

Lokmanya Tilak Jankalyan Shikshan Santha's

Lokmanya Tilak College of Engineering

Sector 4, Vikas Nagar, Koparkhairane, Navi Mumbai 400709

An Autonomous Institute Affiliated to University of Mumbai



Department of Mechanical Engineering

CURRICULUM STRUCTURE

For

THIRD YEAR ENGINEERING

(BASED ON NEP 2020)

w.e.f. A.Y. 2026-27

Approved by Board of Studies on 18/05/2026

Approved by Academic Council on 22/05/2026



Lokmanya Tilak Jankalyan Shikshan Sanstha's
Lokmanya Tilak College of Engineering

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(Approved by AICTE, Accredited by NAAC 'A' Grade & four programs by NBA)

Sector-04, Koparkhairane, Navi Mumbai - 400 709



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Preface

Lokmanya Tilak College of Engineering (LTCE) is founded by a Nagpur-based trust known as Lokmanya Tilak Jankalyan Shikshan Sanstha (LTJSS). The Sanstha was established in 1983, by Honourable Dr. Satish Chaturvedi. At present, there are 28 educational institutes run by the Sanstha in Nagpur. The Sanstha derives its philosophy from the magnanimous mathematician, educationist, social reformer Lokmanya Bal Gangadhar Tilak, who dedicated his life for the cause of Swaraj. Lokmanya Tilak College of Engineering was established in 1994, approved by the All-India Council for Technical Education, New Delhi, recognised by the Govt. of Maharashtra, accredited by NAAC with 'A' grade and is affiliated to the University of Mumbai. Within the span of 30 years of its inception, LTCE has grown leaps and bounds in terms of popular courses being offered at U.G., P.G. and Ph.D. level. Four of its branches viz., Computer, Mechanical, Electrical and Electronics and Telecommunications Engg. have been accredited by NBA. The Institute runs the Undergraduate Programmes in Mechanical Engineering, Computer Engineering, Electronics & Telecommunication Engineering, Electrical Engineering, Computer Science & Engineering (Data Science), Computer Science & Engineering (Artificial Intelligence & Machine Learning) and Computer Science & Engineering (IoT & Cyber Security Including Blockchain Technology). Institute also offers Doctoral Programmes in Mechanical Engineering and Computer Engineering. LTCE stands steadfast in its mission of continuing efforts for the betterment of its students and society.

The National Education Policy 2020, recently implemented by the Government of India, envisions providing quality education to all young people, with the primary goal of nurturing well-rounded, thoughtful, and creative individuals. NEP 2020 also emphasizes the importance of developing character, ethical values, constitutional principles, intellectual curiosity, scientific temper, creativity, and other related virtues. The Government of Maharashtra has instructed autonomous colleges to update their curriculum and begin implementing the National Education Policy (NEP) 2020. We are fully committed to ensuring the effective and meaningful adoption of NEP 2020 in its true essence. At "Lokmanya Tilak College of Engineering", the holistic development of learners has always been our top priority and central focus. LTCE embraced the NEP philosophy as early as 2022 wherein we have introduced the concept of Honors and Minors programs on emerging fields as per the guidelines of University of Mumbai and in 2024, we proudly graduated our first batch under this holistic curriculum. The autonomous curriculum for 2024-28 is structured in line with the recommendations of NEP 2020, AICTE, and UGC. It now includes courses in emerging technologies and multidisciplinary areas to ensure relevance to industry and practical applications. Greater focus has been placed on experiential learning to move away from rote memorization.

Sd/-

Dr. S D Dalvi

BoS Chairman, Mechanical Engg

Sd/-

Dr. Sheeba P. S.

Dean, Academics & Research

Sd/-

Dr. Subhash K. Shinde

Principal

Illustrative Semester wise Credit distribution structure for Four Year UG Engineering Program – One Major, One Multidisciplinary Minor as per Maharashtra State Govt. Resolution:

Semester		I	II	III	IV	V	VI	VII	VIII	Total Credits
Basic Science Course	BSC/ESC	6-8	8-10							14-18
Engineering Science Course		8-10	4-6							12-16
Programme Core Course (PCC)	Program Courses		2	8-10	8-10	10-12	8-10	4-6	4-6	44-56
Programme Elective Course (PEC)						4	8	2	6	20
Multidisciplinary Minor (MD M)	Multidisciplinary Courses			2	2	4	2	2	2	14
Open Elective (OE) Other than a particular program				4	2	2				8
Vocational and Skill Enhancement Course (VSEC)	Skill Courses	2	2		2		2			8
Ability Enhancement Course (AEC -01, AEC-02)	Humanities Social Science and Management (HSSM)	2			2					4
Entrepreneurship/Economics/Management Courses				2	2					4
Indian Knowledge System (IKS)			2							2
Value Education Course (VEC)				2	2					4
Research Methodology	Experiential Learning Courses							4		4
Comm. Engg. Project (CEP)/Field Project (FP)				2						2
Project									4	4
Internship/ OJT								12		12
Co-curricular Courses (CC)	Liberal Learning Courses	2	2							4
Total Credits (Major)		20-22	20-22	20-22	20-22	20-22	20-22	20-22	20-22	160-176

Definition of Credit:

1 Hr. Lecture (L) per week	1 Credit
1 Hr. Tutorial (T) per week	1 Credit
2 Hr. Practical (P) per week	1 Credit
1 Hr. Practical (P) per week	0.5 Credit

Credit Requirements for Award of Degree:

- A total of 167 credits is required for a student to be eligible for the award of an **Undergraduate Degree in Engineering**, including a Multi-Disciplinary Minor, in accordance with the Government of Maharashtra GR dated 04/06/2024.
- A student shall be eligible for the award of an **Undergraduate Degree with Honours/Minor** in Emerging Areas upon earning an additional **18 credits**.

Multiple Exits:

Students will have the flexibility to enter a programme in odd semesters and exit a programme after the successful completion of even semesters as per their future career needs.

Distribution of Credits:

Level	Exit After Semester	Minimum Credits Required	LTCE Credits	Qualification Title	Additional Credit requirements
4.5	II (First Year)	40	44	One Year UG Certificate in relevant discipline	8 credits through Skill-based vocational courses (4 Credits) and Internship/ Apprenticeship/ Project (4 Credits).
5.0	IV (Second Year)	80	86	Two Years UG Diploma in relevant discipline	8 credits through Skill-based vocational courses (4 Credits) and Internship/ Apprenticeship/ Project (4 Credits).
5.5	VI (Third Year)	120	127	Three Years B. Voc. in the relevant Discipline	8 credits through Skill-based vocational courses (4 Credits) and Internship/ Apprenticeship/ Project (4 Credits).
6.0	VIII (Fourth Year)	160	167	B.Tech. in major discipline with multidisciplinary minor	-----
6.0	VIII (Fourth Year)	160+18= 178	167+18= 185	B.Tech. in major discipline with double minor (Multidisciplinary and Emerging minor)	-----

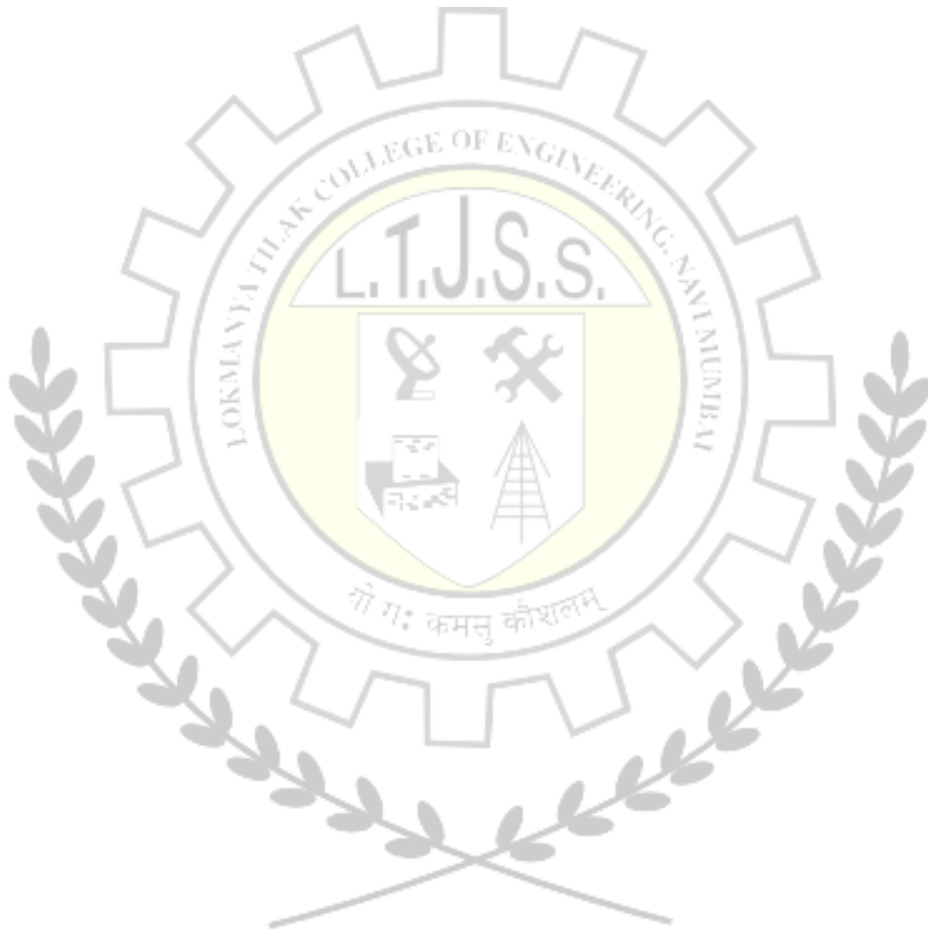
Type of Course	Course Code	No. of Credits as per Maharashtra Govt.	No. of credits as per LTCE
Basic Science Course	BSC	14-18	16
Engineering Science Course	ESC	12-16	14
Programme Core Course	PCC	44-56	49
Programme Elective Course	PEC	20	19
Multidisciplinary Minor	MDM	14	14
Open Elective (OE) Other than a particular program	OE	8	08

Vocational and Skill Enhancement Course	VSEC	8	10
Ability Enhancement Course (AEC -01, AEC-02)	AEC	4	03
Entrepreneurship/Economics/Management Courses	EEMC	4	04
Indian Knowledge System (IKS)	IKS	2	02
Value Education Course (VEC)	VEC	4	04
Research Methodology	ELC	4	03
Comm. Engg. Project (CEP)/Field Project (FP)	ELC	2	02
Project	ELC	4	04
Internship/ OJT	ELC	12	12
Co-curricular Courses (CC)	CC	4	03
Total Credits (Major)		160-176	167
Total Credits (Major+ Honors/Minors)		178-194	167+18=185

Abbreviations:

AEC	Ability Enhancement Course
AEL	Ability Enhancement Laboratory
BSC	Basic Science Course
BSL	Basic Science Laboratory
CEP	Common Engineering Project
CC	Co-curricular courses
CIE	Continuous Internal Evaluation
ESC	Engineering Science Course
ESE	End Semester Exam
ESL	Engineering Science Laboratory
IKS	Indian Knowledge System
L	Lecture
MDM	Multidisciplinary Minor
MSE	Mid Semester Exam

OE	Open Elective
P	Practical
PCC	Programme Core Course
PCL	Programme Core Laboratory
PEC	Programme Elective Course
T	Tutorial
VEC	Value Education Course
VSEC	Vocational and Skill Enhancement Course





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Department of Mechanical Engineering

Third Year Engineering Scheme: Semester V (w.e.f. AY 2026-27)

Course Code	Course Name	Teaching Scheme		Credit Assigned		Total Credits	Examination Scheme					
		L	P	L	P		Internal Assessment		End Semester Exam		Oral &/ Practical	Total
							Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)	Marks	Duration (Hrs)		
MEPCC501	Thermal Engineering	3	-	3	-	3	20	20	60	2	-	100
MEPCC502	CAD-CAM	3	-	3	-	3	20	20	60	2	-	100
MEPCC503	Theory Of Machine	3	-	3	-	3	20	20	60	2	-	100
MEPEC501X	MMC /OT / MSTD	3	-	3	-	3	20	20	60	2	-	100
XXMDM501	Multidisciplinary Minor Course II	3	-	3	-	3	20	20	60	2	-	100
MEVSEC501	Emerging Technology Lab	-	2*+2	-	2	2	-	50	-	-	25	75
MEPCL501	Thermal Engineering Lab	-	2	-	1	1	-	25	-	-	25	50
MEPCL502	CAD-CAM Lab	-	2	-	1	1	-	25	-	-	25	50
MEPEL501X	Program Elective Lab	-	2	-	1	1	-	25	-	-	25	50
XXMDML501	Multidisciplinary Minor Lab II	-	2	-	1	1	-	25	-	-	-	25
Total		15	12	15	6	21	100	250	300	10	100	750

* e - learning course

MEPEC501x: Program Elective Course I	MEPEC5011: Mechanical Measurement Control	MEPEC5012: Optimization Techniques	MEPEC5013: Manufacturing Sciences & Tool Design
MEPEL501x: Program Elective Lab I	MEPEL5011: MMC & MQE Lab	MEPEL5012: Optimization Techniques Lab	MEPEL5013: Manufacturing Sciences Lab



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Department of Mechanical Engineering
Third Year Engineering Scheme: Semester VI (w.e.f. AY 2026-27)

