advance-level/**
- **https://www.classcentral.com/course/swayam-heat-transfer-10061**

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Visit to any Thermal power plant
- Demonstration of working of IC engine/refrigerator
- Video demonstration on Conduction, convection and radiation heat transfer
- Contents related activities (Activity-based discussions)
  - For active participation of students, instruct the students to prepare heat transfer related Flowcharts and Handouts
  - Organizing Group wise discussions on issues
  - Seminars

FUNDAMENTALS OF HEAT TRANSFER LAB

Course Code	**21MEL62**	**CIE Marks**	**50**
L:T:P:S	**0:0:1:0**	**SEE Marks**	**50**
Hrs / Week	**02**	**Total Marks**	**100**
Credits	**01**	**Exam Hours**	**03**

Course outcomes:

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

21MEL62.1	Apply the concept of steady state heat conduction in analytical and numerical method to determine the temperature distributions and heat flux in metal rod and composite wall.
21MEL62.2	Formulate the conduction equations for one dimensional heat transfer systems like Fins, Lumped systems and develop the solution for the temperature distributions within the body
21MEL62.3	Analyze the black body concept of radiation to determine the emissivity of given surfaces
21MEL62.4	Analyze the free convection and forced convection heat transfer in a duct and vertical surface.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEL62.1	3	3	2	-	1	-	-	-	-	-	-	-	3	-
21MEL62.2	3	3	2	-	-	-	-	-	-	-	-	-	3	-
21MEL62.3	3	3	2	-	-	-	-	-	-	-	-	-	3	-
21MEL62.4	3	3	2	-	-	-	-	-	-	-	-	-	3	-

Exp. No. / Pgm. No.	List of Experiments	Hours	COs
	Prerequisite Experiments / Demo		
	• Conduction, convection and radiation concepts and Laws • Engineering Thermodynamics concepts and Laws • Thermal analysis using FEM	2	NA
	PART-A		
1	Determination of Thermal Conductivity of a Metal Rod.	2	21MEL62.1 21MEL62.1
2	Determination of Overall Heat Transfer Coefficient of a Composite wall.	2	21MEL62.1 21MEL62.1
3	Thermal Analysis of Composite walls using FEM.	2	21MEL62.1 21MEL62.1
4	Experiment on Transient Heat Conduction.	2	21MEL62.2
5	Determination of Emissivity of a Surface	2	21MEL62.3
6	Determination of Heat Transfer Coefficient in a free Convection on a vertical/horizontal tube	2	21MEL62.4
	PART-B		
7	Determination of Heat Transfer Coefficient in a Forced Convention on a vertical/horizontal tube.	2	21MEL62.4
8	Determination of Heat transfer co-efficient, efficiency & Effectiveness on a Metallic fin by Free convection	2	21MEL62.4
9	Determination of Heat transfer co-efficient, efficiency & Effectiveness on a Metallic fin by forced convection	2	21MEL62.4
10	Determination of heat transfer coefficient in film wise condensation.	2	21MEL62.4
11	Determination of heat transfer coefficient in drop wise condensation.	2	21MEL62.4

12	Determination of Stephan Bolzman Constant	2	21MEL62.4

PART-C
Beyond Syllabus Virtual Lab Content

- https://sites.google.com/view/vlab-bnmitmech/home/heat-transfer-lab/determination-of-thermal-conductivity-of-a-metal-rod?authuser=0
- https://sites.google.com/view/vlab-bnmitmech/home/heat-transfer-lab/natural-convection?authuser=0
- https://vlab.amrita.edu/index.php?sub=1&brch=194&sim=791&cnt=1
- https://vlab.amrita.edu/index.php?sub=1&brch=194&sim=802&cnt=1

CIE Assessment Pattern (50 Marks – Lab)

RBT Levels		Test (s)	Weekly Assessment
		20	30
L1	Remember	-	-
L2	Understand	5	5
L3	Apply	5	10
L4	Analyze	5	10
L5	Evaluate	5	5
L6	Create	-	-

SEE Assessment Pattern (50 Marks – Lab)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	05
L2	Understand	05
L3	Apply	10
L4	Analyze	20
L5	Evaluate	10
L6	Create	

Suggested Learning Resources:

Reference Books:

1) Heat transfer, a practical approach, Yunus A- Cengel Tata McGraw Hill,5th Ed, ISBN: 9789339223199
2) Principles of heat transfer, Kreith Thomas Learning ,7th Ed, ISBN-13: 978-0495657704
3) Fundamentals of heat and mass transfer, Frank P. Incropera and David P. Dewitt, John Wiley and sons, 7th Ed, ISBN : 978-1-118-37924-0

FINITE ELEMENT METHODS

Course Code	**21MEE63**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

21MEE63.1	Understand the concept of FEM, FE procedure, Interpolations, paraphrase numerical methods
21MEE63.2	Evaluate the desirable characteristics of one dimensional and 2-D element
21MEE63.3	Analyze the problem for applying boundary conditions for 1D elements
21MEE63.4	Apply suitable boundary conditions to a global equation for trusses
21MEE63.5	Determine the unknown field variable in Beams.
21MEE63.6	Evaluate dynamics problems using FEM and Eigen values given applications

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE63.1	3	3	3	3	-	-	-	-	-	-	-	-	-	3
21MEE63.2	3	3	3	3	-	-	-	-	-	-	-	-	-	3
21MEE63.3	3	3	3	3	-	-	-	-	-	-	-	-	-	3
21MEE63.4	3	3	3	3	-	-	-	-	-	-	-	-	-	3
21MEE63.5	3	3	3	3	-	-	-	-	-	-	-	-	-	3
21MEE63.6	3	3	3	3	-	-	-	-	-	-	-	-	-	3

MODULE-1	**INTRODUCTION TO FINITE ELEMENT METHODS**	**21MEE63.1**	**8 Hours**

Introduction to Finite Element Methods**:**

Basic Concept, Historical background, General and Engineering applications of the FEM, Advantages, Classification, Basic steps, Types of elements based on Geometry, bandwidth, Variation formulations using Rayleigh Ritz method and weighted residual methods. Basic Equations and Potential Energy Functional, Numericals.

Interpolation Models: Introduction, Polynomial form of interpolation function, Simplex, Complex, and Multiplex elements, Interpolation polynomial in terms of nodal DOF, Selection of the order of the interpolation polynomial, Convergence requirements, coordinate systems

Text Book	Text Book 1: 1.1 to 1.15
Case Study	Problem solving on Numerical Integration.

MODULE-2	**DERIVATIONS OF 1-D AND 2-D ELEMENTS:**	**21MEE63.2**	**8 Hours**

Shape functions and its properties, Derivation of Shape functions in Global, Local and Natural Co-ordinate systems. Shape functions for Triangular and Quadrilateral element. Strain Displacement matrix for Triangular and Quadrilateral Elements, Numericals on Isoparametric Formulation and Jacobian Matrix.

Text Book	Text Book 1: 3.1to 3.11,6.1-6.4
Case Study	Derivation of Shape functions for various Higher order elements.

MODULE-3	**SOLUTION OF 1-D PROBLEMS:**	**21MEE63.3**	**8 Hours**

Definition, Properties of a stiffness matrix and derivation of Stiffness matrix for 1-D bar element, Essential and Non Essential Boundary conditions, Problems using Elimination and Penalty approach on various loading conditions for Constant cross section ,Tapered cross section and bar with a Gap, Temperature effect on Bar

Text Book	Text Book 1:3.1-3.10
Assignment	Evaluation of Stresses and field variables of structures using ANSYS software.

MODULE-4	**STRUCTURAL ANALYSIS THROUGH FEM FOR BEAMS AND TRUSSES:**	**21MEE63.4 21MEE63.5**	**8 Hours**

Beams: 2-Noded beam element, Finite element formulation, load vector, point load, UDL, shear force and bending moment, Deflection equation, shape functions and stiffness matrixes.
Trusses: Includes study of problems with one, two, three and four bar elements, Equation of truss, stiffness matrix derivation, and assumptions.

Text Book	Text Book 1: 4.1-4.5,5.1-5.3 Text Book 2: 10.1, 10.3, 10.5, 10.7
Case Study	Determination of Field variables related to Frames and Axisymmetric problems.

MODULE-5	**FEM FOR DYNAMIC ANALYSIS**	**21MEE63.6**	**8 Hours**

FEM for Dynamic: System of springs, Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, quadrilateral element, beam element. Lumped mass matrix, Evaluation of Eigen values and Eigen vectors, Applications to bars, stepped bars, and beams.

Applications	Practical applications of Dynamic analysis in spring mass system.
Text Book	Text Book 1: 11.1-11.6

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution		
		Test (s)	Qualitative Assessment (s)	MCQ's
		25	15	10
L1	Remember	5	-	-
L2	Understand	5	-	-
L3	Apply	5	5	5
L4	Analyze	5	5	5
L5	Evaluate	5	5	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources:

Text Books:

1) Chandrupatla T. R. "Introduction to Finite Elements in engineering"- 4th Edition, Pearson, ISBN-13: 978-0132162746
2) Lakshmi Narayana H. V.,"Finite Elements Analysis"– Procedures in Engineering, Universities Press, ISBN-13: 978-83714764

Reference Books:

1) Rae S. S. "Finite Elements Method in Engineering"- 4th Edition, Elsevier, ISBN: 9780750678285
2) P.Seshu, "Textbook of Finite Element Analysis" -PHI, ISBN : 978-81-203-2315-5
3) J.N.Reddy,"Finite Element Method"-McGraw-Hill International Edition. 3rd Ed,ISBN: 9780070607415
4) Bathe K. J. "Finite Elements Procedures"- PHI, ISBN : 978-81-203-1075-9 5) Cook R. D., et al., "Concepts and Application of Finite Element Method" John Wiley & Sons INC 4th edition, ISBN-13: 978-0471356059

Web links and Video Lectures (e-Resources):

- **https://www.youtube.com/watch?v=UOp6JEiJctA&list=PLSGws_74K018SmggufD-pbzG3thPIpF94**
- **https://www.youtube.com/watch?v=0VNIEfX0m4A&list=PLSGws_74K018SmggufD-pbzG3thPIpF94&index=3**
- **https://www.youtube.com/watch?v=jQPwabwnBpg&list=PLSGws_74K018SmggufD-pbzG3thPIpF94&index=27**
- **https://www.youtube.com/watch?v=1JOMM-ytOyU&list=PLSGws_74K018SmggufD-pbzG3thPIpF94&index=4**