Course Code	Course Name	Teaching Scheme		Credit Assigned		Total Credits	Examination Scheme					
		L	P	L	P		Internal Assessment		End Semester Exam		Oral &/ Practical	Total
							Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)	Marks	Duration (Hrs)		
MEPCC601	Design of Machine Elements	3	-	3	-	3	20	20	60	2	-	100
MEPCC602	Refrigeration and air conditioning	3	-	3	-	3	20	20	60	2	-	100
MEPEC601X	Program Elective Course II	3	-	3	-	3	20	20	60	2	-	100
MEPEC602X	Program Elective Course III	3	-	3	-	3	20	20	60	2	-	100
XXMDM601	Multidisciplinary Minor Course III	3	-	3	-	3	20	20	60	2	-	100
MEPCL601	Refrigeration and air conditioning Lab	-	2	-	1	1	-	25	-	-	25	50
MEPCL602	Dynamics of Machinery & Vibration Lab	-	2	-	1	1	-	25	-	-	25	50
MEPEL601X	Program Elective Lab II	-	2	-	1	1	-	25	-	-	-	25
XXMDML601	Multidisciplinary Minor Lab III	-	2	-	1	1	-	25	-	-	-	25
MECEP601	Mini Project II	-	2	-	1	1	-	25	-	-	25	50
Total		15	10	15	5	20	100	225	300	10	75	700

MEPEC601x: Program Elective Course II	MEPEC6011: Finite Element Analysis	MEPEC6012: Computational Fluid Dynamics	MEPEC6013: Computer Aided Engineering
MEPEL601x: Program Elective Lab II	MEPEL6011: Finite Element Analysis	MEPEL6012: Computational Fluid Dynamics Lab	MEPEL6013: Computer Aided Engineering Lab
MEPEC602x: Program Elective Course III	MEPEC6021: Dynamics of Machinery	MEPEC6022: Vibration Control	MEPEC6023: Mechanical Vibration

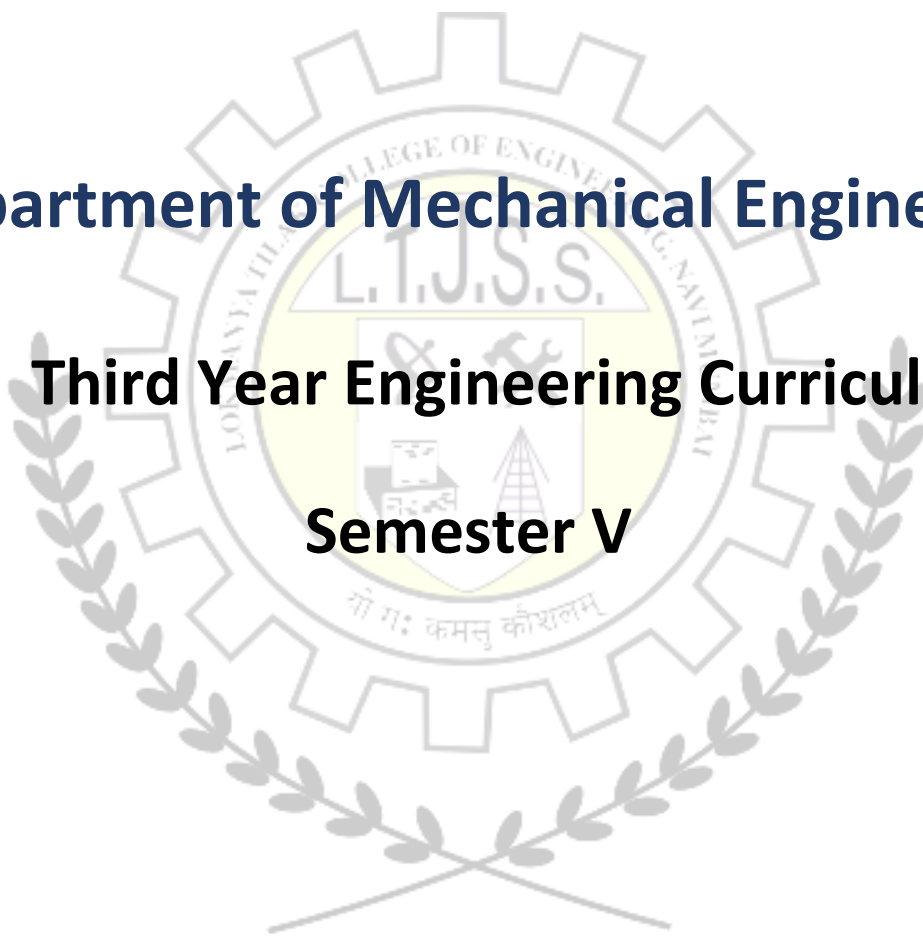
Multidisciplinary Minor (MDM) (14 Credits)

Semester	Computer Engineering (CE)	Electronics & Telecommunication Engineering (ET)	Artificial Intelligence & Robotics (AI&R)	Internet of Things (IT)	Mechanical Engineering (ME)	Electrical Engineering (EE)
IV	CEMDM401: Data Structure and Algorithms	ETMDM401: Microprocessor and Microcontroller	ARMDM401: Artificial Intelligence	ITMDM401: Internet of Things and Applications	MEMDM401: Basics of Mechanical Engineering	EEMDM401: Elements of Electrical System
	CEMDML401: Data Structure and Algorithms Lab	ETMDML401: Microprocessor and Microcontroller Lab	ARMDML401: AI Lab	ITMDML401: Internet of Things Lab	MEMDML401: Mechanical Engineering Lab	EEMDML401: Elements of Electrical System Lab
V	CEMDM501: Database Management System	ETMDM501: Digital Communication & Sensor Technology	ARMDM501: Mechatronics	ITMDM501: Sensors, Actuators and Transducers	MEMDM501: Conventional & Renewable Energy Sources	EEMDM501: Special Machines and Smart grid
	CEMDML501: Database Management System Lab	ETMDML501: Digital Communication & Sensor Technology Lab	ARMDML501: Mechatronics Lab	ITMDML501: Sensors, Actuators and Transducers Lab	MEMDML501: Renewable Energy Sources Lab	EEMDML501: Special Machines and Smart grid Lab
VI	CEMDM601: Big Data Computing	ETMDM601: Digital Image Processing	ARMDM601: Robotics	ITMDM601: Microcontrollers and Application	MEMDM601: Automobile Systems	EEMDM601: Electric Vehicle Technology
	CEMDML601: Big Data Computing Lab	ETMDML601: Digital Image Processing Lab	ARMDML601: Robotics Lab	ITMDML601: Microcontrollers Lab	MEMDML601: Automobile Systems Lab	EEMDML601: Electric Vehicle Technology Lab
VII	CEMDML701: Web Design Lab	ETMDML701: Mobile Computing Lab	ARMDML701: Predictive Maintenance Lab	ITMDML701: PLC and SCADA Lab	MEMDML701: 3D Printing Lab	EEMDML701: Design Management Auditing of Electrical System Lab

Department of Mechanical Engineering

Third Year Engineering Curriculum

Semester V



Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)				3	
MEPCC501	Thermal Engineering	20	20	60	1	2	100	

Prerequisite: Applied Thermodynamics	
Course Objectives: The course aims to	
1	Study the heat transfer concepts applicable for steady state and transient conditions.
2	Study mathematical modelling and design concepts of heat exchangers.
3	Familiarize with the working of steam generator, turbine and their performance.
4	Familiarize with the working of S.I. and C.I. engines and their performance.
Course Outcomes: Learners will be able to	
1	Understand & analyse the three modes of heat transfer in engineering application.
2	Understand & analyse the Transient heat Transfer in Extended surfaces.
3	Analyse performance parameters of different types of heat exchangers.
4	Understand construction and working of internal combustion engines & Alternative fuels used.
5	Understand the importance of Engine lubrication & Cooling systems used in I C Engine
6	Evaluate engine performance and emission characteristics.

Module	Detailed Contents	Hrs.	CO Mapping
01	Modes of Heat Transfer	08	CO1
	<p>Mechanism of conduction, Convection and radiation heat transfer and it's Governing laws.</p> <p>Conduction: Fourier's law, steady-state conduction through plane wall, hollow cylinder, and sphere, Composite wall and critical thickness of insulation.</p> <p>Convection: Newton's law of cooling, forced and free convection, simple empirical correlations.</p> <p>Radiation: black body, Gray body, emissivity, absorptivity, Stefan–Boltzmann law.</p> <p>Numerical Problems: steady 1D conduction, composite wall, convection heat loss.</p>		
02	Extended Surfaces (Fins)	07	CO2
	<p>Need for extended surfaces, types of fins, Differential equation of heat transfer through fins. Fin efficiency and effectiveness. Concept of fin performance under insulated and uninsulated tip. Combined conduction and convection in finned surfaces. Application of fins in engine cylinders and electronic cooling. Free and Forced convection</p> <p>External & Internal flow: Velocity Boundary layer & Thermal Boundary layer, Laminar and turbulent flow over a flat Plate.</p> <p>Numerical Problems: efficiency and effectiveness of fins, temperature distribution along fin.</p>		
03	Heat Exchangers	06	CO3
	<p>Classification of heat exchangers (parallel flow, counter flow, cross flow, shell and tube type), Overall heat transfer coefficient and fouling factor, Log Mean Temperature Difference (LMTD) method, Effectiveness–NTU method and comparison with LMTD approach, heat exchangers and their applications in automobiles and power plants.</p> <p>Numerical Problems: LMTD, overall heat transfer coefficient, heat exchanger effectiveness.</p>		
4	Internal Combustion Engines	07	CO4
	<p>Air-standard cycles: Otto, Diesel, and Dual cycles – PV and TS diagrams, efficiency derivations. Engine components, Classification of IC engines: SI and CI engines, 2-stroke and 4-stroke cycles, Valve and port timing diagrams,</p> <p>Engine components and systems: fuel supply, ignition, cooling, and lubrication systems. Stages of Combustion in SI and CI engines, detonation and knocking control methods. Alternative fuels and introduction to hybrid vehicles.</p>		
05	Engine lubrication and Cooling systems		

	<p>Engine lubrication: Types of lubricants and their properties, SAE rating of lubricants, Types of lubrication systems.</p> <p>Engine Cooling: Necessity of engine cooling, disadvantages of overcooling, Cooling systems and their comparison: Air cooling, Liquid cooling.</p> <p>Supercharging/Turbo-charging: Objectives, Effects on power output and engine efficiency, Methods, Types, Limits.</p>	06	CO5
06	<p>Engine Performance and Testing</p>	08	CO6
	<p>Engine performance parameters: indicated power, brake power, friction power, Mechanical, thermal, volumetric, and overall efficiency, Specific fuel consumption and air-fuel ratio.</p> <p>Engine Testing Methods: Morse test, motoring test, Willans line method, Performance curves and heat balance sheet, Calculation of brake mean effective pressure (BMEP), indicated mean effective pressure (IMEP),</p> <p>Numerical Problems: efficiency calculations, heat balance sheet, performance parameter estimation.</p>		

Text & References Books:

1. Fundamentals of Heat and Mass Transfer by F.P. Incropera and D P deWitt, Wiley India 3rd Edition.
2. Introduction to thermodynamics and Heat transfer by Yunus A Cengel, 2ndEdition, McGraw Hill.
3. Heat and Mass Transfer by PK Nag, TMH.
4. Heat Transfer by S P Sukhatme, University Press.
5. Introduction to Heat Transfer, Som S. K, PHI Publication.
6. Thermal Engineering, Ajoy Kumar, G. N Sah, Narosa Publishing House, New Delhi
7. Internal Combustion Engine, Mathur and Sharma.
8. Internal Combustion Engine by Domkundwar
9. Internal Combustion Engine, V Ganesan, TMH

NPTL Courses: -

1. <https://nptel.ac.in/courses/112/101/112101097/> - Heat and Mass Transfer, IIT Bombay
2. <https://nptel.ac.in/courses/112/105/112105248/> - Heat Exchangers: Fundamentals and Design Analysis, IIT Kharagpur
3. <https://nptel.ac.in/courses/112/104/112104033/> - Engine Combustion, IIT Kanpur
4. <https://nptel.ac.in/courses/112/103/112103262/> - IC Engines and Gas Turbines, IIT Guwahati

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.



Course Code	Course Name	Examination Scheme					Total Marks	Lecture		
		Marks Distribution			Exam Duration (Hrs)				3 Hrs	
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE				Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)							
MEPCC502	CAD CAM	20	20	60	1	2	100			

Prerequisite:

Course Objectives: The course aims to

1	Understand the principles of computer-aided geometric modeling.
2	Understand basic concepts of computer graphics.
3	Acquaint with the process of using biomedical data for 3D modeling.
4	Study programming aspects of subtractive manufacturing process.
5	Familiarize with basic process of additive manufacturing in particularly 3D printing.

Course Outcomes: Learners will be able to

1	Identify suitable computer graphics techniques for 3D modeling.
2	Transform, manipulate objects & store and manage data.
3	Develop 3D model using various types of available biomedical data.
4	Develop the programs for CNC operations.
5	Build and create data for 3D printing of any given object using rapid prototyping and tooling processes.
6	Exchange the CAD data via standards and execute cad cam technologies for reverse engineering applications.