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Visit to any Design company/aero/auto industry
- Demonstration of Structures using ANSYS software.
- Video demonstration of Stress concentration factor for a plate with a hole.
- Problem solving approaches for the Approximation methods.
- Contents related activities (Activity-based discussions)
- For active participation of students, instruct the students to solve the matrix related numericals.
- Organizing Group wise discussions on issues
- Seminars

FINITE ELEMENT METHOD LAB

Course Code	**21MEL63**	**CIE Marks**	**50**
L:T:P:S	**0:0:1:0**	**SEE Marks**	**50**
Hrs / Week	**02**	**Total Marks**	**100**
Credits	**01**	**Exam Hours**	**03**

Course outcomes:

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

21MEL63.1	Formulate the problem, create geometry to determine the field variable of bars under different loading condition
21MEL63.2	Apply boundary condition to solve problems related to rectangular plate to determine stress with different loading conditions.
21MEL63.3	Analysis of truss members to find displacements and stresses with different loading Conditions and to demonstrate the deflection of beams subjected to draw shear force and bending moment diagrams
21MEL63.4	Evaluate the natural frequencies for various boundary conditions in vibrational analysis.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEL63.1	3	2	2	1	3	-	-	-	-	-	-	-	-	3
21MEL63.2	2	2	3	2	3	-	-	-	-	-	-	-	-	3
21MEL63.3	2	2	2	3	3	-	-	-	-	-	-	-	-	3
21MEL63.4	1	3	2	3	3	-	-	-	-	-	-	-	-	3

Exp. No. / Pgm. No.	List of Experiments / Programs	Hours	COs
	Prerequisite Experiments / Programs / Demo		
	• Stress analysis of various structures • Meshing the structures using various analysis software's • Shear Force and Bending Moment Diagrams	2	NA
	PART-A		
1	Introduction To FEA Package And Stress Analysis	2	21MEL63.1
2	Bars Of Constant Cross Section	2	21MEL63.1
3	Bars Of Tapered Cross Section And Stepped Bar	2	21MEL63.1
4	Stress Analysis Of A Rectangular Plate With A Hole	2	21MEL63.2
5	Problems With 2 bar Trusses.	2	21MEL63.3
6	Problems With 3 and 4 bar Trusses	2	21MEL63.3
	PART-B		
7	Beams: Cantilever With Various Loading Conditions	2	21MEL63.3
8	Beams: Simply Supported Beams With Different Loadi Ng Conditions	2	21MEL63.3
9	Dynamic Analysis: Fixed-Free Beam For Natural Frequency	2	21MEL63.4
10	Dynamic Analysis Of A Bar Subjected To Forcing Function	2	21MEL63.4
11	Dynamic Analysis Of A Fixed-Fixed Bar Subjected To Forcing Function.	2	21MEL63.4
12	Dynamic Analysis: Free-Free Beam For Natural Frequency		

PART-C

Beyond Syllabus Virtual Lab Content

(To be done during Lab but not to be included for CIE or SEE)

- **https://www.youtube.com/watch?v=7qTUut3cPnM&list=PLye_WDkVjjiW6C6D9Qdlc0phBdQz254Pd**

- https://www.youtube.com/watch?v=2WgsJvq-1es

CIE Assessment Pattern (50 Marks – Lab)

RBT Levels		Test (s)	Weekly Assessment
		20	30
L1	Remember	-	-
L2	Understand	-	5
L3	Apply	5	10
L4	Analyze	5	10
L5	Evaluate	5	5
L6	Create	-	-

SEE Assessment Pattern (50 Marks – Lab)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	-
L2	Understand	10
L3	Apply	10
L4	Analyze	20
L5	Evaluate	10
L6	Create	-

Suggested Learning Resources:

Text Books:

1) Rae S. S. "Finite Elements Method in Engineering"- 4th Edition, Elsevier, ISBN: 9780750678285
2) P.Seshu, "Textbook of Finite Element Analysis" -PHI, ISBN : 978-81-203-2315-5
3) J.N.Reddy,"Finite Element Method"-McGraw-Hill International Edition. 3rd Ed,ISBN: 9780070607415
4) Bathe K. J. "Finite Elements Procedures"- PHI, ISBN : 978-81-203-1075-9 5) Cook R. D., et al., "Concepts and Application of Finite Element Method" John Wiley & Sons INC 4th edition, ISBN-13: 978-0471356059

EXPLORATORY DATA ANALYSIS USING MODERN TOOLS

Course Code	**21MEE641**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**3**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

21MEE641.1	Understand the fundamentals concepts of data science
21MEE641.2	Interpret the data using programming skills
21MEE641.3	Visualize the data using adequate tools
21MEE641.4	Perform exploratory data analysis using fundamental skills
21MEE641.5	Evaluate the results based on the EDA algorithms
21MEE641.6	Analyze the concepts of data engineering

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE641.1	3	-	3	-	3	-	-	-	-	-	-	2	-	2
21MEE641.2	3	-	3	-	3	-	-	-	-	-	-	2	-	2
21MEE641.3	3	-	3	-	3	-	-	-	-	-	-	2	-	2
21MEE641.4	3	-	3	-	3	-	-	-	-	-	-	2	-	2
21MEE641.5	3	-	3	-	3	-	-	-	-	-	-	2	-	2
21MEE641.6	3	-	3	-	3	-	-	-	-	-	-	2	-	2

MODULE-1	**Introduction: Data science**	**21MEE641.1 21MEE641.2**	**8 Hours**

Introduction: What is Data Science? Big Data and Data Science hype – and getting past the hype, Why now? – Datafication, Current landscape of perspectives, A data Science Profile, Skill sets. Statistical Inference, Populations and samples, Big Data, new kinds of data, modelling, statistical modeling probability distributions, fitting a model, - Introduction to R

Case Study / Applications	Stats Data sample analysis using Excel
Text Book:	Text Book 1 & 2: Section 4 (EDA)

MODULE-2	**EDA - Introduction**	**21MEE641.3 21MEE641.4 21MEE641.5**	**8 Hours**

Exploratory Data Analysis and the Data Science Process: Basic tools (plots, graphs and summary statistics) of EDA, Philosophy of EDA, The Data Science Process, Case Study: RealDirect (online real estate firm). Algorithms, machine Learning Algorithms,

Case Study / Applications	Application of stress concentration – Case study.
Text Book:	Text Book 1 & 2: Section 4 (EDA)

MODULE-3	**EDA – Approach in problem solving**	**21MEE641.3 21MEE641.4 21MEE641.5**	**8 Hours**

Spam Filter, Linear Regression and Spam Filter, K-NN and spam Filter,, Naïve Bayes Algorithm, Spam Filter using Naïve Bayes, Laplace Smoothing,, Comparing Naïve Bayes to K-NN, Scraping the Web, introduction to Logical Regression and M6D case study

Case Study / Applications	Case study: To identify the types of threaded fasteners used in IC engines		
Text Book	Text Book 1 & 2: Section 4 (EDA)		
MODULE-4	**EDA - Algorithm**	**21MEE641.3**	**8 Hours**
Three Basic Algorithms: Linear Regression, k-Nearest Neighbours (kNN), k-means, R Programs for the algorithms			
Case Study / Applications	Determination of the screw diameters, pitch of power screws used in lathe machines and UTM		
Text Book	Text Book 1 & 2: Section 4 (EDA)		
MODULE-5	**Data Engineering**	**21MEE641.6**	**8 Hours**
Data Engineering, Map reduce, Word Frequency Problem,, Map Reduce Solution, Other Examples of Map Reduce, Pregel-An Introduction. Data Visualization: Basic principles, ideas and tools for data visualization. Mining SocialNetwork Graphs: Social networks as graphs, Clustering of graphs, Direct discovery of communities in graphs, Partitioning 2 of graphs			
Case Study / Applications	Identification of the gear parameters physically by using gear tooth vernier		
Text Book	Text Book 1 & 2: Section 4 (EDA)		

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution	
		Test (s)	NPTEL
		25	25
L1	**Remember**	5	-
L2	**Understand**	5	5
L3	**Apply**	5	10
L4	**Analyze**	5	10
L5	**Evaluate**	5	-
L6	**Create**	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	**Remember**	**10**
L2	**Understand**	**10**
L3	**Apply**	**10**
L4	**Analyze**	**10**
L5	**Evaluate**	**10**
L6	**Create**	**--**

Suggested Learning Resources:

Text Books:

1. Cathy O Neil, Rachel Schutt, 2014, "Doing Data Science-Straight Talk from the Frontline", Orielly
2. Jure Leskovek, Anand Rajaraman, Jeffrey Ullman, 2014 Mining of Massive Data Sets, Cambridge University Press

Reference Books:

1. Kevin Murphy, 2013, Machine learning: A Probabalistic Perspective,
2. Peter Bruce, Andre Bruce, Practical Statistics for Data Scientists, Orielly Series

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=q4pyaVZjqk0
- https://www.stat.cmu.edu/~hseltman/309/Book/chapter4.pdf

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Data identification from external resources like Kaggle and other online data base.
- Interpretation of data into .csv file
- Data engineering and visualization
- Data analysis and model building
- Model validation for test and train data.

MACHINE LEARNING FOR MECHANICAL ENGINEERS

Course Code	**21MEE642**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs. / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course Outcomes:

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

21MEE642.1	Understand the fundamentals of Machine Learning and apply basics of Python Programming to solve ML Algorithms.
21MEE642.2	Apply the fundamental concepts of Linear Regression in Supervised Learning.
21MEE642.3	Apply the fundamental concepts of Logistic Regression in Supervised Learning.
21MEE642.4	Design a model using Supervised ML algorithms for Classification, Prediction and Clustering.
21MEE642.5	Evaluate the Performance Metrics of all ML algorithms in Unsupervised Learning.
21MEE642.6	Analyze the concepts of Reinforcement Learning.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE642.1	3	-	-	-	2	-	-	-	-	-	-	2	-	2
21MEE642.2	3	3	2	-	2	-	-	-	-	-	-	2	-	2
21MEE642.3	3	3	3	-	2	-	-	-	-	-	-	2	-	2
21MEE642.4	3	2	2	3	2	-	-	-	-	-	-	2	-	2
21MEE642.5	3	2	2	2	2	-	-	-	-	-	-	2	-	2
21MEE642.6	3	2	2	2	2	-	-	-	-	-	-	2	-	2

MODULE-1	**FUNDAMENTALS OF ML**	**21MEE642.1**	**8 Hours**

Meaning, Definition, Google Vs AI, Approach of ML, ML processes, Applications of ML, Types of ML with examples, ML Techniques, Qualitative and quantitative data, LDA.
Basics of Python Programming: Python datatypes, Data handling with python, NumPy, Pandas, Matplotlib, Decision and control loops.