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction	08	CO1
	Computer Graphics: 1.1 Introduction: CAD CAM Process, Scope of CAD/CAM in product life cycle, CAD/CAM hardware and software. 1.2 Parametric representation of curves and surfaces: Synthetic Curves-Bezier curves, Hermite Curves, B-spline curves. Surface representation. 1.3 Modeling types: Wire Frame Modeling, Surface Modeling, Solid Modeling: Constructive solid geometry (CSG), Boundary Representation (B- Rep), Parametric Modeling, feature based modeling, Constraint Based Modeling.		
02	Geometric Transformation: 2.1 Homogeneous Coordinate system, Matrix representation, Concatenations, 2D and 3D geometric transformation (Translation, Reflection, Scaling, Rotation)	06	CO2

03	Introduction to Bio CAD modeling :	06	C03
	3.1 Overview of bio modeling process: Introduction to biomedical scanning methods: Computed tomography (CT), Cone beam CT (CBCT), Magnetic resonance (MR), Noncontact surface scanning, Medical scan data, point cloud data, reading and interpreting DICOM files using sample files in software. Modeling based on Biomedical data 3.2 Working with medical scan data: Pixel data operations, Using CT data: a worked example, Point cloud data operations, Two-dimensional formats, Pseudo 3D formats, True 3D formats, File management and exchange.		
04	CAM: Subtractive Manufacturing	08	C04
	4.1 Introduction: NC/CNC/DNC machines, constructional details, operating principles. 4.2 CNC machining practices and programming: setup, and operation of two- and three- axis CNC machines programming using manual part programming method, Canned Cycles.		
05	Additive Manufacturing:	08	C05
	5.1 Rapid Prototyping: Introduction, Classification of RP Processes, Advantages & disadvantages. RP Applications; in Design, Concept Models, Form & fit checking, Functional testing, CAD data verification, Rapid Tooling, and bio fabrication. 5.2 Working Principle, Application, Advantages & disadvantages: of Stereolithography Apparatus (SLA) Selective Laser Sintering (SLS), 3D Printing, Fused Deposition Modeling (FDM), and Laminated Object Manufacturing (LOM)		
06	Data Exchange, Interoperability and Reverse Engineering:	06	C06
	6.1 Need for interoperability between CAD/CAM/CAE systems 6.2 Data exchange standards: IGES, STEP, STL, DXF, Parasolid, JT, 3MF 6.3 CAD file structure and hierarchy, Model verification, healing, and validation 6.4 Reverse engineering: point cloud generation, mesh reconstruction, Applications in product design, additive manufacturing, and inspection		

Text Books:

1. Computer graphics by F.S. Hill, Jr., Pearson (Prentice Hall).
2. CAD/ CAM, Theory & Practice, Ibrahim Zeid, R. Sivasubramanian, Tata McGraw Hill Publications
3. CAD/CAM Principles and Applications, P. N. Rao, Tata McGraw Hill Publications
4. CAD/CAM Computer Aided and Manufacturing, Mikell P. Groover and Emory W. Zimmers, Jr., Eastern Economy Edition
5. CNC Technology and Programming, Krar, S., and Gill, A., McGraw Hill Publishers.

References:

1. Medical Modelling -the Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
2. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson | D. W. Rosen | B. Stucker, Springer Publication.
3. Rapid Prototyping and Manufacturing, P. F. Jacobs, Society of Manufacturing Engineers
4. Advanced Machining and Manufacturing Processes, Kaushik Kumar DivyaZindani, J. Paulo Davim, Springer International Publishing

Internal Assessment (40 Marks)**A. Mid Semester Exam (20 Marks)**

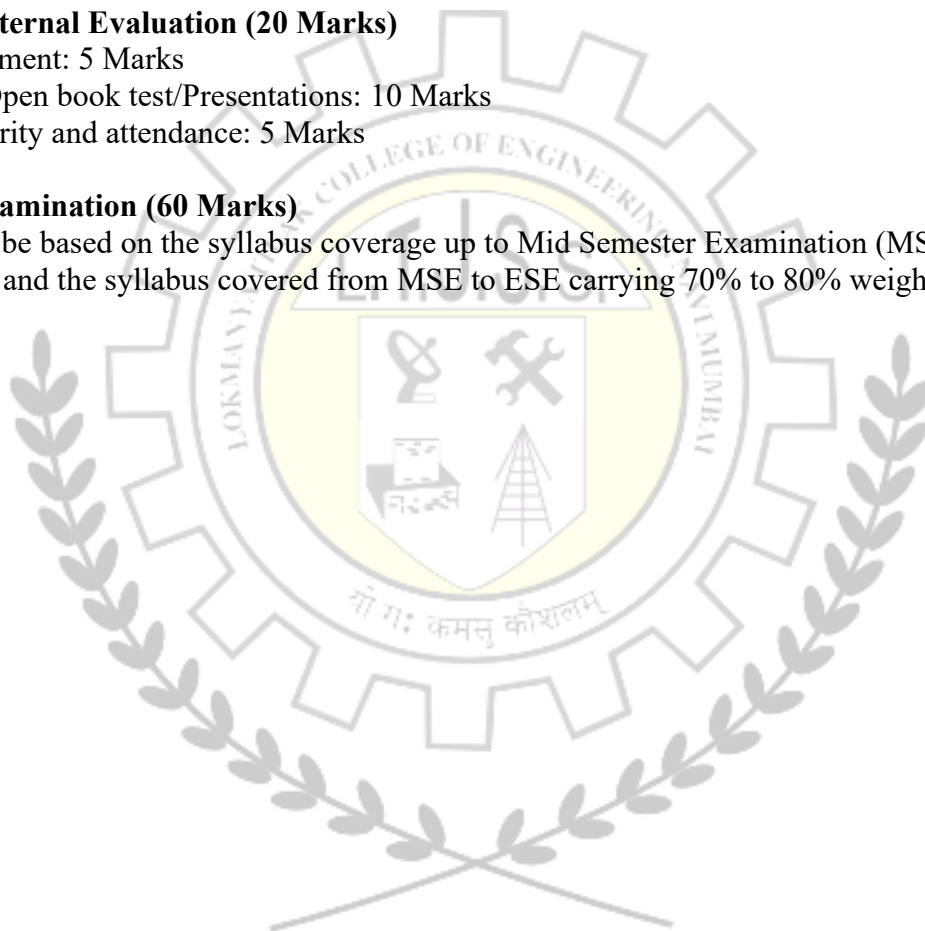
Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentations: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.



Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)				3	
MEPCC503	Theory of Machine	20	20	60	1	2	100	

Prerequisite: Engineering Mechanics, Strength of Materials

Course Objectives: The course aims to

1	Acquaint with basic concept of kinematics and kinetics of machine elements
2	Familiarize with basic and special mechanisms
3	Study functioning of motion and power transmission machine elements

Course Outcomes: Learners will be able to

1	Determine mass moment of Inertia of composite bodies and Identify various components of mechanisms
2	Identify and understand various special Mechanisms
3	Draw velocity and acceleration diagrams of various mechanisms
4	Draw motion graphs for various cam mechanisms
5	Study and analyze various mechanical drives
6	Study and analyze Gear drive and Gear train

Module	Detailed Contents	Hrs.	CO Mapping
01	Kinetics of Rigid Bodies and Basic Kinematics of Machine 1.1 Kinetics of Rigid Bodies Concept of mass moment of inertia and its application to standard objects. Kinetics of rigid bodies: Application of D'Alembert Principle and Work and energy principle, Law of Conservation of energy 1.2 Basic Kinematics of Machine Structure, Machine, Mechanism, Kinematic link & its types, Kinematic pairs, Types of constrained motions, Types of Kinematic pairs, Kinematic chains, Types of joints, Degree of freedom (mobility), Kutzbach mobility criterion, Grübler's criterion & its limitations, Four bar chain and its inversions, Grashoff's law, Slider crank chain and its inversions, Double slider crank chain and its inversions.	07	CO1
	Study of Special Mechanisms 2.1 Straight line generating mechanisms: Introduction to Exact straight line generating mechanisms - Peaucillier's and Hart's Mechanisms, Introduction to Approximate Straight line generating mechanisms- Watt's, Grasshopper mechanism, Tchebicheff's mechanisms 2.2 Offset slider crank mechanisms - Pantograph, Hook-joint (single and double).		
02		04	CO2

	2.3 Steering Gear Mechanism - Ackerman, Davis steering gears		
03	Velocity and Acceleration Analysis of Mechanisms	08	CO3
	3.1 Velocity Analysis of Mechanisms (mechanisms up to 6 links) Velocity analysis by instantaneous centre of rotation method (Graphical approach), Velocity analysis by relative velocity method (Graphical approach) 3.2 Acceleration Analysis of Mechanisms (mechanisms up to 6 links) Acceleration analysis by relative method including pairs involving Coriolis acceleration (Graphical approach)		
04	Cam and Follower Mechanism	08	CO4
	4.1 Cam and its Classification based on shape, follower movement, and manner of constraint of follower; Followers and its Classification based on shape, movement, and location of line of movement; Cam and follower terminology 4.2 Plot motion graphs for motions of the follower(SHM, Constant acceleration and deceleration, Constant velocity, Cycloidal)		
05	Belts, Chains and Brakes	07	CO5
	5.1 Belts: Introduction, Types and all other fundamentals of belting, Dynamic analysis –belt tensions, condition of maximum power transmission 5.2 Chains: Study of types of chains, chordal action, variation in velocity ratio, length of chain 5.3 Brakes: Introduction, types and working principles, Introduction to braking of vehicles		
06	Gears and Gear Trains	08	CO6
	6.1 Gears- Introduction, Types, Law of gearing, Forms of teeth, Details of gear terminology, Path of contact, Arc of contact, Contact ratio, Interference in involutes gears, Minimum number of teeth for interference free motion, Methods to control interference in involutes gears, Static force analysis in gears - spur, helical, bevel, worm & worm wheel 6.2 Gear Trains: Kinematics and dynamic analysis of simple and compound gear trains, reverted gear trains, epi-cycle gear trains with spur or bevel gear combination		

Text Books:

1. S.S. Ratan, "Theory of Machines", Tata McGraw Hill
2. Ghosh and A.K. Mallik, "Theory of Mechanisms and Machines", East-West Press
3. J.J. Uicker, G.R. Pennock, and J.E. Shigley, "Theory of Machines and Mechanism", Oxford Higher Education
4. P.L. Ballaney, "Theory of Machines", Khanna Publishers
5. M.A. Mostafa, "Mechanics of Machinery", CRC Press
6. R.L. Norton, "Kinematics and Dynamics of Machinery", McGraw Hill
7. A.G. Erdman, G.N. Sander, and S. Kota, "Mechanism Design: Analysis and Synthesis Vol I", Pearson

References:

Links for online NPTEL/SWAYAM courses:

1. <https://nptel.ac.in/courses/112/105/112105268/>

2. <https://www.youtube.com/playlist?list=PLYRGB44zNZWVibVLmWANp-7obQzOhJLRt>
3. <http://www.nptelvideos.in/2012/12/kinematics-of-machines.html>

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

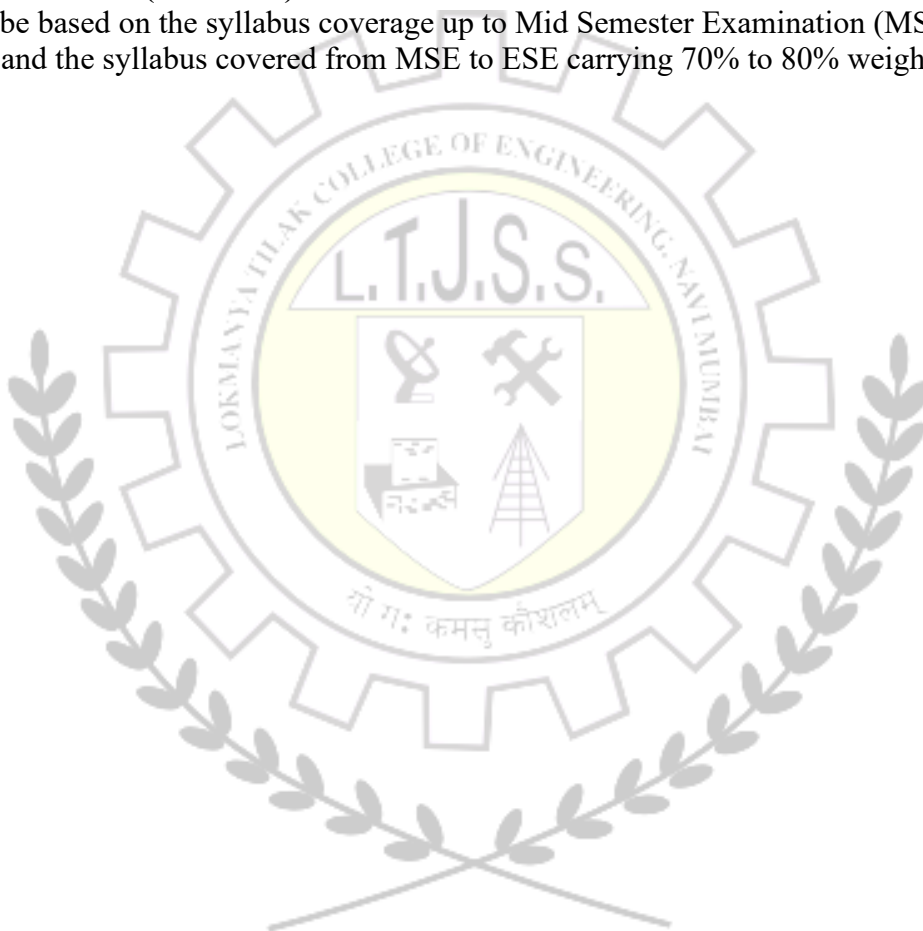
Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.



Course Code	Course Name	Examination Scheme					Total Marks	Lecture		
		Marks Distribution			Exam Duration (Hrs)				3 Hrs	
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE				Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)							
MEPEC5011	Mechanical Measurement & Control	20	20	60	1	2	100	3		

Prerequisite: Applied Mathematics -I for Mechanical Engg, Applied Mathematics-II

Course Objectives: The course aims to

1	Study the principles of precision measuring instruments & their significance.
2	Familiarise with the handling & use of precision measuring instruments/equipment.
3	Impart knowledge of the architecture of the measurement system and deliver the working principle of the mechanical measurement system.
4	Study the concept of mathematical modelling of the control system.
5	Acquainted with control systems under different time domains.

Course Outcomes: Learners will be able to

1	Handle, operate and apply the precision measuring instruments /equipment.
2	Analyse simple machined components for dimensional accuracy and functionality.
3	Classify various static characteristics and types of errors occurring in the system.
4	Classify and select the proper measuring instrument for displacement, pressure, and temperature measurements.
5	Design mathematical models for systems/processes, analyse standard input responses and errors, and differentiate control system types and time-domain specifications.
6	Analyse the difficulties associated with stability.