Case Study	Simple Linear Regression Examples.
Text Book	Text Book 1: 2.1-2.5

MODULE-2	**SUPERVISED LEARNING-I**	**21MEE642.2**	**8 Hours**

Linear Regression – SLR and MLR Model building, Estimation of parameters using OLS, Performance Evaluation- Confusion Matrix, Accuracy, Precision, Recall, ROC Curves, Support vector mechanics (SVM), Non-linear SVM, Kernel functions.
Logistic Regression – Introduction, Binary logical regression, Estimation of parameters, Sensitivity, Specificity, Multi-class classification, One Vs One, One Vs Rest, Gain chart, Lift chart.

Case Study	Multi Linear Regression Examples.

Text Book	Text Book 2: Pg. 21, 93		
MODULE-3	**SUPERVISED LEARNING-II**	**21MEE642.3**	**8 Hours**
Concept and terminology, Decision Trees, Classification and Regression tree (CART), Gini gain, Entropy & Information gain computation, RF- Algorithm, Cost Functions- MSE, MAE, R-Square, Estimation of values of regression coefficients, Naïve Bayes classifier, KNN for classification, Overfitting, Underfitting, Bias and Variance.			
Case Study	Decision Tree Examples		
Text Book	Text Book 1: 3.1-3.7, Text Book 2: Pg. 49, 213		
MODULE-4	**UNSUPERVISED LEARNING**	**21MEE642.4**	**8 Hours**
Distance-based models, Distance Metrics, Clustering, k-means clustering, Algorithm, Principle Component Analysis (PCA).			
Case Study	Logistic Regression Examples.		
Text Book	Text Book 2: Pg. 115, 161		
MODULE-5	**REINFORCEMENT LEARNING**	**21MEE642.5**	**8 Hours**
Reinforcement Learning: Active and Passive RL, Learning from rewards, Generalization concept, Inverse RL, Application learning Task, q-Learning.			
Case Study	Logistic Regression Examples.		
Text Book	Text Book 1-13.1-13.8, Text Book 2- pg.517		

CIE Assessment Pattern (50 Marks – Theory) –

RBT Levels		Marks Distribution	
		Test (s)	NPTEL
		25	-
L1	Remember	5	5
L2	Understand	5	10
L3	Apply	5	10
L4	Analyze	5	-
L5	Evaluate	5	-
L6	Create	-	-

SEE Assessment Pattern (50 Marks – Theory) –

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	-

Suggested Learning Resources:

Text Books:

1) "Machine Learning", By Tom Mitchell, McGraw Hill, 2017.
2) "Introduction to Machine Learning", By E. Alpaydin, PHI, 2005.

Reference Books:

1) "Introduction to Machine Learning with Python", By Andreas Muller, Shroff/O'Reilly, 2016, ISBN: 978-9352134571.
2) "Hands-On Machine Learning with Scikit-Learn and Tensor Flow", By Shroff/O'Reilly, 2017.

Web links and Video Lectures (e-Resources):

- **https://onlinecourses.nptel.ac.in/noc23_cs11/unit?unit=16&lesson=17**
- **https://www.ibm.com/topics/machine-learning**
- **https://www.geeksforgeeks.org/machine-learning/**
- **https://en.wikipedia.org/wiki/Machine_learning**

Activity-Based Learning (Suggested Activities in Class)/ Practical Based Learning

- Visit to any Manufacturing/Aero/Auto Industry
- Video demonstration of latest trends in mobility/robotics
- Contents related activities (Activity-based discussions)
  - For active participation of students, instruct the students to prepare Flowcharts and Handouts
  - Organizing Group wise discussions on issues
  - Seminars

CONTROL ENGINEERING

Course Code	**21MEE643**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

21MEE643.1	Apply various control systems concepts to mechanical models and identify the control parameters for safe usage of the system.
21MEE643.2	Analyze and categorize the transient and steady state response of mechanical control systems to interpret the practical problems
21MEE643.3	Apply the reduction methods and evaluate the outputs for transfer function of control systems with suitable representations and documentation
21MEE643.4	Determine the stability conditions and represent the values using graphical methods so as to facilitate the learning process further and recommend improvements if needed
21MEE643.5	Design and develop system with controlled parameters and compensate the system responses to maintain the optimal functionality.
21MEE643.6	Analyze and solve the problem using MAT-Lab programming

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE643.1	3	2	2	2	2	-	-	-	-	-	-	-	-	3
21MEE643.2	3	2	2	-	1	-	-	-	-	-	-	-	-	3
21MEE643.3	3	2	2	2	2	-	-	-	-	1	-	-	-	3
21MEE643.4	3	2	2	2	2	-	-	-	-	-	-	-	-	3
21MEE643.5	3	2	2	2	2	-	-	-	-	-	-	-	-	3
21MEE643.6	3	2	2	2	2	-	-	-	-	-	-	-	-	3

MODULE-1	**INTRODUCTION TO CONTROL SYSTEMS**	**21MEE643.1**	**8 Hours**

Introduction: Concept of automatic controls, Open loop and closed loop systems, Concepts of feedback, requirements of an ideal control system, Types of controllers- Proportional, Integral Proportional Integral, Proportional Integral Differential controllers Mathematical Models: Transfer function models, models of mechanical systems(FV &FI analogy).

Self-study	Explore the Challenges of current signal systems which are manual and automatic.
Text Book	Text Book 1: 1.1-1.9, 2.1-2.6,7.19,6.8

MODULE-2	**TRANSIENT AND STEADY STATE RESPONSE ANALYSIS**	**21MEE643.2**	**8 Hours**

Transient and Steady State Response Analysis: Introduction, first order and second order system response to step, ramp and impulse inputs, concepts of time constant and its importance in speed of response.

Self-study / Applications	Desirable identification of systems with steady and transient state responses for inputs.
Text Book	Text Book 1: 7.1-7.17

MODULE-3	**BLOCK DIAGRAMS AND SFG**	**21MEE643.3, 21MEE643.4**	**8 Hours**

Block Diagrams and Signal Flow Graphs: Transfer Functions definitions, function, block representation of systems elements, reduction of block diagrams, Signal flow graphs: Mason's gain formula.

Self-study	Explore the problems with capabilities of reducing to SFG.
Text Book	Text Book 1: 4.1-4.4,5.1-5.9

MODULE-4	**FREQUENCY RESPONSE ANALYSIS**	**21MEE643.5**	**8 Hours**

Frequency Response Analysis: Polar plots, Nyquist stability criterion, Stability analysis, Relative stability concepts, Gain margin and phase margin,. Frequency Response Analysis Using Bode Plots: Bode attenuation diagrams, Stability analysis using Bode plots

Self-study / Case Study	Execute unsolved problems
Text Book	Text Book 1:10.1-10.10,11.1-11.11

MODULE-5	**ROOT LOCUS PLOTS**	**21MEE643.6**	**8 Hours**

Root Locus Plots: Definition of root loci, General rules for constructing root loci, Analysis using root locus plots using graphical representation, relative stability. System Compensation: types of compensation system, design of lead and lag compensator, designing proportional controller for desired angle.

Self-study / Case Study /	Execute unsolved problems
Text Book	Text Book 1: 9.1-9.13

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution	
		Test (s)	NPTEL
		25	25
L1	Remember	5	-
L2	Understand	5	5
L3	Apply	5	10
L4	Analyze	5	10
L5	Evaluate	5	-
L6	Create	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources:

Text Books:

1) Control Engineering, V.U.Bakshi & U.A.Bakshi , Technical Publications, 2014 edition,ISBN-13: 978-9350996577

Reference Books:

1. Control Systems Engineering,S.Salivahanan,2015 Pearson publications, ISBN:978-93-325-3413-1
2. Control System Engineering, I J Nagrath & M Gopal, New Age International Pvt Ltd; Sixth edition (January 2017), ISBN – 13: 978-9386070111
3. Modern Control Engineering, Katsuhiko Ogata, Pearson Publication, 5th Ed. ISBN-13: 978-0136156734

Web links and Video Lectures (e-Resources):

- **https://www.electrical4u.com/control-engineering-historical-review-and-types-of-control-engineering/**
- https://www.youtube.com/watch?v=HcLYoCmWOjI
- **https://www.youtube.com/watch?v=10WwDd2QopQ**

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Video demonstration of daily operated control systems.
- Contents related activities (Activity-based discussions)
  - For active participation of students, instruct the students to prepare Flowcharts and Handouts
  - Organizing Group wise discussions on issues

SMART MATERIALS AND INTELLIGENT SYSTEM DESGN

Course Code	**21MEE644**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

21MEE644.1	Gain the knowledge on the characteristics of materials such as Metals, Polymers and Ceramics.
21MEE644.2	Analyse the characteristics of Electro, Magneto Rheological fluids and Chromic materials for various mechanical systems.
21MEE644.3	Apply the Electro strictive and Magneto strictive materials in the design of different materials.
21MEE644.4	Evaluate the properties of shape memory alloys with other class of materials and Propose its suitability for a range of applications in Mechanical and Bio medical.
21MEE644.5	Build the smart materials towards the development of smart composites.
21MEE644.6	Identify multi-disciplinary concepts in materials, composites, basic electronics, control system and informatics

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE644.1	3	2	-	-	-	-	-	-	-	-	-	-	-	-
21MEE644.2	3	2	-	-	-	-	-	-	-	-	-	-	-	3
21MEE644.3	3	2	3	1	-	-	-	-	-	-	-	-	-	3
21MEE644.4	3	2	2	-	-	1	-	-	-	-	-	-	-	-
21MEE644.5	3	2	2	-	-	-	-	-	-	-	-	-	1	-
21MEE644.6	3	2	-	-	-	-	-	-	-	-	-	-	-	3

MODULE-1	**INTRODUCTION TO SMART MATERIALS**	**21MEE 644.1**	**08 Hours**

Introduction: Characteristics of metals, polymers and ceramics. Introduction to smart materials. Classification of smart materials. Sensing and actuation: Principles of electromagnetic, acoustics, chemical and mechanical sensing and actuation. Types of sensors and their applications. Compatibility with conventional and advanced materials.

Case Study / Applications	Investigate the Challenges of Smart materials, Compare with traditional areas of science and engineering.
Text Book	Text Book 1: 1.2, 1.3, 1.4, 1.15, 1.16

MODULE-2	**SHAPE MEMORY ALLOYS**	**21MEE 644.2**	**08 Hours**

History of shape memory alloys. Classification of shape memory alloys. NITINOLS – melting, casting and forming of NITINOLS, shape memory and pseudo elasticity. Mechanical and bio medical applications of NITINOL. Vibration control through shape memory alloys.

Applications	Investigate shape memory alloys for *Mechanical and bio medical applications*.
Text Book	Text Book 1: 2.1, 2.3, 2.4 to 2.14

MODULE-3	**PIEZOELECTRIC MATERIALS**	**21MEE 644.3, 21MEE 644.4**	**08 Hours**

Piezoelectric properties, piezoelectric materials. Making of piezoelectric actuators. Inchworm linear motor and application of piezo - actuators for precision movement control. Piezoresistors as sensors. Magnetostrictive materials. Magnetostrictive actuators.

Applications	Explore piezoelectric materials and its industrial Applications.
Text Book	Text Book 2: 3.1, 3.2, 3.5, 3.7, 3.8

MODULE-4	ELECTRO RHEOLOGICAL (ER) AND MAGNETO RHEOLOGICAL (MR) FLUIDS	21MEE 644.5	08 Hours
Mechanisms and properties, fluid composition and behavior. Applications to clutches, vibration dampers and others. Chromic materials – thermo chromic, photochromic, piezochromic materials and their applications.			
Applications	Explore piezochromic materials and their applications.		
Text Book	Text Book 1: 5.1, 5.3, 5.5, 5.7,		
MODULE-5	**ADVANCES IN SMART STRUCTURES & MATERIALS**	**21MEE 644.6**	**08 Hours**
Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, Self-Healing Polymers, Intelligent System Design, Emergent System Design Structures: applications in environment such as aerospace and transportation vehicles, manufacturing, repair and maintainability aspects.			
Case Study / Applications	Survey on Smart structures and materials, design, applications and case studies of the same.		
Text Book	Text Book 2: 10.1 , 10.2, 10.3		

CIE Assessment Pattern (50 Marks – Theory) –

RBT Levels		Marks Distribution	
		Test (s)	NPTEL
		25	25
L1	Remember	5	-
L2	Understand	5	5
L3	Apply	5	10
L4	Analyze	5	10
L5	Evaluate	5	-
L6	Create	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources:

Text Books:

1) Smart Materials and Structures, M V Gandhi and B S Thompson Chapmen & Hall, London, 1992, Springer ,ISBN-13: 978-0412370106 2)
2) Analysis and Design, A. V. Srinivasan, „Smart Structures –Cambridge University Press, New York, 2001, (ISBN : 0521650267)

Reference Books:

1) Smart Materials and Structures, Banks HT, RC Smith, Y Wang, Massow S A, Wiley – Blackwell, ISBN-13: 978-0471970248
2) An Introduction for Scientists and Engineers, EsicUdd, Optic Sensors: John Wiley & Sons, New York, 1991 (ISBN: 0471830070)

Web links and Video Lectures (e-Resources):

- **https://onlinecourses.nptel.ac.in/ZIC5JFIHni4**
- **https:// onlinecourses.nptel.ac.in /yXHlIowQntk**
- **https:// onlinecourses.nptel.ac.in.be/rak3PI58-hQ**
- **https://onlinecourses.nptel.ac.in /VWKXbge1-1E /VWKXbge1-1E**
- **https:// onlinecourses.nptel.ac.in /ync30eHVD8s**

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Visit to any R and D smart material lab/aero/auto industry
- Demonstration of piezoelectric materials and its industrial Applications
- Demonstration of Mechanical and bio medical applications of Shape memory Alloys
- Demonstration of Intelligent System Design, Emergent System Design with flow charts
- Video demonstration of latest trends in smart materials and Shape memory Alloys
- Contents related activities (Activity-based discussions)
  - For active participation of students, instruct the students to prepare Flowcharts and Handouts
  - Organizing Group wise discussions on issues
  - Seminars

BIO INSPIRED DESIGN AND INNOVATION

Course Code	**21MEE645**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

21MEE645.1	Verify the biomimetics principles in relation to the needs at that moment
21MEE645.2	Evaluate the bio-material properties for health care applications
21MEE645.3	Investigate novel bioengineering initiatives by evaluating design and development principles
21MEE645.4	Formulate bio-based solutions for socially vital issues with critical thought
21MEE645.5	Comprehend the bio computing optimization through research and experiential learning.
21MEE645.6	Review the fundamental biological ideas through pertinent industrial applications and case studies

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEE645.1	3	3	3	3	2	-	-	-	1	1	-	2	3	3
21MEE645.2	3	3	3	3	2	-	-	-	1	1	-	2	3	3
21MEE645.3	3	3	3	3	2	-	-	-	1	1	-	2	3	3
21MEE645.4	3	3	3	3	2	-	-	-	1	1	-	2	3	3
21MEE645.5	3	3	3	3	2	-	-	-	1	1	-	2	3	3
21MEE645.6	3	3	3	3	2	-	-	-	1	1	-	2	3	3

MODULE-1	**BIO-INSPIRED DESIGN AND ENGINEERING**	**21MEE645.1**	**8 Hours**

Bio-Inspired Engineering and design, History, Evolution, Basics of Biomimetics and other Disciplines, Rawling's Classifications, Need for Bio-Inspired Designs. Bio inspired Additive manufacturing techniques, (self-healing, self-assembly).

Self-study / Case Study / Applications	Investigate the Challenges of Bio inspired design, Compare with traditional areas of science and engineering.
Text Book	Text Book 1: 1.2, 1.3, 1.4, 1.13, 1.15, 1.16

MODULE-2	**BIO MATERIALS AND BIO HEALTHCARE DESIGN**	**21MEE645.2**	**8 Hours**

Biomaterials, Design of Forms- (Hexagonal unit cells, Intrinsic disorder, anisotropy), Design of materials- (Hierarchy, fracture tough materials, structural colours, Actuating Materials, Bio-Compatible Materials). Bio-Mechanics, Applications of Biomaterials and Bio systems in Health care design (Human Prosthetics, Parasitic Wasp-Inspired Needle, Octopus-Inspired Sucker for Tissue Grafting, Peacock-Inspired Biosensors, Gecko-Inspired Surgical Glue) Robotics, Marine and Aeronautical.

Self-study / Case Study / Applications	Investigate Bio-Compatible alloys and polymers for human implants and health care applications.
Text Book	Text Book 1: 2.2, 2.3, 2.4 to 2.15

MODULE-3	**BIO SUSTAINABLE DEVELOPMENT**	**21MEE645.3, 21MEE645.4**	**8 Hours**

Innovations in Energy (Termite mound inspired shopping malls), Innovations in Resource-Air (purification, filtration), Dew water collection systems, water purification, desalination, Management of spaces, designs for megastructures.

Self-study / Case Study / Applications	Explore the Bio inspired environmental constructions and development.

Text Book	Text Book 2: 3.1, 3.3, 3.5, 3.7, 3.10		
MODULE-4	**BIO COMPUTING AND OPTIMISATION**	**21MEE645.5**	**8 Hours**
No Free Lunch Theorem, Bat Algorithm, Flower Pollination Algorithm, Genetic Algorithm- Crossover and Mutation Operations. Bio-Inspired Optimisation, Ant Colony Optimisation (ACO), Swam Intelligence- Particle Swam Optimisation (PSO).			
Self-study / Case Study / Applications	Scrutinize the Different types of Optimization techniques, genetic research.		
Text Book	Text Book 1: 6.1, 6.3, 6.5, 6.7, Text Book 2: 10.1, 10.3, 10.5, 10.7		
MODULE-5	**APPLICATIONS OF BIO-INSPIRED INNOVATIONS**	**21MEE645.6**	**8 Hours**
Bioinspired innovations in– Automotive, Automation, Materials and Manufacturing, Sensors, Controllers, Communications, Healthcare, Agriculture, food production, and Sports, Environment infrastructure. Carbon Neutral Solutions (Coral Reefs, Eco-cements), Carbon Free Solutions (Lotus leaf inspired paints), eco-restorations (Eco-friendly pesticide).			
Self-study / Case Study / Applications	Survey on Bio inspired Innovations, design, applications and case studies of the same.		
Text Book	Text Book 2: 12.1 to 12.10		

CIE Assessment Pattern (50 Marks – Theory) –

RBT Levels		Marks Distribution		
		Test (s)	Qualitative Assessment (s)	MCQ's
		25	15	10
L1	Remember	5	-	-
L2	Understand	5	-	-
L3	Apply	5	5	5
L4	Analyze	5	5	5
L5	Evaluate	5	5	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources:

Text Books:

1)Helena Hashemi Farzaneh, Udo Lindemann, "A Practical Guide to Bio-inspired Design", Springer Vieweg, 1st edition 2019, ISBN-10 : 366257683X, ISBN-13 : 978-3662576830

2)Torben A. Lenau, Akhlesh Lakhtakia," Biologically Inspired Design: A Primer (Synthesis Lectures on Engineering, Science, and Technology)", Publisher: Morgan & Claypool Publishers, 2021, ISBN-10: 1636390471, ISBN-13: 978-1636390475

Reference Books:

1)French M, "Invention and evolution: Design in nature and engineering", Publisher: Cambridge University Press, 2020

2)Pan L., Pang S., Song T. and Gong F. eds, "Bio-Inspired Computing: Theories and Applications", 15th International Conference, BIC-TA 2020, Qingdao, China, October 23-25, 2020, Revised Selected Papers (Vol. 1363). Springer Nature, 2021

3)Wann D, "Bio Logic: Designing with nature to protect the environment", Wiley Publisher, 1994

Web links and Video Lectures (e-Resources):

- **https://onlinecourses.nptel.ac.in/noc22_ge24/preview**
- **https://biodesign.berkeley.edu/bioinspired-design-course/**
- https://www.youtube.com/watch?v=cwxXY9Qe8ss
- **https://www.youtube.com/watch?v=V2GvQXvjhLA**
- **https://nsf-gov-resources.nsf.gov/2023-03/Bio-inspired%20Design%20Workshop%20Report_2232327_October%202022_Final.508.pdf**

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Video demonstration of latest trends in bio inspired design
- Contents related activities (Activity-based discussions)
  - For active participation of students, instruct the students to prepare Flowcharts and Handouts
  - Organizing Group wise discussions on issues
  - Seminars

SOCIAL CONNECT & RESPONSIBILITY

Course Code	**21MEK65**	**CIE Marks**	**50**
L:T:P:S	**0:0:1:0**	**SEE Marks**	**50**
Hrs / Week	**02**	**Total Marks**	**100**
Credits	**01**	**Exam Hours**	**02**

Course outcomes:

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

21MEK65.1	Realize social responsibility through societal activities
21MEK65.2	Review the history and culture of city through community interaction
21MEK65.3	Develop responsible connection for societal benefits
21MEK65.4	Cultivate the best practices for diverse scenarios
21MEK65.5	Build planning and organizational skills
21MEK65.6	Develop deep drive into societal challenges being addressed by NGO(s), social enterprises & the Government

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
21MEK65.1	-	-	-	-	-	3	2	2	3	2	-	1	2	2
21MEK65.2	-	-	-	-	-	3	2	2	3	2	-	1	2	2
21MEK65.3	-	-	-	-	-	3	2	2	3	2	-	1	2	2
21MEK65.4	-	-	-	-	-	3	2	2	3	2	-	1	2	2
21MEK65.5	-	-	-	-	-	3	2	2	3	2	-	1	-	-
21MEK65.6	-	-	-	-	-	3	2	2	3	2	-	1	-	-

MODULE-1	**PLANTATION AND ADOPTION OF A TREE**	**21MEK65.1, 21MEK65.2**	**3 Hours**

Plantation of a tree that will be adopted for four years by a group of B.E students. They will also execute a documentary or a photoblog describing the plant's origin, its usage in daily life, and its appearance in folklore and literature.