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction to Metrology	06	CO1
	1.1.Need and importance of inspection and measurement, Fundamental principles, definitions, and standards of measurement, Errors in measurement and methods of minimizing errors. 1.2.Limits, fits, and tolerances; hole-based and shaft-based systems, Types of fits and tolerance grades, Basic concept of Go and No-Go gauges and Taylor's principle, Design of Go and No-Go gauges.		
	Self-Learning Topic: Identify everyday life examples where different types of fits are used.		
02	Surface Finish, Thread Measurement and Gear Measurement	07	CO2
	2.1.Principle of interference, Concept of flatness, Flatness testing, Optical flats, Optical Interferometer and Laser interferometer. 2.2.Surface texture measurement: Importance of surface conditions, surface roughness parameters - Ra, Ry, Rz, RMS value, etc., Surface roughness measuring instruments. 2.3.Screw Thread measurement: Two-wire and three-wire methods,		

	<p>Floating carriage micrometre.</p> <p>2.4.Gear measurement: Measurement using rollers and Parkinson's Tester.</p>		
	Self-Learning Topic: Study Gear terminology and Gear tooth comparator		
03	Generalized Measurement System	06	C03
	<p>3.1.Significance of Mechanical Measurements, Classification of measuring instruments, generalised measurement system, types of inputs: Desired, interfering and modifying inputs.</p> <p>3.2.Static characteristics: Static calibration, Linearity, Static Sensitivity, Accuracy, Static error, Precision, Reproducibility, Threshold, Resolution, Hysteresis, Drift, Span & Range, etc.</p>		
	Self-Learning Topic: Identify common measuring devices encountered in day-to-day life.		
04	Displacement, Strain, Pressure & Temperature Measurement	07	C04
	<p>4.1.Displacement Measurement: LVDT, potentiometer, capacitive and digital transducers, Nozzle Flapper transducer.</p> <p>4.2.Strain Measurement: strain gauge, gauge factor, bridge circuit, strain-gauge-based load and torque measurement.</p> <p>4.3.Pressure Measurement: Bourdon tube, diaphragm, bellows, piezoelectric pressure sensor.</p> <p>4.4.Temperature Measurement: Resistance thermometers (RTD), thermistor, thermocouple, pyrometer.</p>		
	Self-Learning Topic: Explore advanced industrial applications of displacement, strain, pressure and temperature sensors, also study how these sensors are integrated with digital control, automation and Industry 4.0 systems in real-world practice.		
05	Control System & Time response of the control system	08	C05
	<p>5.1.Introduction to control systems, Classification of control systems. Open-loop and closed-loop systems.</p> <p>5.2.Mathematical modelling of control systems, concept of transfer function, Block diagram algebra.</p> <p>5.3.Transient and steady state analysis of first and second order systems, Time Domain specifications. Step response of second order system, Steady-state error, error coefficients, steady state analysis of different types of systems using step, ramp and parabolic inputs.</p>		
	Self-Learning Topic: Study real-life examples of open-loop and closed-loop control systems.		
06	Stability of Control System	08	C06
	<p>6.1. Introduction to concepts of stability, the Routh criteria for stability.</p> <p>6.2.Experimental determination of frequency response, Stability analysis using Root locus, Bode plot.</p>		
	Self-Learning Topic: Identify various elements of a control system and explain their respective functions.		

Text Books:

- 1.Engineering. Metrology, I.C. GUPTA, Dhanpat Rai Publications.
- 2.Engineering. Metrology, R. K. Jain, Khanna Publisher.
- 3.Measurement Systems: Applications and Design, by EO Doebelin,5th Edition, McGraw-Hill.
- 4.Mechanical Engineering Measurements, A. K. Sawhney, Dhanpat Rai & Sons, New Delhi.
- 5.Instrumentation & Mechanical Measurements, A. K. Thayal .
- 6.Control System Engineering by Nagrath I.J. and Gopal M, Wiley Eastern Ltd.

References:

1. Modern Control Engineering: by K. Ogata, Prentice Hall.
2. Control Systems by Dhanesh Manik, Cengage Learning .
3. Engineering Metrology and Measurements by N V Raghavendra and L Krishnamurthy, Oxford University Press.
4. Instrumentation and Control System, W. Bolton, Elsevier.
5. Experimental Methods for Engineers by J P Holman, McGraw Hills Int. Edition.
6. Engineering Experimentation by EO Doebelin, McGraw-Hill Int. Edition.
7. Mechanical Measurements by S P Venkateshan, John Wiley & Sons .
8. https://onlinecourses.nptel.ac.in/noc25_me65/preview
9. https://onlinecourses.nptel.ac.in/noc25_ee104/preview
10. nptel.ac.in/courses/112106179

Internal Assessment (40 Marks)**A. Mid Semester Exam (20 Marks)**

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

- 1.Assignment: 5 Marks
- 2.Quiz/Open book test/Presentation: 10 Marks
- 3.Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to the Mid Semester Examination (MSE), carrying 20% to 30% weightage, and the syllabus covered from MSE to ESE, carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme					Total Marks	Lecture	
		Marks Distribution			Exam Duration (Hrs)				Total Credits
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE			
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)						
MEPEC5012	Optimization Techniques	20	20	60	1	2	100	3	

Prerequisite: Mathematics and calculus	
Course Objectives: The course aims to	
1	Understand the need and origin of the optimization methods
2	Understand various linear, nonlinear and other optimization techniques.
3	Understand various multi criterion and multi-objective decision making methods.
4	Understand recent tools in optimization
Course Outcomes: Learners will be able to	
1	Identify the types of optimization problems and apply the calculus method to single variable problems
2	Formulate the problem as Linear Programming problem and analyse the sensitivity of a decision variable.
3	Apply various linear and non-linear techniques for problem solving in various domain
4	Apply multi-objective decision making methods for problem in manufacturing environment and other domain.
5	Apply multi criterion decision making methods for problem in manufacturing environment and other domain.
6	Apply Design of Experiments method for Optimization

Module	Detailed Contents	Hrs.	CO Mapping
01	Basic Concepts: Statement of the Optimization Problem, Basic Definitions, Optimality Criteria for Unconstrained Optimization, Optimality Criteria for Constrained Optimization, Engineering Application of Optimization, Classification of Optimization Problems. Classical Optimization Techniques: Single variable optimization	6	CO1
02	Linear Programming Problem: Formulation, Simplex method, Big M Method, Two Phase, Primal to Dual, Dual Simplex method, Sensitivity Analysis and applications of LP Transportation and Assignment Models.	8	CO2
03	Integer Programming Model: Gomory's cutting plane method, Branch & Bound Technique. Non L.P. Model: Lagrangian method & Kuhn tucker Method, Newton's method. Discrete Event Simulation: Generation of Random Variable, Simulation Processes, Monte-Carlo Technique.	6	CO3

04	Multi Objective Decision making (MODM) Methods: Introduction to Multi objective optimization, Traditional Techniques such as, quadratic programming, geometric programming, Numerical on goal programming and dynamic programming. Introduction to Non-traditional optimization Techniques such as Genetic Algorithm, particle swarm, genetic algorithms, simulated annealing and Techniques based on Neural network & Fuzziness	8	CO4
05	Multi Criterion Decision-making (MCDM) Methods: Introduction to multi criterion optimization Simple Additive Weighting (SAW) Method Weighted Product Method (WPM) Analytic Network Process (ANP) Analytic Hierarchy Process (AHP) Method TOPSIS Method PROMETHEE	6	CO5
06	Robust Design Methods: DOE and Taguchi techniques Full Factorial Design: The basics of "full factorials", ANOVA, Factorial effects and plots, and Model evaluation Fractional Factorial Design: The one-half fraction and one-quarter of the 2k design, The general 2k-p fractional factorial design Application of related software (Minitab, Design Expert or MATLAB)	8	CO6

Text Books:

1. S.S. Rao, "Engineering Optimization - Theory and Practice", John Wiley and Sons Inc.
2. Ranjan Ganguli, "Engineering Optimization - A Modern Approach" Universities Press
3. Pablo Pedregal, "Introduction to Optimization", Springer
4. L.C. Jhamb, "Quantitative Techniques Vol. 1 and 2", Everest Pub. House
5. Pierre D.A., "Optimization, Theory with Application", John Wiley & sons.
6. R V Rao, "Decision Making in the Manufacturing Environment Using Graph Theory and Fuzzy Multiple Attribute Decision Making" (Springer Publication).
7. Ritter, H., Martintez, T., &Schulten, K., Addison, "Neural Computation and Self-Organizing Maps"- Wesley Publishing Company
8. Douglas C. Montgomery, "Design and analysis of experiments" (John Wiley & Sons Inc.)
9. Saravanan R, "Manufacturing Optimization through Intelligent Techniques", Taylor & Francis (CRC Press)-2006.

Links for online NPTEL/SWAYAM courses:

1. <https://nptel.ac.in/courses/112/101/112101298/> - Optimization from Fundamentals, IIT Bombay
2. <https://nptel.ac.in/courses/110/105/110105087/> - Design and Analysis of Experiments, IIT Kharagpur
3. <https://nptel.ac.in/courses/111/104/111104075/> - Analysis of Variance and Design of Experiments I, IIT Kanpur
4. <https://nptel.ac.in/courses/111/104/111104078/> - Analysis of Variance and Design of Experiments II, IIT Kanpur

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)				3	
MEPEC5013	Manufacturing Sciences and Tool Design	20	20	60	1	2	100	

Prerequisite: Basic Machining	
Course Objectives: The course aims to	
1	To familiarise with the basic concepts of machining science like mechanics of machining, tool wear, tool life and surface roughness.
2	To familiarise with various single point cutting tools designing processes
3	To familiarise with various multipoint cutting tools designing processes
4	To study the economics of machining process
Course Outcomes: Learners will be able to	
1	Calculate the values of various forces involved in the machining operations
2	Design various single and multipoint cutting tools
3	Analyse heat generation in machining operation and coolant operations
4	Illustrate the properties of various cutting tool materials and hence select an appropriate tool material for particular machining application
5	Demonstrate the inter-relationship between cutting parameters and machining performance measures like power requirement, cutting time, tool life and surface finish
6	Analyse economics of machining operations

Module	Detailed Contents	Hrs.	CO Mapping
01	<p>Introduction</p> <p>Metal Cutting Theory: Orthogonal and oblique cutting, various types of chips, Mechanics of orthogonal steady state metal cutting, shear plane and shear plane angle, Merchant's force circle, stresses, shear strain, velocity relations, rate of strain, energy considerations, Concept of specific power consumption in machining, Ernst and Merchant's model & modified model for orthogonal cutting, Lee and Shaffer model, Analytical modelling of machining operations, mechanistic modelling of machining, slip line field analysis, finite element analysis, modelling of material properties</p> <p>Dynamometry: Dynamometer requirements, force measurement, electric transducers, strain gage lathe dynamometer, strain rings, milling dynamometer, drilling dynamometer, surface grinding dynamometer, piezoelectric dynamometry.</p>	8	CO1

02	<p>Temperatures in metal cutting and cutting fluids: Heat generation in metal cutting, heat transfer in a moving material, temperature distribution in metal cutting, temperature in primary deformation zone, temperature in secondary deformation zone, effect of cutting speed on temperature, prediction of temperature distribution in machining, measurement of cutting temperature, work tool thermocouple, direct thermocouple measurement, radiation methods, hardness and microstructure changes in steel tools Cutting fluid types, the action of coolants, the action of lubricants, characteristics of an efficient lubricant in metal cutting, application methods of cutting fluid, cutting fluid maintenance and environmental considerations, disposal of cutting fluids, dry cutting and minimum quantity lubrication, cryogenic cooling.</p>	7	CO2
03	<p>Cutting tool materials and machining induced surface integrity 3.1 Properties of cutting tool materials, Major tool material types, Plain carbon steel, high speed steel, cast alloys, cemented tungsten carbide, titanium carbides, ceramic and cermet tools, synthetic diamond, polycrystalline diamond (PCD), cubic boron nitride (CBN), coated tools 3.2 Measurement and specification of surface finish, primary cutting edge finish, fracture roughness, BUE formation and its influence on finish, secondary cutting edge finish, geometrical contribution to roughness, edge finishing, residual stress and micro hardness .</p>	6	CO3
04	<p>Tool life and machining economics: Definition, flank wear and crater wear, criteria for tool failure, effect of cutting parameters and tool geometry on tool life, Taylor's tool life equation, Experimental methods to find Taylor exponents, Components of product cost, Optimum cutting velocity for minimum cost of production and maximum production rate.</p>	7	CO4
05	<p>Design of single point cutting tools: Different systems of tool nomenclature like MRS, ORS and NRS, Interrelationship among different systems of nomenclature for tool angles, Constructional features of solid tool, tipped tools, mechanically held regrind able insert type tools and throw away tip type tools, Design of shanks, cutting tip and chip breakers for HSS and Carbide tools, ISO coding system for tipped tools and tool holders.</p>	7	CO5
06	<p>Design of multi point cutting tools : Various types such as flat form tool, tangential form tool, circular form tool, constructional details and fields of application, Profile design of flat and circular form tools, Broach nomenclature, design steps for circular pull type, key way and spline broaches, Design of face and peripheral milling cutters.</p>	7	CO6

Text Books:

- 1.Fundamentals of Metal Machining and Machine Tools, Third Edition by Winston A. Knight, Geoffrey Boothroyd, CRC press Taylor and Francis group
- 2.Metal Cutting Principles by Milton Clayton Shaw,2 nd Edition, Oxford University Press
- 3.Cutting Tools by P H Joshi, A H Wheeler Publishing Co Ltd
- 4.ASM Handbook, Vol. 16: Machining by Joseph R. Davis,9 th Edition, ASM International

5. Fundamentals of Metal Cutting and Machine Tools by B. L. Juneja, G. S. Sekhon and Nitin Seth, 2nd Edition, New Age International
6. Metal Cutting Theory and Cutting Tool Design, by V. Arshinov and G. Alekseev, Mir publishers, Moscow
7. Typical Examples and Problems in Metal Cutting and Tool Design, by N. Nefedov and K. Osipov, Mir publishers, Moscow

References:

1. E.J.A. Armarego and R. H. Brown-The Machining of Metals
2. G Boothroyd-Fundamentals of Metal Machining and Machine tools
3. A. Ghosh and Asok Mallik- Machining Science
4. G. K. Lal and S. K. Choudhury-Fundamental of Manufacturing Processes
5. M. C. Shaw-Metal Cutting Principles
6. <https://nptel.ac.in/courses>

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

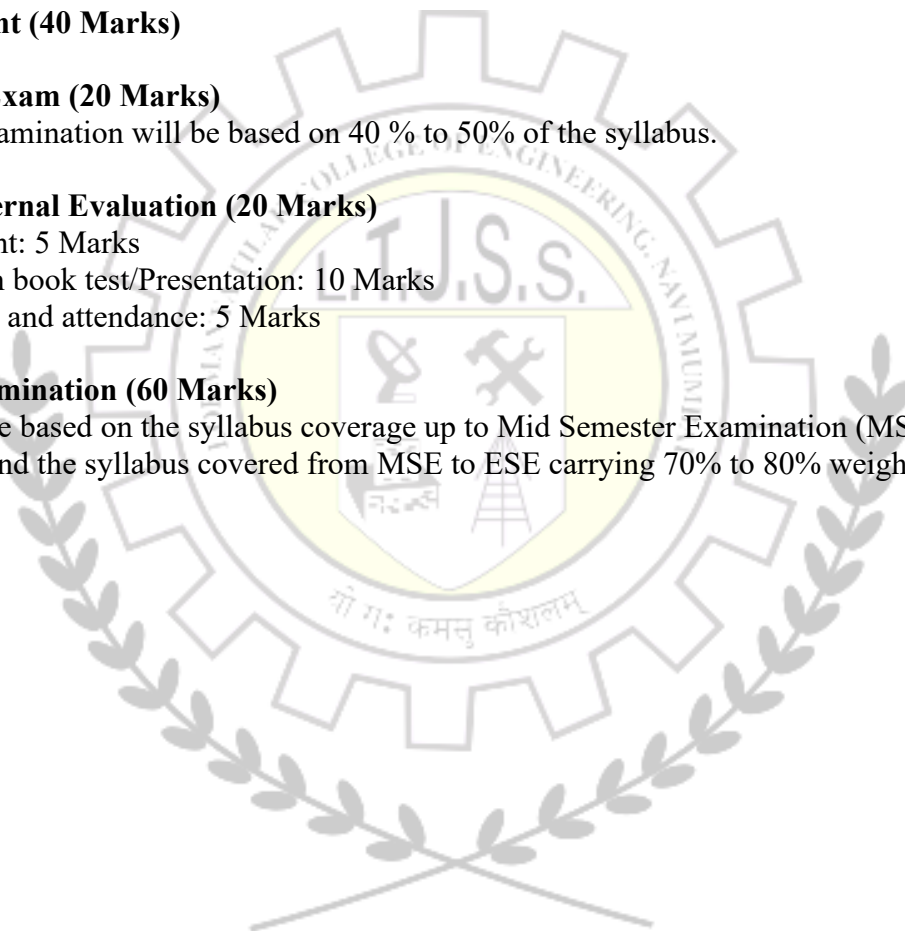
Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.



Course Code	Course Name	Examination Scheme					Total Marks	Lecture	
		Marks Distribution			Exam Duration (Hrs)				Total Credits
		Internal Assessment		Oral	MSE	ESE			
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)						
MEVSEC501	Emerging Technology Lab	-	50	25	-	-	75	2	

* e- learning

Course Objectives: The course aims to	
1	Bridge the gap between academic learning and industry skill requirements.
2	Encourage students to complete recognized online certification courses.
3	Provide hands-on exposure in emerging technologies
4	Promote independent learning, portfolio building, and employability skills.
Course Outcomes: Learners will be able to	
1	Identify and pursue relevant industry skills through online learning platforms.
2	Demonstrate practical understanding of emerging technology.
3	Enhance skills through online certifications.
4	Integrate multiple technical skills in a project.

<p>Learners should select any course from MKCL/ NPTEL/ SWAYAM/ MOOCS/ Infosys Springboard/ Edunet/ Coursera, etc. #</p>
<p>Few suggested certification courses are: 3D Modelling(SolidWorks / Autodesk Fusion 360 / CATIA), CNC programming, 3D printing, and rapid prototyping , ANSYS ,IoT, Automation and Robotics Fundamentals (Mechatronics and control systems), MATLAB for Engineers, Python for Mechanical Engineering Applications, Non-Destructive Testing (Level I / II), AI Tools for Engineering Design Optimization, Thermal Energy Systems Simulation(Heat exchangers, HVAC, and PCM modelling), Electric Vehicles and Hybrid Systems(EV design, battery systems, and thermal management) etc.</p> <p>The course duration should be 28 to 30 Hours.</p> <p># Any other relevant topics in discussion with the concerned faculty.</p>

Continuous Internal Evaluation (50 Marks)

1. Lab Performance: **10 Marks**
2. Presentation: **10 Marks**
3. Online Certification or Skill Based Project\$: 25
4. Regularity and Attendance: 5 Marks

\$Course project is compulsory for those students who have not enrolled for online certification courses. However, such students have to complete 2 hours of e-learning per week during the college hours.

At the end of the Semester, Learner must submit a file containing their Lab performances, Online Certifications/ Course Project report.

Oral Exam (25 Marks)

An Oral exam will be held based on the Online Certification Courses/ Skill Based project.

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
MEPCL501	Thermal Engineering Lab	-	25	25	-	-	50	

Prerequisite: Applied Thermodynamics

Course Objectives: The course aims to

1	Familiarize the concept of various modes of heat transfer through experimental approaches.
2	Make conversant of concept of heat transfer mechanisms in various engineering applications.
3	Acquaint with the various methods for measurement of engine performance and emission parameters

Course Outcomes: Learners will be able to

1	Estimate thermal conductivity of engineering materials.
2	Compute convective heat transfer coefficient h by free/forced convection
3	Analyse heat transfer parameters in various engineering applications.
4	Performance and emission parameters at different operating conditions.
5	Analyse performance variation with load at constant speed; discuss optimal operating point and dominant loss paths.
6	Estimate heat transfer coefficient and effectiveness of heat exchanger.

A) Suggested List of Experiments (Any Six)

Sr. No.	List of Experiments	CO Mapping
01	Measurement of thermal conductivity of metal rod	CO1
02	Measurement of heat transfer coefficient of composite material (Lag pipe)	CO1
03	Measurement of heat transfer coefficient by free/forced convection.	CO2
04	Performance analysis of extended surfaces under free and force convection.	CO2
05	Verification of Stefan Boltzmann Law.	CO3

06	To perform Load test along with heat balance sheet on Single cylinder Diesel engine with Rope brake dynamometer.	CO4
07	To perform Load test along with heat balance sheet on Multi cylinder petrol engine with Electrical dynamometer.	CO4
08	Determination of frictional power and mechanical efficiency of the Multi-cylinder Petrol Engine by Morse test.	CO5
09	To perform Load test along with heat balance sheet on Single cylinder petrol/kerosene engine with Electrical dynamometer. (speed constant)	CO6
10	To study the various heat exchangers	CO6
11	Estimation of overall heat transfer coefficient and effectiveness of heat exchanger.	CO6

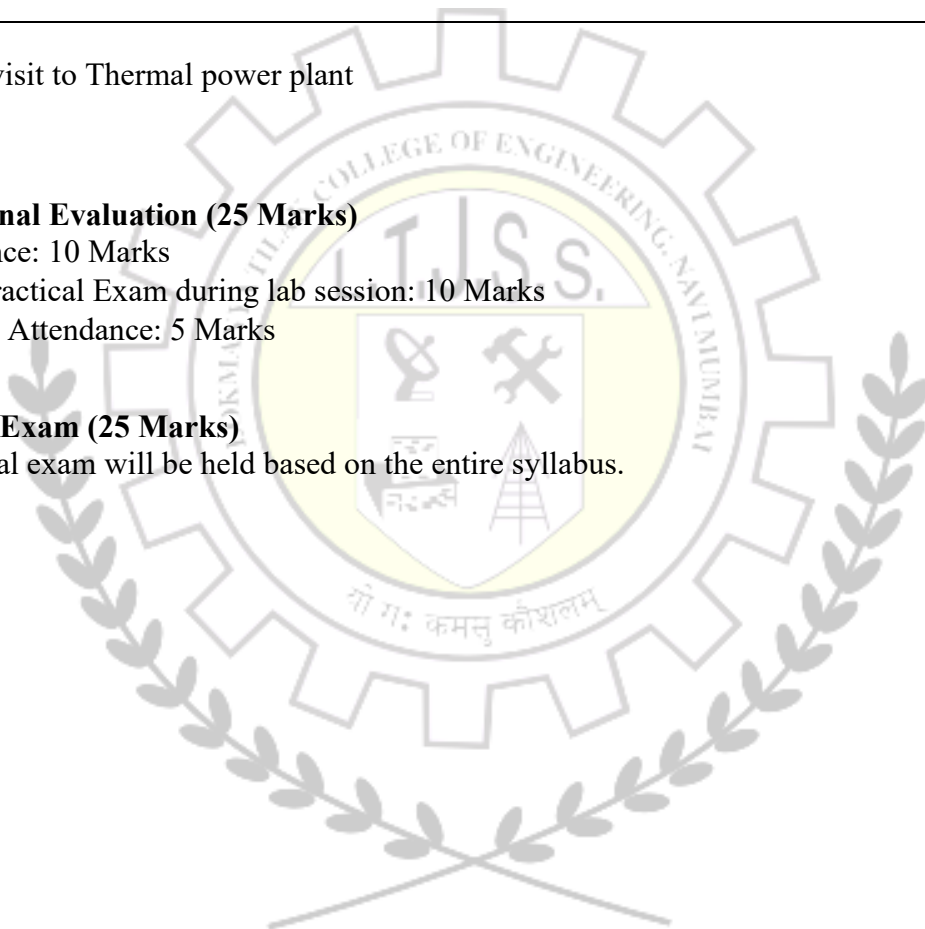
B) Industrial visit to Thermal power plant

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

An Oral & Practical exam will be held based on the entire syllabus.



Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
MEPCL502	CAD CAM Lab	-	25	25	-	-	50	

Prerequisite: MEVSEC301 CAD Modeling Lab

Course Objectives: The course aims to

01	Understand the dimension-driven design, associativity, and design intent capture.
02	Familiarize with subtractive manufacturing process in particular CNC systems.
03	Familiarize with additive manufacturing process in particularly 3D printing.
04	Acquaint with basic process of 3D modeling using biomedical data.

Course Outcomes: Learners will be able to

1	Create a parametric part using design parameters and constraints (dimensions & relations).
2	Develop and execute part programming for any given specific operation. Build any given object using various CNC operations.
3	Demonstrate CAM Tool path and prepare NC- G code.
4	Develop 3D model using available biomedical data
5	Build any given real-life object using 3D printing process
6	Understanding interoperability and data translation

Suggested List of Experiments (Any Six)

Sr. No.	List of Experiments	CO Mapping
01	Generation of any Assembly model along with Production drawing for any of the system by creating 3D modeling with assembly constraints, Interference check, Exploded view, GD&T, Bill of material.	CO1
02	Parametric & Feature-Based Modeling with Constraints: Tasks: Design a parametric component like bracket: define main dimensions as variables (length, width, hole spacing etc.) Apply geometric constraints (parallel, concentric) and dimensional relations (equations). Change a primary parameter and regenerate model; capture screenshots of updated geometry and BOM. Deliverables: Parametric CAD file, a small table of parameters & equations, screenshot showing parameter change.	CO1

03	Part programming and part fabrication on CNC Turning trainer/Simulation using open-source applications. (Involving processes like Step turning, facing, Taper turning, threading, etc.) (One job in a group of 4-5 students, simulation on individual basis)	CO2
04	Part programming and part fabrication on CNC Milling trainer /Simulation using open-source applications. (Involving processes like contouring, drilling, facing, pocketing etc.) (One job in a group of 4-5 students, simulation on individual basis)	CO2
05	Industrial visit /Case Study: Report on a visit conducted to any Commercial CNC Machining Centre.	CO2
06	Tool-path generation by translation of part geometry from computer aided design (CAD) to computer aided manufacturing (CAM) systems	CO3
07	Post processing of Code generated via CAM system	CO3
08	Development of a 3D CAD model from DICOM files Creation of 3D model from 2D images using any image processing software like, 3D Slicer (open source). Data Acquisition, Data Processing tools like, volume rendering, segmentation, thresholding, scissors, etc.	CO4
09	Simulation / Fabrication of a 3D Mechanical Structure via Additive Manufacturing Process Chain as (CAD Modeling → STL Generation → Slicing → Printing etc.)	CO5
10	Development of physical 3D mechanical structure Via: Generation of G&M codes, file transfer to FDM machine, and 3D printing for a bio medical application.	CO5
11	Development of CAD solid model of a physical component using reverse engineering concepts. (in a group of 3-4 students)	CO6
12	A CASE Study report on CAD CAM technology for reverse engineering applications.	CO6

NOTE: Any 6 experiments to be conducted covering all CO'S.

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

An Oral & Practical exam will be held based on entire syllabus.

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
MEPEL5011	MMC & MQE Lab	-	25	25	-	-	50	

Prerequisite: Fundamental concepts of mechanical and physical measurements, Understanding of units, significant figures, and basic error analysis, Basic knowledge of sensors, transducers, and simple electrical circuit behaviour.

Course Objectives: The course aims to

1	Study calibration procedures for various measuring instruments,
2	Examine the functional principles of mechanical measurement systems.
3	Become familiar with different types of control systems.
4	Understand the operational working of gauges,
5	Acquire knowledge of gear parameter measurement techniques, and
6	Gain familiarity with precision measurement operations and the instruments/equipment used for measurement.