Self-study / Case Study / Applications	Investigate the Myth and Literature of the particular Tree that is chosen. Compare its properties with other kind of trees around and list out the benefits of that tree to the society.

MODULE-2	**HERITAGE WALK AND CRAFTS CORNER**	**21MEK65.1, 21MEK65.2, 21MEK65.3**	**3 Hours**

Heritage tour, knowing the history and culture of the city, connecting to people around through their history, knowing the city and its craftsman, photoblog and documentary on evolution and practice of various craft forms.

Self-study / Case Study / Applications	Investigate/ Identify the Valuable Historical Places and Monuments in the city and make a Photoblog/Documentary.

MODULE-3	**ORGANIC FARMING AND WASTE MANAGEMENT**	**21MEK65.4, 21MEK65.5**	**3 Hours**

Usefulness of organic farming, wet waste management in neighboring villages, and implementation in the campus

Self-study / Case Study / Applications	Report the Documentary on the necessity of water conservation.		
MODULE-4	**WATER CONSERVATION**	**21MEK65.4, 21MEK65.5, 21MEK65.6**	**3 Hours**
Knowing the present practices in the surrounding villages and implementation in the campus, documentary or photo blog presenting the current practices.			
Self-study / Case Study / Applications	Make a report on the need of conservation of resources and segregation of waste.		
MODULE-5	**FOOD WALK**	**21MEK65.3, 21MEK65.4**	**3 Hours**
City's culinary practices, food lore, and indigenous materials of the region used in cooking.			
Self-study / Case Study / Applications	Investigate and report the important Organic Farming sites in your city.		

CIE Assessment Pattern (50 Marks – Activity based) –

- **Each module is evaluatedfor50 Marks and average of all the five modules will be the final marks.**

CIE component for each module	Marks
Planning and scheduling the social connect	15
Information/Data collected during the social connect	15
Analysis of the information/data and report writing	20
Total (each module)	**50**

SEE Assessment Pattern (50 Marks – Activity based)

SEE	Marks
Presentation	20
Jamming session / Open Mic	15
Group discussion / debate	15
Total	**50**

Activity-Based Learning / Practical Based learning

- Platform to connect to others and share the stories with others:
  - Jamming session
  - Open mic
  - Poetry
- Share the experience of Social Connect.
- Exhibit the talent like playing instruments, singing, one-act play, art-painting, and fine art.

Pedagogy:

- The students will be divided into groups. Each group will be handled by faculty mentor.
- Faculty mentor will design the activities (particularly Jamming sessions, open mic and poetry)
- The course is mainly activity-based that will offer a set of activities for the student that enables them to connect with fellow human beings, nature, society, and the world at large.
- The course will engage students for interactive sessions, open mic, reading group, storytelling sessions, and semester-long activities conducted by faculty mentors.
- Studentsshouldpresenttheprogressoftheactivitiesaspertheschedulintheprescribedpracticalsessioninthefield.
- There should be positive progress in the vertical order for the benefit of society in general through activities.

Plan of Action:

- Each student should do activities according to the scheme and syllabus.
- At the end of semester student performance has to be evaluated by the faculty mentor for the assigned activity progress and its completion.
- At last consolidated report of all activities from 1st to 5th, compiled report should be submitted as per the instructions and scheme.
- Practice Session Description:
    - Lecture session in field to start activities
    - Students Presentation on Ideas
    - Commencement of activity and its progress
    - Execution of Activity
    - Case study-based Assessment, Individual performance
    - Sector/ Team wise study and its consolidation
    - Videobasedseminarfor10minutes by each student at the end of semester with Report.

Module Name	Group Size	Location	Magnitude	Activity	Reporting
Plantation and adoption of a tree	03–05	Farmers Land or Road side or Community area or institution's campus, anyone location to be selected.	Students must monitor till end of B Tech degree	Site selection Select suitable species in consultation with horticulture, forest or agriculture department. Interact with NGO/Industry and community to plant Tag the plant for continuous monitoring	Report shall behand written with paintings, sketches, poster, video and/or photograph with Geotag.
Heritage walk and crafts corner	03-05	Preferably Within the city where institution is located or home town of the student group	One or two: One can beat structure or a heritage building the other can be heritage custom or practice	Survey in the form of questioner by connecting to the people and asking. No standard questioner to be given by faculty and has to be evolved involving students. Questions during survey can be asked in local language but report language is English.	

Waste management	03-05 More than one group Can be assigned one task based on magnitude o ftask.	Preferably in the near by villages and within the campus.	One	Report on importance and benefits of Waste management. Reportonsegregation,collection,transportationanddisposal.Suggestion for composting. Visit nearby village/location to sensitize farmers and public about waste management and also document	
Water Conservation	03–05	Rain water harvesting demonstration available in the campus or surroundings	One	Visit lakes/pond/river/drywell to involve on rejuvenation activity. Or Assessment of Water budget in the campus / village Report on traditional water conservation practices(to minimize wastage)	
Food Walk	03-05	Within the city where institution is located Food culture of student's resident region	One	Survey local food center s and identify the specialty Identify and study the food ingredients Report on the regional foods Report on Medicinal s values of the local food grains, and plants.	

INNOVATION/ENTREPRENEURSHIP/ SOCIETAL INTERNSHIP			
Course Code	**21MEE66**	**CIE Marks**	**50**
L: T:P: S	**0:0:3:0**	**SEE Marks**	**50**
Teaching Hrs/Week	**40**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Mandatory Internship Guidelines

Introduction

The rise in global competition has prompted organizations to devise strategies to have a talented and innovative workforce to gain a competitive edge. Developing an internship policy is an impactful strategy for creating a future talent pool for the industry. The internship (a form of experiential learning) program helps fresh pass–outs in gai ning professional know-how and benefits corporate sectors. The internship also enhances the student's employability skills passing out from Technical Institutions. [AICTE Internship Policy.pdf page 4]

The following list provides a brief illustrative overview of the knowledge, skills, work habits, and character traits commonly associated with 21st-century skills and to be acquired by graduates:

1. Critical thinking, problem-solving, reasoning, analysis, interpretation, synthesizing information.
2. Scientific literacy and reasoning, the scientific method.
3. Research skills and practices, interrogative questioning.
4. Creativity, artistry, curiosity, imagination, innovation, personal expression.
5. Information and communication technology (ICT) literacy, media and internetliteracy, data interpretation, and analysis, computer programming.
6. Oral and written communication, public speaking and presenting, listening.
7. Economic and financial literacy, entrepreneurialism.
8. Global awareness, multicultural literacy, humanitarianism.
9. Environmental and conservation literacy, ecosystems understanding.
10. Civic, ethical, and social-justice literacy.
11. Leadership, teamwork, collaboration, cooperation, facility in using virtualworkspaces.
12. Perseverance, self-direction, planning, self-discipline, adaptability, initiative.
13. Health and wellness literacy, including nutrition, diet, exercise, and publichealth and safety.

The internship experience will augment the outcome-based learning process andinculcate various attributes mentioned above in a student in line with the graduate attributes defined by the NBA and NEP 2020.

Following are the intended objectives of internship training;

(i) Expose Technical students to the industrial environment, which cannot be simulated in the classroom and hence create competent professionals in the industry.

(ii) Provide possible opportunities to learn, understand and sharpen the real-time technical/managerial skills required at the job.

(iii) Get exposed to the current technological developments relevant to the subject area of training.

(iv) Use the experience gained from the industrial internship in discussions held inthe classrooms.

(v) Create conditions conducive to the quest for knowledge and its applicability on the job.

(vi) Learn to apply Technical knowledge in real industrial situations.

(vii) Gain experience in writing reports in Technical works/projects.

(viii) Expose students to the engineer's responsibilities and ethics.

(ix) Familiarize with various materials, processes, products, and applications along with relevant aspects of quality control and safety measures.

(x) Promote academic, career, and/or personal development.

(xi) Expose the students to future employers.

(xii) Make students available to industry for employment.

(xiii) Understand the psychology of the workers and their habits, attitudes, and approach to problem-solving.

(xiv) Understand the social, economic, and administrative considerations that influence the working environment of industrial organizations.

Internship training helps the institute to:

(a) Build and enhance industrial relations.

(b) Make the placement process easier.

(c) Improve institutional credibility & branding.

(d) Improve the teaching-learning process.

(e) Expose of Staff to Industrial process.

(f) Serve humankind.

Internship - II involving Innovation/ Societal /Entrepreneurship

Scheduled during the intervening period of IV and V semester

During the intervening period of IV and V semesters, students shall be ready for industrial experience. Therefore, they shall choose to undergo an Internship involving Innovation / Entrepreneurship related activities. Students may choose to work on innovation or entrepreneurial activities or both resulting in start-up or undergo internship with industry/ NGO's/ Government organizations/ Micro/ Small/ Medium enterprises to make themselves ready for the industry. In case students want to undergo an internship at his/her family business, he /she shall be permitted provided, a declaration by a parent is submitted directly to the Principal of the institution. [AICTE Internship Policy, Pdf page 8]

With the consent of the internship guide and Principal of the institution, students shall be allowed to carry out the internship at their hometown (within and outside the state), provided favorable facilities are available. [Report and Recommendation of Task Force on Internship in Engineering and Diploma, Task Force Chair Prof Karisiddappa, Hon'bleVice-Chancellorr, VTU, Belagavi]

In case, students wish to take both Innovations, and Entrepreneurship internships, they shall be permitted to take up both. Internship – II period, in such cases, can extend marginally by a few days, provided it will not interfere with the academic calendar ofthe higher semester.

Innovation

Innovation refers to a new or improved product or process or a combination there of that differs marginally or significantly from the unit's previous product.

An innovation center is a place where students are encouraged to implement the innovative ideas formed through imagination, brainstorming sessions, design thinking and associated activities to bring them to reality. It is a place, where creative minds are shaped.

Entrepreneurship

Entrepreneurship refers to setting up a new business or business, taking on financial risks in the hope of profit.

It involves investment to undertake production along with arranging inputs like land, labor, material and capital, introducing new techniques and products, identifying new sources for the enterprise, etc.

Incubation Center:

An organized unit designed for innovation as well as to accelerate the growth and success of new entrepreneurial companies through mentorship and an array of businesssupport resources and services that could include physical space, capital, coaching, common services, and networking connections.

Startup

An entity that develops a business model based on either product innovation or service innovation and makes it scalable, replicable, and self-reliant. [Gazette Notification No. G.S.R. 127(E)dated February 19, 2019]

An entity shall be considered as a Startup,

(i) Up to a period of ten years from the date of incorporation/ registration, if it is incorporated as a private limited company (as defined in the Companies Act, 2013) or registered as a partnership firm (registered under section 59 of the Partnership Act, 1932) or a limited liability partnership (under the Limited Liability Partnership Act, 2008) in India.

(ii) Turnover of the entity for any of the financial years since incorporation/ registration has not exceeded one hundred crore rupees.

(iii) Entity is working towards innovation, development or improvement of productsor processes or services, or if it is a scalable business model witha high potential of employment generation or wealth creation.

Provided that an entity formed by splitting up or reconstruction of an existing business shall not be considered a Startup. [startup_policy_2019.pdf 10]

Places of Innovation/Entrepreneurial Activities

Students shall carry out Innovation or Entrepreneurial activities or both at the Incubation Center and Entrepreneurship Cell of the parent institution or elsewhere such as ATAL Incubation Centers [A flagship of Atal Innovation Mission (AIM), NITI Aayog for promoting the culture of innovation and entrepreneurship in India], institutes of national importance, public sector units, IT companies, government organizations, and non-governmental organizations, industries including MSME, etc.

Institutes should deter students to opt for internships at places established for commercial benefits.

Assessment Rubrics for Innovation / Entrepreneurship Activities

Once the internship begins, the students are required to maintain diary/journal and submit a report every week to the guide. These reports (which can also be submitted by email) should summarize the activities in which the student was involved during the previous week period. At the end of the internship, each student is required to submit the hard copy of the consolidated diary/journal and report for evaluation. The report should clearly indicate the learning and achievements of the internship.

MINI PROJECT

Course Code	**21MEE67**	**CIE Marks**	**50**
L: T:P:S	**0:0:1:0**	**SEE Marks**	**50**
Hrs / Week	**02**	**Total Marks**	**100**
Credits	**01**	**Exam Hours**	**03**

Course outcomes:

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

21MEE67.1	Identify an open ended problem in area of mechanical engineering
21MEE67.2	Identify the methods and materials required for the project work
21MEE67.3	Apply the theoretical concepts to solve industrial problems with teamwork and multidisciplinary approach.
21MEE67.4	Formulate and implement innovative ideas for social and environmental benefit
21MEE67.5	Analyze the results to come out with concrete solutions
21MEE67.6	Demonstrate professionalism with ethics; present effective communication skills and relate engineering issues to broader societal context

Mini Project Roadmap: Guiding Principles for Mini Project Success

Project Overview:

- Clearly define the project's scope, objectives, and expected outcomes.
- Provide a brief description of the problem the project aims to solve or the functionality it should implement.

Project Milestones:

- Set clear project milestones and deadlines for various phases, such as planning, design, implementation, testing, and presentation.

Project Requirements:

- List the specific features or functionality that students need to implement in their projects.
- Clearly state any constraints or limitations they should be aware of during development.

Testing and Quality Assurance:

- Incorporate testing practices into their development process.
- Specify the types of testing (e.g., unit testing, integration testing)

Collaboration and Communication:

- If the project involves teamwork, outline expectations for collaboration, including communication channels and responsibilities within the team.

Documentation:

- Emphasize the importance of thorough documentation throughout the project.
- Require students to maintain documentation for code, design, and usage instructions.

Presentation:

- Require students to present their projects to the class, explaining their design choices, challenges faced, and how they overcame them.

CIE Assessment Pattern (50 Marks – Reviews as per the rubric statements defined)

RBT Levels		Exam Marks Distribution (50)
L1	**Remember**	**-**
L2	**Understand**	**-**
L3	**Apply**	20
L4	**Analyze**	10
L5	**Evaluate**	10
L6	**Create**	10

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	**Remember**	**-**
L2	**Understand**	**-**
L3	**Apply**	20
L4	**Analyze**	10
L5	**Evaluate**	10
L6	**Create**	10

NATIONAL SERVICE SCHEME (NSS)

Course Code	**21NSS84**	**CIE Marks**	**50**
L:T:P:S	**0:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**02**	**Total Marks**	**100**
Credits	**00**	**Exam Hours**	**02**

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

21NSS84.1	Understand the importance of his / her responsibilities towards society
21NSS84.2	Analyze the environmental and societal problems/issues and will be able to design solutions for the same.
21NSS84.3	Evaluate the existing system and to propose practical solutions for the same for sustainable development.
21NSS84.4	Implement government or self-driven projects effectively in the field.

Mapping of Course Outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
21NSS84.1	-	-	-	-	-	3	1	1	3	2	2	1
21NSS84.2	-	-	-	-	-	3	1	1	3	2	2	1
21NSS84.3	-	-	-	-	-	3	1	1	3	2	2	1
21NSS84.4	-	-	-	-	-	3	1	1	3	2	**2**	1

Semester	CONTENT	HOURS
5th to 8th	**PART A** ONENSS–CAMP @College/University/State or Central Govt Level/ NGO's/General Social Camps **PART B** **1.** Organic farming, Indian Agriculture (Past, Present and Future) Connectivity for marketing **2.** Waste management–Public, Private and Govtorganization,5R's. **3.** Setting of the information imparting club for women leading to contribution in social and economic issues. **4.** Water conservation techniques–Role of different stakeholders–Implementation. **5.** Preparing an actionable business proposal for enhancing the village income and approach for implementation. **6.** Helping local schools to achieve good results and enhance their enrolment in Higher/technical/vocational education. **7.** Developing Sustainable Water management system for rural areas and implementation approaches.	Total 32 Hrs/ Semester 2 Hrs/week
	8. Contribution to any national level initiative of Government of India. For. eg. Digital India, Skill India, Swachh Bharat, Atmanirbhar Bharath, Make in India, Mudra scheme, Skill development programs etc. **9.** Spreading public awareness under rural outreach programs. (minimum5programs). **10.** Organize National integration and social harmony events/workshops / Seminars. (Minimum02programs). **11.** Govt. school Rejuvenation and helping them to achieve good infrastructure.	

CIE Assessment Pattern (50 Marks – Practical) –

1. **PART A:** Compulsorily students have to attend one camp.
2. **PART B:** Students have to take up anyone activity on the above said topics and have to prepare content for awareness and technical contents for implementation of the projects and have to present strategies for implementation of the same.
3. CIE will be evaluated based on their presentation, approach and implementation strategies.

CIE Components	Marks
Presentation1-Selection of topic-(phase1)	10
Experiential Learning Presentation 2 (phase2)	10
Case Study-based Teaching-Learning	10
Sector-wise study & consolidation	10
Video based seminar (4-5 minutes per student)	10
Total	**50**

SEE Assessment Pattern (50 Marks – Practical)

- Implementation strategies of the project with report duly signed by the Dept's Coordinator, HoD and Principal.
- Atlast it should be evaluated by the NSS Coordinator.
- Finally consolidated report should be sent to the University.

Suggested Learning Resources:

Reference Books:

1. NSS Course Manual, Published by NSS Cell, VTU Belagavi.

Pre-requisites to take this Course:

1. Students should have a service-oriented mindset and social concern.
2. Students should have dedication to work at any remote place, anytime with available resources and proper time management for the other works.
3. Students should be ready to sacrifice some of the time and wishes to achieve service-oriented targets on time.

PHYSICAL EDUCATION (PE) (SPORTS AND ATHLETICS)

Course Code	**21PES84**	**CIE Marks**	**50**
L:T:P:S	**0:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**2**	**Total Marks**	**100**
Credits	**00**	**Exam Hours**	**02**

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

21PES84.1	Demonstrate the starting and finishing positions of different track and jump events.
21PES84.2	Demonstrate the holding and releasing stances in various throwing events, and takeoff and landing position in various jumping events of Athletics.
21PES84.3	Demonstrate the specific skills and techniques of the selected game/event.
21PES84.4	Demonstrate and describe the rules and regulations of specific games.