Course Outcomes: Learners will be able to

1	Measure linear and angular dimensions accurately using appropriate precision measuring devices.
2	Apply the inspection gauge to check or measure surface parameters.
3	Measure various parameters of gear tooth profiles and screw threads using precision measurement tools and equipment.
4	Measure different mechanical parameters by using sensors.
5	Calibrate displacement, pressure, and vacuum measuring sensors using standard calibration procedures
6	Analyse the response of a control system.

Suggested List of Experiments (Any Six)

Sr. No.	List of Experiments: Metrology	CO Mapping
1	Experiments on linear and angular measurement using Vernier calliper, Micrometre and Bevel protractor.	CO1
2	Experiments on surface measurement by using Surface roughness tester.	CO2
3	Experiments on the measurement of gear parameters using the Gear	CO3
4	Experiments on screw thread measurement using screw thread	CO3
5	Experiments on linear/angular measurements of screw/gear/single point tool using Optical profile projector or Tool maker's	CO3
6	Experiment using a Mechanical / Pneumatic type Comparator.	CO1
7	Experiments on flatness measurement by Autocollimator / Interferometry method.	CO2

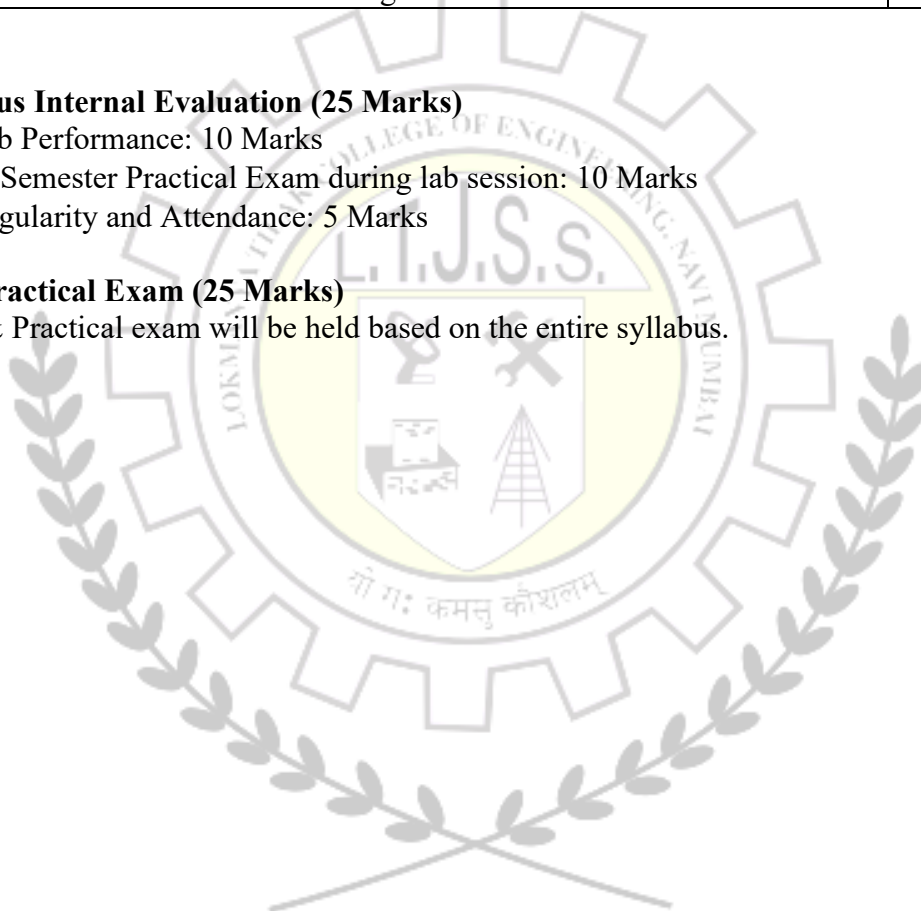
List of Experiments: Measurement & Control		
1	Experiments on the measurement of displacement by sensors like LVDT, Potentiometers, etc.	CO4
2	Experiments on calibration/measurement of pressure by gauges or	CO5
3	Experiments on the measurement of vibration by accelerometers.	CO5
4	Experiments on feedback control systems and servomechanisms.	CO6
5	Experiment on frequency response system identification / transient state response of a control system.	CO6
6	Experiment on the design of a PID controller for a system, or simulate and tune a PID controller using LabVIEW.	CO6

Continuous Internal Evaluation (25 Marks)

4. Lab Performance: 10 Marks
5. In-Semester Practical Exam during lab session: 10 Marks
6. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

An Oral & Practical exam will be held based on the entire syllabus.



Course Code	Course Name	Examination Scheme					Lecture	
		Marks Distribution			Exam Duration (Hrs)			Total Marks
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE	Total Credits	
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					
MEPEL5012	Optimization Techniques Lab	-	25	25	-	-		50

Prerequisite: Mathematics

Course Objectives: The course aims to

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

Course Outcomes: Learners will be able to

1	Understand basics and engineering applications of optimization
2	Get familiar with mathematical software to solve optimization problems in MATLAB
3	Understand basics of Classical Optimization Techniques
4	Understand Elimination Methods of Unconstrained Optimization
5	Understand Interpolation Methods of Unconstrained Optimization
6	Understand basics and engineering applications of optimization

Suggested List of Experiments (Any six)

Sr. No.	Title	CO Mapping
1	Introduction to Optimization	CO1
2	Introduction to MATLAB for solving optimization problems	CO2
3	Use of DOE for Classical Optimization Techniques	CO3
4	Use of statistical technique (ANOVA)	CO4
5	Unconstrained Optimization: Interpolation Method	CO5
6	Unconstrained Optimization: Direct Root Methods	CO6
7	Constrained Optimization: Equality Constraints	CO6
8	Constrained Optimization: Inequality Constraints	CO6

Continuous Internal Evaluation (25 Marks)

- 1.Lab Performance: 10 Marks
- 2.In-Semester Practical Exam during lab session: 10 Marks
- 3.Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

An Oral & Practical exam will be held based on the entire syllabus.

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)				1	
MEPEL5013	Manufacturing Sciences Lab	-	25	25	-	-	50	

Prerequisite:	
Course Objectives: The course aims to	
1	Study conventional machining operations
2	Familiarize with Design of Experiments
3	Acquaint with Non Traditional machining operations
Course Outcomes: Learners will be able to	
1	Estimate tool life, cutting forces, etc under varying conditions
2	Analyze effect of input parameters on response using DOE
3	Estimate forces for various machining operations using dynamometer
4	Measure temperature using thermocouples
5	Measure tool wear and surface finish
6	Identify machining parameters for various Non Traditional machining operations

List of Experiments (Any six)

Sr No.	Details	CO Mapping
1	Experiment to test Tool Life under varying conditions	CO1
2	To perform machining experiments to measure cutting forces, temperature, and tool wear (to validate single point design)	CO1
3	Use DOE to vary input parameters and analyse their effect on output response	CO2
4	Use of Dynamometer to measure forces during machining operations	CO3
5	Measure the temperature at the tool-workpiece interface using a pyrometer or embedded thermocouples	CO4
6	To measure the extent of tool wear (e.g., flank wear, crater wear) using a toolmaker's microscope or an electron microscope.	CO5

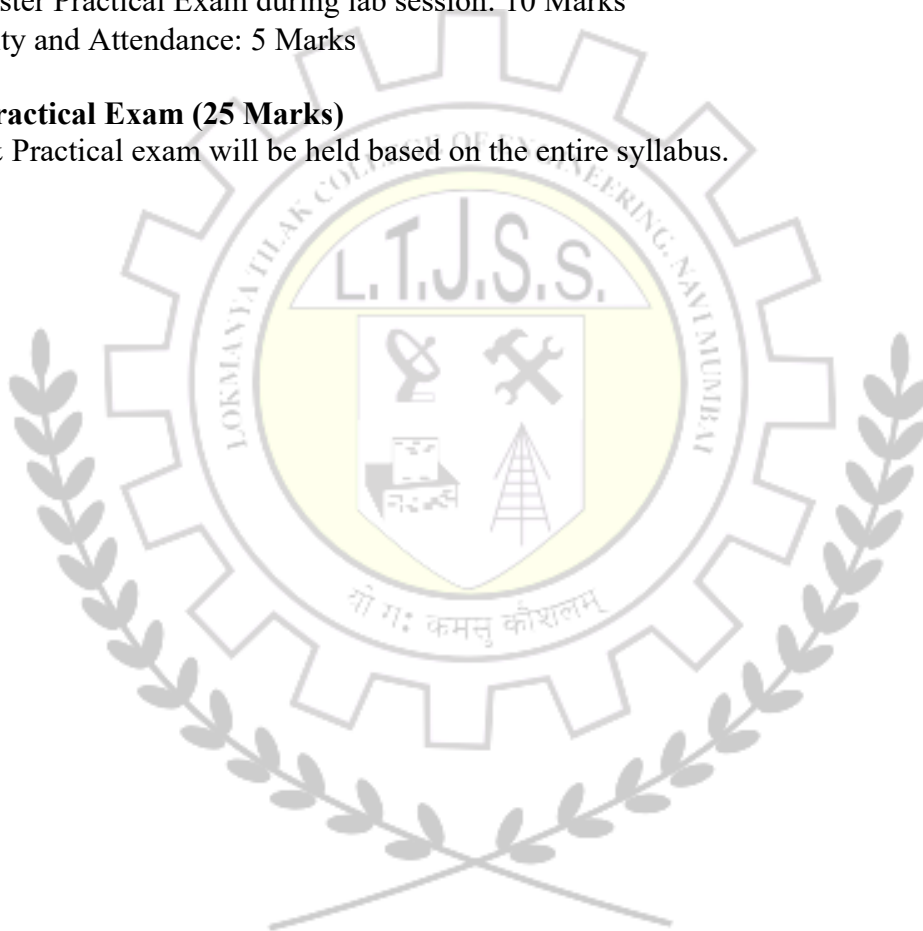
7	Use a surface roughness tester (profilometer) to quantify the quality of the machined surface finish.	CO5
8	Experiment on Machining of hexagon and square in shaping machine.	CO1
9	Experiment on Different Non Traditional machining operations with process parameters	CO6

Continuous Internal Evaluation (25 Marks)

- 1.Lab Performance: 10 Marks
- 2.In-Semester Practical Exam during lab session: 10 Marks
- 3.Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

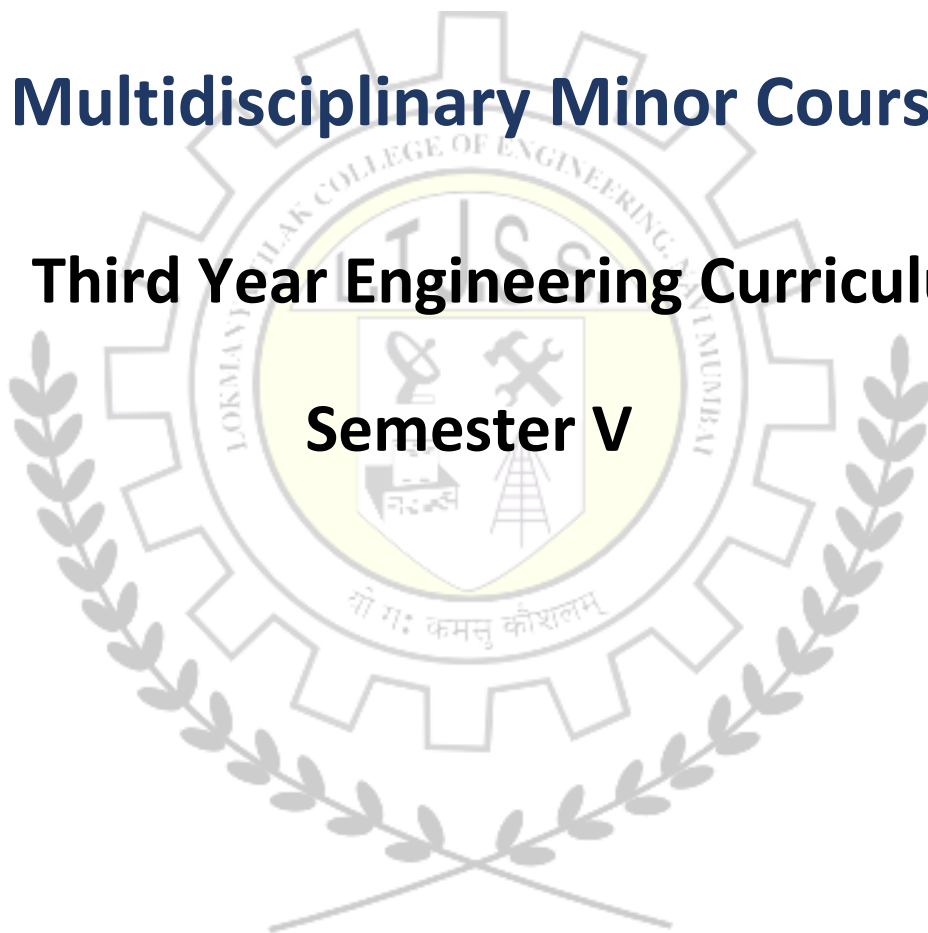
An Oral & Practical exam will be held based on the entire syllabus.



Multidisciplinary Minor Course II

Third Year Engineering Curriculum

Semester V



Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
CEMDM501	Database Management System	20	20	60	1	2	100	

Course Objectives: The course aims to	
1	Learn and practice data modelling using the entity-relationship and developing database designs.
2	Implement the use of Structured Query Language (SQL) and learn SQL syntax.
3	Illustrate the needs of database processing and learn techniques for controlling the consequences of concurrent data access
4	Analyse the concept of database security and privacy
Course Outcomes: Learners will be able to	
1	Describe the fundamentals of database systems
2	Implement the different data models and design issues in database.
3	Design ER diagram, relational schemas, apply concepts of normalization to relational database design.
4	Analyse the basics model of relational Algebra, calculus.
5	Experiment views, triggers and querying the database using SQL.
6	Implement transaction management, concurrency control. database security and privacy

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction to Databases	4	CO1
	Introduction to databases, History of database system, Benefits of Database system over traditional file system, relational databases, three tier database architecture, Data independence		
02	Data Models	3	CO2
	The importance of data models, Introduction to various data models (hierarchical, Network, Relational, Entity relationship and object model), Basic building blocks, Business rules, Degrees of data abstraction		
03	Database Design, ER-Diagram and Unified Modelling Language	10	CO3
	Database design and ER Model: overview, ER-Model and its Constraints, ER-Diagrams, ERD Issues, weak entity sets Codd's rules, Relational Schemas, Introduction to UML Relational database model: Logical view of data, keys, integrity rules. Relational Database design: features of good relational database design, atomic domain		
04	Relational Algebra and Calculus	10	CO4
	Relational algebra: Introduction, Selection and projection, set operations, renaming, Joins, Division, syntax, semantics. Operators, grouping and ungrouping, relational comparison. Calculus: Tuple relational calculus, Domain relational Calculus, calculus vs algebra, computational capabilities. Normalization methods : 1NF, 2NF, 3NF, BCNF, 4NF, 5NF		
05	Constraints, Views and SQL	10	CO5
	What is constraints, types of constrains, Integrity constraints, SQL: data definition, aggregate function, Null Values, nested sub queries, Joined relations. Triggers. Views: Introduction to views, data independence, security, updates on views, comparison between tables and views SQL Tools : MySQL, ORACLE 10G, POSTGRESQL		

06	Transaction management and Concurrency control	5	CO6
	Transaction management: ACID properties, serializability and concurrency control, Lock based concurrency control (2PL, Deadlocks), Time stamping methods, optimistic methods, database recovery management. Database Security and privacy: Issues, Access Control based on grant and revoke privileges		

Text Books:

1. Silberschatz, H Korth, S Sudarshan, “Database System and Concepts”, Fifth Edition McGraw-Hill
2. Rob, Coronel, “Database Systems”, Seventh Edition, Cengage Learning.
3. Ramez Elmasri, Shamkant B. Navathe, “Fundamentals of Database System”, Seventh Edition, Person.
4. G. K. Gupta, “Database Management Systems”, McGraw – Hill.

References:

1. Peter Rob and Carlos Coronel, “Database Systems Design, Implementation and Management”, Thomson Learning, 5th Edition.
2. P.S. Deshpande, “SQL and PL/SQL for Oracle 11g, Black Book”, Dreamtech Press
3. Mark L. Gillenson, Paulraj Ponniah, “Introduction to Database Management”, Wiley
4. Raghu Ramkrishnan and Johannes Gehrke, “Database Management Systems”, TMH
5. Debabrata Sahoo “Database Management Systems| Tata McGraw Hill, Schaum
6. <https://www.w3schools.in/dbms/>
7. <https://www.tutorialspoint.com/dbms/index.htm>
8. <https://www.studytonight.com/dbms/>

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
ETMDM501	Digital Communication and Sensor Technology	20	20	60	1	2	100	

Prerequisite: Basic Electronics and Electrical Engineering, Discrete mathematics fundamentals

Course Objectives: The course aims to

1	Develop a foundational understanding of digital communication systems, including their key components and underlying principles.
2	Analyze the techniques of source coding, channel capacity, error control, and the transmission of digital signals over communication channels.
3	Understand sensor types, key parameters, and their integration with digital systems.
4	Introduce concepts of inductive and capacitive transducers, and microsensors & micro-actuators, for practical application in measurement and control systems.

Course Outcomes: Learners will be able to

1	Describe the basic structure of a digital communication system and explain key channel parameters and transmission types.
2	Analyze the implications of Shannon-Hartley Capacity theorem while designing the efficient Source encoding technique.
3	Explain the concept and need for designing efficient Forward Error Correcting codes.
4	Understand the impact of inter-symbol interference (ISI) in baseband transmission and evaluate various digital modulation techniques.
5	Understand appropriate sensors and design corresponding signal-conditioning circuits based on their key characteristics such as range, resolution, sensitivity, and accuracy.
6	Describe the principles, construction, characteristics, and applications of inductive, capacitive, and micro sensors used for measurement and instrumentation.

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction to Digital Communication Systems	04	CO1
	Elements of basic digital communication system, Communication channel characteristics: bit rate, baud rate, bandwidth, repeater distance, Advantages and disadvantages of Digital transmission, significance of digitization: PCM encoding of voice and image signals		
02	Information Theory and Source Coding	06	CO2
	Measure of Information, Entropy, Information rate, Channel capacity, Shannon-Hartley Capacity Theorem and its Implications, Source coding: Huffman coding, Code Efficiency & Redundancy		
	Self-Learning Topic: Study how source coding reduces data size in practical file compression and transmission.		
03	Channel Coding	06	CO3
	Need for channel encoding, Concept of Error detection and correction, Forward Error correction Linear block codes: Hamming Distance, Hamming Weight, Systematic codes, Syndrome, Cyclic codes: Generator polynomial for Cyclic codes, Systematic cyclic codes Convolution codes: Convolution encoder, Impulse response of encoder		
04	Digital Transmission Fundamentals & Modulation Strategies	12	CO4
	Digital Transmission Fundamentals: Baseband and Passband Transmission, Line codes and their desirable properties, PSD of digital data, Baseband PAM transmission: Concept of Inter symbol interference (ISI), Eye diagram Types of digital modulation techniques and their advantages; concept of coherent vs. non-coherent detection Shift-keying techniques: Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), Differential Phase Shift Keying (DPSK), Quadrature Phase Shift Keying (QPSK): Types, Quadrature Amplitude Modulation (QAM): block diagrams of transmitter/receiver, working principle, key waveforms & constellation diagrams		
	Self-Learning Topic: M-ary encoding: M-ary FSK and M-ary PSK		
05	Fundamentals of Sensor Technology	06	CO5
	Introduction to Sensors, Classification, Selection, and Characteristics of Sensors: Range; resolution, Sensitivity, error, repeatability, linearity and accuracy Primary Sensing Elements and Signal Conditioning, Principles, Construction, and Applications of Common Sensors (potentiometer, Proving Rings, Strain Gauges, Resistance thermometer, Thermistor, Hot-wire anemometer, Resistance		

	Hygrometer, Photo-resistive sensor).		
06	Transducer and Microsensor Technologies	08	CO6
	Inductive transducers: - Principle of operation, construction details, characteristics and applications of LVDT, Induction potentiometer, variable reluctance transducer, synchros, microsyn Capacitive transducers: - Principle of operation, construction details, characteristics of Capacitive transducers – different types & signal conditioning- Applications: capacitor microphone, capacitive pressure sensor, proximity sensor Micro Sensors and Micro Actuators: Principles, Types and examples		
	Self-Learning Topic: Force and pressure micro sensors, position and speed micro sensors, acceleration micro sensors, chemical sensors, biosensors, temperature micro sensors and flow micro sensors		

Text Books:

1. H. Taub, D. Schilling, and G. Saha-Principles of Communication Systems, Tata Mc-Graw Hill, New Delhi, Third Edition, 2012.
2. Haykin Simon-Digital Communications, John Wiley and Sons, New Delhi, Fourth Edition, 2014.
3. Jacob Fraden, “Hand Book of Modern Sensors: physics, Designs and Applications”, 2015, 3rd edition, Springer, New York.
4. Patranabis. D, “Sensors and Transducers”, Wheeler publisher, 1994.

References:

1. T L Singal-Analog and Digital Communication, Tata Mc-Graw Hill, New Delhi, First Edition, 2012.
2. Lathi B P, and Ding Z-Modern Digital and Analog Communication Systems, Oxford University Press, Fourth Edition, 2017.
3. Sergej Fatikow and Ulrich Rembold, “Microsystem Technology and Microbotics”, First edition, Springer –Verlag NEwYork, Inc, 1997.
4. Jon. S. Wilson, “Sensor Technology Hand Book”, 2011, 1st edition, Elsevier, Netherland
5. NPTEL : <https://nptel.ac.in/courses/108102120>
6. NPTEL : <https://nptel.ac.in/courses/108106193>

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme					Total Marks	Lecture		
		Marks Distribution			Exam Duration (Hrs)				3 Hrs	
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE				Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)							
ARMDM501	Mechatronics	20	20	60	1	2	100			

Prerequisite: Fundamentals of Electrical & Electronics Engineering, Basics of Sensors & Instrumentation

Course Objectives: The course aims to

1	Study key elements of the Mechatronics system.
2	Familiarise with concepts of sensor characterisation, actuators and their interfacing with microcontrollers.
3	Introduce ADC/DAC conversion and basic signal filtering concepts
4	Study the design of pneumatic and hydraulic circuits.
5	Study and understand electropneumatic circuits and PLC Design
6	Demonstrate system reliability, communication interfaces and real mechatronic system integration.

Course Outcomes: Learners will be able to

1	Explain elements of the mechatronics systems and the mechatronics design process
2	Identify the suitable sensor and actuator for a mechatronics system
3	Analyze ADC/DAC processes and apply suitable signal filtering techniques for measurement systems.
4	Design & develop pneumatic/hydraulic circuits.
5	Design and develop electropneumatic circuits and PLC ladder logics.
6	Interpret system reliability aspects, communication interfaces and industrial case studies of mechatronic systems.

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction to Mechatronics	05	CO1
	1.1. Definition, scope and evolution of Mechatronics, Key elements of Mechatronic system (mechanical structure, sensors, actuators, electronics, control unit, software),		
	1.2. Integrated design approach in Mechatronics vs conventional design, Mechatronics design process (problem identification, modelling, simulation, prototyping, implementation)		
	Self-Learning Topic: Real-life mechatronic system identification (elevator, printer, washing machine, etc.)		
02	Selection of Sensors & Actuators	07	CO2
	2.1. Sensors: Criteria for selection of sensors based on requirements, principle of measurement, sensing method, performance chart, etc. (Displacement, temperature, acceleration, force/pressure) based on static and dynamic characteristics.		

	<p>2.2. Actuators: Selection of actuators based on principle of operation, performance characteristics, maximum loading conditions, safety, etc. Principle and selection of mechatronic actuators, i) DC motors, ii) Stepper Motors, iii) Solenoid Actuators, iv) Servo Motors, v) BLDC</p> <p>Self-Learning Topic: Examples of sensors used in household appliances Selection of an actuator for a small robotic arm</p>		
03	<p>Data Acquisition, Signal Conditioning & Microcontroller System Theory</p> <p>3.1. Concept of Bit accuracy/width and Sampling speed, sampling theorem, aliasing, Nyquist criteria, ADC (Analog to Digital Converter), Successive approximation method and sample and hold circuitry, DAC (Digital to Analog Converter), R-2R circuit and DAC resolution</p> <p>3.2. Signal Filters: Low pass, High Pass and Band Pass with circuit diagrams for simple cases</p> <p>Self-Learning Topic: Use of low-pass filter in removing noise from a sensor signal, Applications of band-pass filters</p>	07	CO3
04	<p>Design of Pneumatic & Hydraulic Circuits</p> <p>4.1. Design of Pneumatic Sequencing Circuits using the Cascade method and the shift register method (up to 2 cylinders)</p> <p>4.2. Basic Hydraulic Circuits: Meter in, meter out, and bleed off circuits; Intensifier circuits, Regenerative Circuit, Counterbalance valve circuit and sequencing circuits.</p> <p>Self-Learning Topic: Identification of hydraulic circuits used in industry, Safety precautions in handling hydraulic and pneumatic systems</p>	08	CO4
05	<p>Design of Electro-pneumatic Circuits</p> <p>5.1. Electro-pneumatic Circuits Design of Electro-Pneumatic Circuits using single solenoid and double solenoid valves, with and without grouping.</p> <p>5.2. PLC Discrete Control Systems Design of Pneumatic circuits using PLC Control (ladder programming only) up to 2 cylinders, with applications of Timers and Counters and concept of Flag and latching.</p> <p>Self-Learning Topic: Identification of electro-pneumatic components used in industrial Automation</p>	08	CO5
06	<p>Reliability, communication, and Case studies</p> <p>6.1. Reliability, maintainability, safety, and fault diagnosis in mechatronic systems</p> <p>6.2. Communication Protocols (overview only), CAN, UART, SPI, I2C (basics only)</p> <p>6.3. Case Studies: Automotive ABS, CNC feed drive system, Pick & place robot, Smart manufacturing cell</p>	07	CO6

Text Books:

1. Applied Mechatronics- A. Smaili and F. Mrad, OXFORD university press
2. Mechatronics System Design, Shetty and Kolk, Cengage Learning, India Edition
3. Introduction to Mechatronics, AppuKuttan K.K., OXFORD Higher Education
4. Pneumatic Circuits and Low-Cost Automation by Fawcett JR
5. Electromechanical Design Handbook, Walsh, McGraw-Hill
6. Electro-mechanical Engineering - An Integrated Approach, Fraser and Milne
7. Frank Petruzella, " Programmable Logic Controllers", McGraw-Hill Education; 4 edition

References:

1. Industrial Hydraulics: Pippenger
2. Vickers Manual on Hydraulics
3. Hydraulic Valves and Controls: Pippenger
4. Fundamentals of pneumatics: Festo series
5. Mechatronics, Nitaigour Mahalik, Tata McGraw-Hill
6. Mechatronics, HMT
7. John W Webb and Reis, Ronald A., "Programmable Logic Controllers: Principles & Applications", Prentice Hall.