Mapping of Course Outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
21PES84.1	-	-	-	-	-	3	-	-	2	-	-	1
21PES84.2	-	-	-	-	-	3	-	-	2	-	-	1
21PES84.3	-	-	-	-	-	3	-	-	2	-	-	1
21PES84.4	-	-	-	-	-	3	-	-	2	-	-	1

Semester	CONTENT	HOURS
5th	**Fitness Components:** Meaning and Importance, Fit India Movement, Definition of fitness, Components of fitness, Benefits of fitness, Types of fitness and Fitness tips. **Practical Components:** Speed, Strength, Endurance, Flexibility, and Agility **Athletics**: 1. Track -Sprints: • Starting Techniques: Standing start and Crouch start(its variations)use of Starting Block. • Acceleration with proper running techniques. • Finishing technique: Run Through, Forward Lunging and Shoulder Shrug. 2. Jumps- Long Jump: Approach Run, Take-off, Flight in the air (Hang Style/Hitch Kick)and Landing 3. Throws- Shot Put: Holding the Shot, Placement, Initial Stance, Glide, Delivery Stance and Recovery (Perry O'Brien Technique) **Kabaddi OR Kho-Kho** **Kabaddi:** A. Fundamental skills 1. Skills in Raiding: Touching with hands, Use of leg-toe touch, squat leg thrust, side kick, mule kick, arrow fly kick, crossing of baulk line. Crossing of Bonus line. 2. Skills of holding the raider: Various formations, catching from particular position, different catches, catching formation and techniques. 3. Additional skills in raiding: Escaping from various holds, techniques of escaping from chain formation, offense and defense. 4. Game practice with application of Rules and Regulations. B. Rules and their interpretations and duties of the officials. **Kho-Kho:** A Fundamental skills	Total 32 Hrs/ Semester 2 Hrs/week

	1. Skills in Chasing: Sit on the box (Parallel &Bullet toe method),Getup from the box(Proximal & Distal foot method),Give Kho(Simple,Early, Late& Judgment),Pole Turn, Pole Dive, Tapping, Hammering, Rectification of foul. 2. Skills in running: Chain Play, Ring play and Chain & Ring mixed play. 3. Game practice with application of Rules and Regulations. B. Rules and their interpretations and duties of the officials.	
6th	**Athletics**: 1. Track -110 Mtrs and 400Mtrs: • Hurdling Technique: Lead leg Technique, Trail leg Technique, Side Hurdling, Over the Hurdles • Crouch start (its variations)use of Starting Block. • Approach to First Hurdles, In Between Hurdles, Last Hurdles to Finishing. 2. Jumps- High jump: Approach Run, Take-off, Bar Clearance (Straddle) and Landing. 3. Throws- Discus Throw: Holding the Discus, Initial Stance Primary Swing, Turn, Release and Recovery (Rotation in the circle). **Volleyball OR Throw Ball** **Volleyball:** A. Fundamental skills 1. Service: Under arm service, Side arm service, Tennis service, Floating service. 2. Pass: Under arm pass, Over-head pass. 3. Spiking and Blocking. 4. Game practice with application of Rules and Regulations B. Rules and their interpretation and duties of officials. **Throw Ball:** A. Fundamental skills: Over hand service, Side arm service, two hand catching, one hand over head return, side arm return. B. Rules and their interpretations and duties of officials **Football OR Hockey** **Football:** A. Fundamental Skills 1. Kicking: Kicking the ball with inside of the foot, Kicking the ball with Full Instep of the foot, Kicking the ball with Inner Instep of the foot, Kicking the ball with Outer Instep of the foot and Lofted Kick. 2. Trapping: Trapping- the Rolling ball, and the Bouncing ball with sole of the foot. 3. Dribbling: Dribbling the ball with Instep of the foot, Dribbling the ball with Inner and Outer Instep of the foot. 4. Heading: In standing, running and jumping condition. 5. Throw-in: Standing throw-in and Running throw-in. 6. Feinting: With the lower limb and upper part of the body. 7. Tackling: Simple Tackling, Slide Tackling. 8. Goal Keeping: Collection of Ball, Ball clearance-kicking, throwing and deflecting. 9. Game practice with application of Rules and Regulations.	

	C. Rules and their interpretation and duties of officials. **Hockey:** A. Fundamental Skills 1. Passing: Short pass, Longpass, pushpass, hit 2. Trapping. 3. Dribbling and Dozing 4. Penalty stroke practice. 5. Penalty corner practice. 6. Tackling: Simple Tackling, Slide Tackling. 7. Goal Keeping, Ball clearance- kicking, and deflecting. 8. Game practice with application of Rules and Regulations. B. Rules and their interpretation and duties of officials.	
7th	**Athletics**: 1. Track -Relay Race: • Starting, Baton Holding/Carrying, Baton Exchange in between zone, and Finishing • Crouch start (its variations) use of Starting Block. • Approach to First Hurdles, In Between Hurdles, Last Hurdles to Finishing. 2. Jumps- Triple Jump: Approach Run, Take-off, Flight in the Hop, Step, Jump and Landing 3. Throws- Javelin Throw: Grip, Carry, and Recovery (3/5 Impulse stride). Release **Cricket OR Baseball** **Cricket:** A. Fundamental skills 1. Batting- Forward Defense Stroke, Backward Defense Stroke, OffDrive, On Drive, Straight Drive, Cover Drive, Square Cut. 2. Bowling-Out-swing, In-swing Off Break, Leg Break and Googly. 3. Fielding: Catching - The High Catch, The Skim Catch, The Close Catch and throwing at the stumps from different angles. Long Barrier and Throw, Short Throw, Long Throw, Throwing on the Turn. 4. Wicket Keeping B. Rules and their interpretation and duties of officials. **Baseball:** A. Fundamental skills: 1. Player Stances – walking, extending walking, L stance, cat stance Grip – standard grip, choke grip 2. Batting – swing and bunt. 3. Pitching 4. Baseball: slider, fast pitch, curve ball, drop ball, rise ball, change up, knuckle ball, screw ball B. Rules and their interpretations and duties of officials **Basketball OR Net Ball** **Basketball:** A. Fundamental Skills 1. Passing: Two hand Chest Pass, Two hands Bounce Pass, One hand Baseball Pass, Side arm Pass, Overhead Pass, Hook Pass. 2. Receiving: Two hand receiving, One hand receiving, Receiving in stationary position, Receiving while Jumping and Receiving while Running. 3. Dribbling: How to start dribble, drop dribble, High Dribble, Low Dribble,	

	Reverse Dribble, Rolling Dribble. 4. Shooting: Lay-up shot and its variations, One hand set shot, Two hands jump shot, Hook shot, Free Throw. 5. Rebounding: Defensive rebound and Offensive rebound. 6. Individual Defence: Guarding the player with the ball and without the ball, Pivoting. 7. Game practice with application of Rules and Regulations. **Netball:** A. Fundamental Skills 1. Catching: one handed, two handed, with feet grounded and in flight. 2. Throwing (Different passes and their uses): One hand passes (shoulder, high shoulder, underarm, bounce, lob), two hand passes (Push, overhead and bounce). 3. Footwork: Landing on one foot, landing on two feet, Pivot, Running pass. 4. Shooting: One hand, forward step shot, and backward step shot. 5. Techniques of free dodge and sprint, sudden sprint, sprint and stop, sprinting with change at speed. 6. Defending: Marking the player, marking the ball, blocking, inside the circle, outside the circle. Defending the circle edge against the passing. 7. Intercepting: Pass and shot. 8. Game practice with application of Rules and Regulations. B. Rules and their interpretation and duties of officials.	
8th	**Athletics**: A. Track -Combined Events: a. Heptathlon all the 7 events b. Decathlon: All 10 Events B. Jumps- Pole Vault: Approach Run, Planting the Pole, Take-off, Bar Clearance and Landing. C. Throws- Hammer Throw: Holding the Hammer, Initial Stance Primary Swing, Turn, Release and Recovery (Rotation in the circle). **Shuttle Badminton OR Table Tennis** **Shuttle Badminton:** A. Fundamental skills D. Basic Knowledge: Various parts of the Racket and Grip. E. Service: Short service, Long service, Long-high service. F. Shots: Over head shot, Defensive clear shot, Attacking clear shot, Drop shot, Net shot, Smash. G. Game practice with application of Rules and Regulations. B. Rules and their interpretation and duties of officials. **Table Tennis:** A. Fundamental skills: 1. Basic Knowledge: Various parts of the Racket and Grip(Shake Hand & PenHold Grip). 2. Stance: Alternate & Parallel. 3. Push and Service: Backhand &Forehand. 4. Chop: Backhand & Forehand. 5. Receive: Push and Chop with both Backhand & Forehand. 6. Game practice with application of Rules and Regulations. B. Rules and their interpretations and duties of officials **Handball OR Ball Badminton** **Handball:** A. Fundamental Skills 1. Catching, Throwing and Ball control, 2. Goal Throws: Jumpshot, Centershot, Diveshot, Reverseshot.	

	3. Dribbling: High and low. 4. Attack and counter attack, simple counter attack, counter attack from two wings and center. 5. Blocking, Goal Keeping and Defensive skills. 6. Game practice with application of Rules and Regulations. B. Rules and their interpretations and duties of officials **Ball badminton:** A. Fundamental Skills 1. Basic Knowledge: Various parts of the Racket and Grip. 2. Service: Short service, Long service, Long-high service. 3. Shots: Overhead shot, Defensive clearshot, Attacking clearshot, Dropshot, Netshot, Smash. 4. Game practice with application of Rules and Regulations. B. Rules and their interpretation and duties of officials.	

CIE Assessment Pattern (50 Marks – Practical) –

CIE to be evaluated every semester end based on practical demonstration of Sports and Athletics activities learnt in the semester.

CIE	Marks
5th Semester	10
6th Semester	10
7th Semester	15
8th Semester	15
Total	**50**

SEE Assessment Pattern (50 Marks – Practical)

SEE	Marks
Athletics	20
Kabaddi OR Kho-Kho	05
Volleyball / Throw ball	05
Football/Hockey	05
Netball/Basketball	05
Shuttle Badminton / Table Tennis	05
Handball/ Badminton	05
Total	**50**

Suggested Learning Resources:

Reference Books:

1. Saha, A.K. Sarir Siksher Ritiniti, Rana Publishing House, Kalyani.
2. Bandopadhyay,K. Sarir Siksha Parichay, Classic Publishers, Kolkata.
3. Petipus, etal. Athlete's Guide to Career Planning, Human Kinetics.
4. Dharma,P.N. Fundamentals of Track and Field, Khel Sahitya Kendra, NewDelhi.
5. Jain,R. Play and Learn Cricket, Khel Sahitya Kendra, New Delhi.
6. Vivek Thani, Coaching Cricket ,Khel Sahitya Kendra, NewDelhi.
7. Saha,A.K.Sarir SiksherRitiniti,RanaPublishingHouse,Kalyani.
8. Bandopadhyay,K. Sarir Siksha Parichay, Classic Publishers, Kolkata
9. Naveen Jain, Play and Learn Basketball, Khel Sahitya Kendra, NewDelhi.
10. Dubey,H.C. Basketball, Discovery Publishing House, NewDelhi.
11. RachanaJain, Teach Yourself Basketball, Sports Publication.
12. JackNagle,Power Pattern Offences for Winning basketball,ParkerPublishingCo.,NewYork.
13. RenuJain, Play and Learn Basketball, Khel Sahitya Kendra,NewDelhi.
14. SallyKus, Coaching Volleyball Successfully, HumanKinetics.
15. Saha, A. K. Sarir Siksher Ritiniti, Rana Publishing House, Kalyani.

YOGA			
Course Code	**21YOG84**	**CIE Marks**	**50**
L:T:P:S	**0:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**2**	**Total Marks**	**100**
Credits	**00**	**Exam Hours**	**02**

Course outcomes:

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

21YOG84.1	Use Yogasana practices in an effective manner
21YOG84.2	Become familiar with an authentic foundation of Yogic practices
21YOG84.3	Practice different Yogic methods such as Suryanamaskara, Pranayama and some of the Shat Kriyas
21YOG84.4	Use the teachings of Patanjali in daily life.

Mapping of Course Outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
21YOG84.1	-	-	-	-	-	3	-	-	2	-	-	1
21YOG84.2	-	-	-	-	-	3	-	-	2	-	-	1
21YOG84.3	-	-	-	-	-	3	-	-	2	-	-	1
21YOG84.4	-	-	-	-	-	3	-	-	2	-	-	1

Semester	CONTENT	HOURS
5th	**Introduction of Yoga:** Aim and Objectives of yoga, Prayer: Yoga,its origin ,history and development. Yoga, its meaning, definitions. Different schools of yoga, importance of prayer **Brief introduction of yogic practices for common man:** Yogic practices for common man to promote positive health **Rules and regulations:** Rules to be followed during yogic practices by practitioner **Misconceptions of yoga:** Yoga its misconceptions, Difference between yogic and non-yogic practices. **Suryanamaskara:** 1. Suryanamaskar prayer and its meaning, Need, importance and benefits of Suryanamaskar. 2. Suryanamaskar 12 count,2rounds **Kapalabhati:** Meaning, importance and benefits of Kapalabhati - 40strokes/min3rounds **Different types of Asanas**: 1. Sitting: Padmasana, Vajrasana, Sukhasana 2. Standing: Vrikshana, Trikonasana, Ardhakati Chakrasana 3. Prone line: Bhujangasana, Shalabhasana 4. Supineline: Utthitadvipadasana, Ardhahalasana, Halasana **Patanjali's Ashtanga Yoga**: Yama, Niyama **Pranayama:** Suryanuloma –Viloma, Chandranuloma-Viloma	Total 32 Hrs/ Semester 2 Hrs/week
6th	**Suryanamaskara:** Suryanamaskar 12 count,4rounds **Kapalabhati:** Revision of Kapalabhati -60strokes/min3rounds **Different types of Asanas**: 1. Sitting: Paschimottanasana, Ardha Ushtrasana, Vakrasana, Aakarna Dhanurasana 2. Standing: Parshva Chakrasana, Urdhva Hastothanasana, Hastapadasana 3. Prone line: Dhanurasana 4. Supine line: Karna Peedasana, Sarvangasana, Chakraasana **Patanjali's Ashtanga Yoga**: Asana, Pranayama	

	Pranayama: Chandra Bhedana, Nadishodhana, Surya Bhedana	
7th	**Suryanamaskara:** Suryanamaskar 12 count,8rounds **Kapalabhati:** Revision of Kapalabhati - 80strokes/min3rounds **Different types of Asanas**: 1. Sitting: Yogamudra in Padmasana, Vibhakta Paschimottanasana, Yogamudra in Vajrasana 2. Standing: Parivritta Trikonasana, Utkatasana, Parshvakonasana 3. Prone line: Padangushtha Dhanurasana, Poorna Bhujangasana / Rajakapotasana 4. Supine line: Navasana/Noukasana, Pavanamuktasana, Sarvangasana **Patanjali's Ashtanga Yoga**: Pratyahara, Dharana **Pranayama:** Ujjayi, Sheetali, Sheektari	
8th	**Suryanamaskara:** Suryanamaskar 12 count,12rounds **Kapalabhati:** Revision of Kapalabhati - 100strokes/min3rounds **Different types of Asanas**: 1. Sitting: Bakasana, Hanumanasana, Ekapada Rajakapotasana 2. Standing: Parivritta Trikonasana, Utkatasana, Parshvakonasana 3. Prone line: Mayurasana 4. Supine line: Setubandhasana, Shavasanaa (Relaxation posture) 5. Balancing: Sheershasana **Patanjali's AshtangaYoga**: Dhyana (Meditation), Samadhi **Pranayama:** Bhastrika, Bhramari, Ujjai **Shat Kriyas:** Jalaneti and sutraneti, Sheetkarma Kapalabhati	

CIE Assessment Pattern (50 Marks – Practical) –

CIE to be evaluated every semester end based on practical demonstration of Yogasana learnt in the semester.

CIE	Marks
5th Semester	10
6th Semester	10
7th Semester	15
8th Semester	15
Total	**50**

SEE Assessment Pattern (50 Marks – Practical)

SEE	Marks
Suryanamaskara	10
Kapalabhati	10
Asanas	10
Patanjali's Ashtanga Yoga	10
Pranayama / Shat Kriyas	10
Total	**50**

Suggested Learning Resources:

Reference Books:

2. Swami Kuvulyananda: Asma (Kavalyadhama, Lonavala)
3. Tiwari, O P: Asana Why and How
4. Ajitkumar: Yoga Pravesha (Kannada)
5. Swami Satyananda Saraswati: Asana Pranayama, Mudra, Bandha (Bihar School of yoga, Munger)
6. Swami Satyananda Saraswati: Surya Namaskar (Bihar School of yoga, Munger)
7. Nagendra H R: The art and science of Pranayama
8. Tiruka: Shatkriyegalu (Kannada)
9. Iyengar B K S: Yoga Pradipika (Kannada)
10. Iyengar B K S: Light on Yoga (English)

Appendix A: List of Assessment Patterns

S.NO	Pattern of Assessments
1	Assignments
2	Group Discussions
3	Case Study / Caselets
4	Practical-Orientation on Design Thinking
5	Participatory & Industry-Integrated Learning
6	Practical Activities / Problem Solving Exercises
7	Class Presentations
8	Analysis of Industry / Technical / Business Reports
9	Reports on Industrial Visit
10	Industrial / Social / Rural Projects
11	Participation in external seminars / Workshops
12	Any Other Academic Activity
13	Online / Offline Quizzes

APPENDIX B: Outcome Based Education

Outcome-based education (OBE) is an educational theory that bases each part of an educational system around goals (outcomes). By the end of the educational experience each student should have achieved the goal. There is no specified style of teaching or assessment in OBE; instead classes, opportunities, and assessments should all help students achieve the specified outcomes.

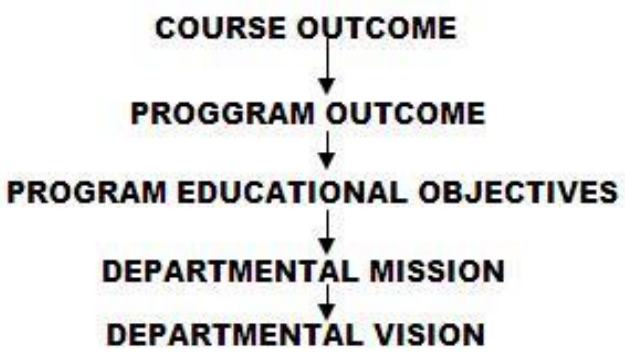
There are three educational Outcomes as defined by the National Board of Accreditation:

Program Educational Objectives: The Educational objectives of an engineering degree program are the statements that describe the expected achievements of graduate in their career and also in particular what the graduates are expected to perform and achieve during the first few years after graduation. [nbaindia.org]

Program Outcomes: What the student would demonstrate upon graduation. Graduate attributes are separately listed in Appendix C

Course Outcome: The specific outcome/s of each course/subject that is a part of the program curriculum. Each subject/course is expected to have a set of Course Outcomes

Mapping of Outcomes



APPENDIX C: The Graduate Attributes of NBA

Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

Conduct investigations of complex problems: The problems that cannot be solved by straightforward application of knowledge, theories and techniques applicable to the engineering discipline that may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions that require consideration of appropriate constraints/requirements not explicitly given in the problem statement (like: cost, power requirement, durability, product life, etc.) which need to be defined (modeled) within appropriate mathematical framework that often require use of modern computational concepts and tools.

Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

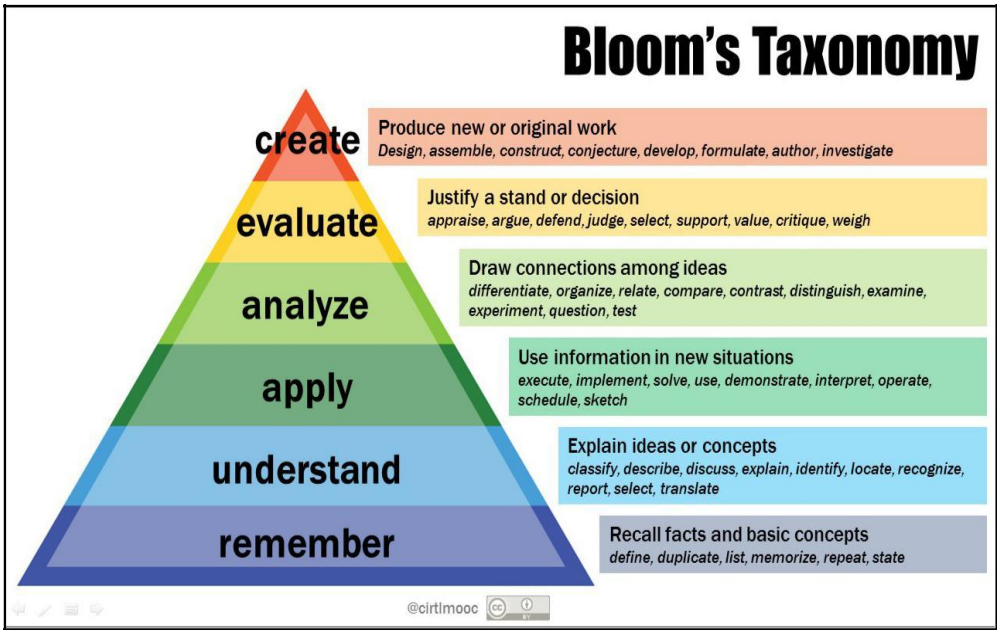
Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

APPENDIX D: BLOOM'S TAXONOMY

Bloom's taxonomy is a classification system used to define and distinguish different levels of human cognition—i.e., thinking, learning, and understanding. Educators have typically used Bloom's taxonomy to inform or guide the development of assessments (tests and other evaluations of student learning), curriculum (units, lessons, projects, and other learning activities), and instructional methods such as questioning strategies.



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