NPTEL/SWAYAM courses:

- a. https://onlinecourses.nptel.ac.in/noc21_me27/preview
- b. <https://nptel.ac.in/courses/117105082>

Internal Assessment (40 Marks)**A. Mid Semester Exam (20 Marks)**

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to the Mid Semester Examination (MSE), carrying 20% to 30% weightage, and the syllabus covered from MSE to ESE, carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
ITMDM501	Sensors Actuators and Transducers	20	20	60	1	2	100	

Prerequisite: Students should be able to implement the fundamental knowledge of the IoT system.	
Course Objectives: The course aims to	
1	To understand the working principles and classifications of sensors, actuators, and transducers.
2	To learn micro and MEMS sensors and actuators for IoT systems.
3	To study electrical interfacing, signal conditioning, and calibration techniques.
4	To design IoT-based systems using real-time sensing and actuation.
Course Outcomes: Upon successful completion of this course, the learner will be able	
1	Explain operating principles and classifications of sensors, actuators, and transducers.
2	Identify and select appropriate sensors for various IoT applications.
3	Describe actuator types and their control techniques.
4	Explain transduction mechanisms and their practical implementation.
5	Design and implement IoT-based systems integrating sensors, actuators, and transducers.
6	Understand the concept of Advanced transducers and their IoT integration

Prerequisite: Students should be able to implement the fundamental knowledge of the IoT system.	
Course Objectives: The course aims to	
1	To understand the working principles and classifications of sensors, actuators, and transducers.
2	To learn micro and MEMS sensors and actuators for IoT systems.
3	To study electrical interfacing, signal conditioning, and calibration techniques.
4	To design IoT-based systems using real-time sensing and actuation.
Course Outcomes: Upon successful completion of this course, the learner will be able	
1	Explain operating principles and classifications of sensors, actuators, and transducers.
2	Identify and select appropriate sensors for various IoT applications.
3	Describe actuator types and their control techniques.
4	Explain transduction mechanisms and their practical implementation.
5	Design and implement IoT-based systems integrating sensors, actuators, and transducers.
6	Understand the concept of Advanced transducers and their IoT integration

Module	Detailed Contents	Hrs.	CO Mapping
01	Fundamentals and Classification of Sensors: 1.1 Introduction to sensors and measurement systems. 1.2 Sensor characteristics: sensitivity, resolution, accuracy, range, hysteresis, drift, and linearity. 3. Classification: active/passive, analog/digital, contact/non-contact sensors. 4. Types of sensors for measurement of : flow, temperature, pressure, proximity, force/strain, speed/velocity, displacement/position, acceleration/motion, sound, vibration, humidity, gas, biosensor, pH, infrared, image/vision 5. Selection criteria and standards for sensors. 1.6 Overview of smart sensors and IoT sensor nodes. 1.7 Applications: Home automation, smart lighting, temperature monitoring Self-Learning Topic: Application for moisture measurement	08	CO1
	Micro and MEMS Sensors for IoT: 2.1 Introduction to MEMS and micro-sensors. 2.2 MEMS fabrication techniques (lithography, etching, deposition, packaging) 2.3 Micro-sensors: <ul style="list-style-type: none"> • Accelerometer, gyroscope, pressure, flow, temperature, and humidity sensors • Biosensors and chemical sensors 2.4 Integration of MEMS sensors in IoT platforms (smartphones, wearables, vehicles) 2.5 Sensor calibration, signal conditioning, and interfacing. Self-Learning Topic: Case Study: MPU6050 IMU, BMP280 environmental sensor, DHT11		
02		06	CO2

03	Fundamentals of Actuators and Drive Mechanisms 1. Introduction to actuators – principle, classification, and characteristics 3.2 Electrical actuators: <ul style="list-style-type: none"> • DC motor, stepper motor, servo motor • Control techniques (PWM, H-bridge) 3. Pneumatic and hydraulic actuators – basic operation and control valves. 4. Mechanical actuators- operation and types and control circuit. 5. Smart actuators and drive circuits for IoT. 6. Thermal actuators- basic operation and control circuit. 7. Magnetic actuator-basic operation and control circuit 8. Applications: Smart door locks, automatic fans.	08	CO3
	Self-Learning Topic: Application in robotic arms		
04	Micro-Actuators and Intelligent Actuation Systems 4.1 MEMS micro-actuators: electrostatic, piezoelectric, thermal, and magnetic types. 4.2 Shape memory alloy (SMA) actuators. 4.3 Micro-pumps, micro-valves, and micro-grippers. 4.4 Interfacing actuators with microcontrollers and IoT boards (Arduino, ESP32, Raspberry Pi)	06	CO4
	Self-Learning Topic: Case studies: micro-actuators in biomedical devices and robotics		
05	Transducer Fundamentals and Signal Conditioning: 1. Concept of transduction and transducers 2. Types of transduction mechanisms: resistive, inductive, capacitive, piezoelectric, and optical. 3. Conversion principles and energy domains. 4. Static and dynamic characteristics of transducers. 5. Signal conditioning: amplification, filtering, isolation, ADC/DAC, noise reduction. 6. Applications: Strain measurement, pressure.	07	CO5
	Self-Learning Topic: Application in force detection.		
06	Advanced Transducers and IoT Integration 1. Optical fiber, ultrasonic, and photoelectric transducers. 2. Smart and digital transducers. 3. Wireless transducer networks and IoT interfacing. 4. Calibration, compensation, and error analysis. 5. Data acquisition systems and sensor fusion. 6. Cloud-based monitoring (Thing Speak, Blynk, MQTT).	07	CO6
	Self-Learning Topic: Case Studies: Smart agricultural sensing system and IoT-enabled vibration and air-quality transducer networks.		

Text Books

1. D. Patranabis, *Principles of Industrial Instrumentation*, Tata McGraw Hill
2. Arshdeep Bahga & Vijay Madisetti, *Internet of Things: A Hands-On Approach*
3. Clarence W. de Silva, *Sensors and Actuators: Engineering System Instrumentation*, CRC Press

References:

1. Franky Hillenbrand, *MEMS Sensors and Actuators*, Springer
2. John G. Webster, *Measurement, Instrumentation, and Sensors Handbook*
3. Misra, A Mukharjee, A Roy, “Introduction to IoT”, Cambridge University Press
4. A. Mukharjee, C. Roy , Sudip Misra, “Introduction to Industrial Internet of Things and Industry 4.0”,

Website Reference / Video Courses:

1. NPTEL Course: **Introduction to Industrial Internet of Things and Industry 4.0** By Prof. S. Misra , Dept. of Computer Science and Engineering, IIT Kharagpur.:- Web link-

https://onlinecourses.nptel.ac.in/noc21_cs20/preview

Internal Assessment (40 Marks)**A. Mid Semester Exam (20 Marks)**

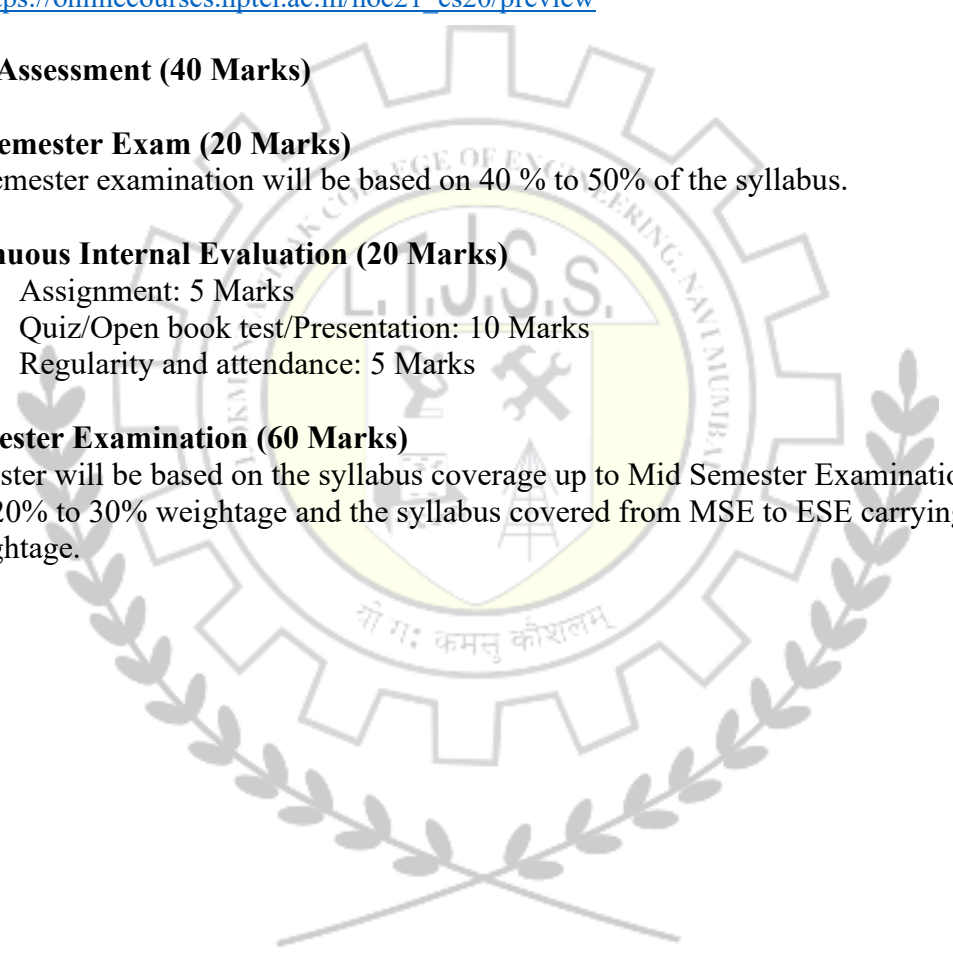
Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.



Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
MEMDM501	Conventional & Renewable Energy Sources	20	20	60	1	2	100	

Prerequisite: Thermal Engineering	
Course Objectives: The course aims to	
1	Study working principles of various renewable energy sources and their utilities
2	Study working principles of various Thermal & Hydro Electric Power plants.
3	Study economics of harnessing energy from renewable energy sources
Course Outcomes: Learners will be able to	
1	Analyze the various energy sources & its availability in India & world.
2	Describe the operating principle of Thermal & hydel power plants.
3	Describe the operating principle of nuclear power plants.
4	Analyze different solar collectors using geometrical parameters and photovoltaics for generation of solar energy & its application
5	Identify and analyze various wind turbine energy harnessing techniques.
6	Identify various Mini & Micro Hydro Electric Plants & wind turbine energy harnessing techniques

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction to Energy	05	CO1
	Types of Energy, energy scenario in India & world, Energy demand & supply & consumption trend.		
02	Thermal & hydroelectric Power.	10	CO2
	Fossil fuels: coal, natural gas formation & use Thermal power generation: basic layout & working., hydro power plants: principal, types & components. Advantages, disadvantages & environmental impacts.		
	Self-Learning Topic: Hydrology		
03	Nuclear Energy:	06	CO3
	Nuclear fission, fusion, components & layout of Nuclear Power plants, Site Selection. Safety & waste disposal		
	Self-Learning Topic: Nuclear Materials		

04	Solar Energy:	08	C04
	Solar Radiation, Sun Earth Angle, Solar Measurement Devices, Solar Energy Collectors. Application of Solar Energy		
05	Wind Energy:	07	C05
	Resources of Wind, Classification of Wind Mills, Wind Energy Conversion System (WECS), Performance Characteristics of Wind Mill, Application of wind energy & Site Selection.		
06	Other Renewable Energy Sources:	06	C06
	Mini & Micro Hydro Electric Plants, Application & Site Selection. Hybrid Energy, Economic Environmental & Regulatory Aspects of Renewable Sources.		
	Self-Learning Topic: Hydrology		

Text Books:

1. "Non-conventional Energy Sources", G.D. Rai, 6th Edition, Khanna Publishers, ISBN: 978-81-7409-073-7
2. "Solar Energy: Principles of Thermal Collection and Storage", SP Sukhatme and J K Nayak, 4th Edition, Tata McGraw Hill Publishing Co. Ltd.
3. "Renewable Energy Sources", J W Twidell & Anthony D. Weir, 3rd Edition 2015, ELBS Pub, ISBN: : 978-1-315-76641-6
4. Power Plant Engineering by Prof, V M Domkundwar
5. Power Plant Engineering by Prof Rajput

References:

1. <https://nptel.ac.in/courses/103103206>
2. <https://nptel.ac.in/courses/103107157>
3. <https://nptel.ac.in/courses/115105127>

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

C. End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)				3	
EEMDM501	Special Machines and smart grid	20	20	60	1	2	100	

Prerequisite: Basic Electrical Engineering, Electric Machine

Course Objectives: The course aims to

1	Understand how to integrate renewable energy sources, such as solar and wind, into both existing and future power grids.
2	Learn the construction, principle of operation, and performance characteristics of various special machines.
3	Identify and understand the applications of special machines and smart grid in modern technology.

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

1	Describe the construction, principle of operation, performance characteristics and control schemes of stepper motors.
2	Describe the construction, principle of operation, performance characteristics and control schemes of switched reluctance, motors.
3	Describe the construction, principle of operation, performance characteristics and control schemes of BLDC motor.
4	Describe the construction, principle of operation, performance characteristics and control schemes of PMSM motors.
5	Analyze the necessity and architectures of smart grid.
6	Understand the concept of distributed generation and its operation.

Module	Detailed Contents	Hrs.	CO Mapping
01	Stepper Motors:	07	CO1
	1.1 Construction and working principle.		
	1.2 Types: Variable Reluctance, Permanent Magnet, and Hybrid Stepper Motors.		
	1.3 Torque–angle characteristics, static and dynamic performance		
	1.4 Drive and control circuits (unipolar/bipolar, open-loop and closed-loop control)		
	1.5 Microcontroller or Arduino-based stepper control		
1.6 Applications: CNC machines, robotics and printers			
	Self Learning Topic: Application in positioning system		

02	Switched Reluctance Motors (SRM)	07	CO2
	2.1 Construction and operating principle		
	2.2 Torque production and control methods		
	2.3 Converter topologies for SRM drives		
	2.4 Sensor and sensorless control techniques		
	2.5 Design and performance considerations		
2.6 Applications: Electric vehicles and renewable energy systems			
Self Learning Topic: Applications in industrial drives			
03	Brush less DC Motors (BLDC)	07	CO3
	3.1 Brush less dc motor drive for servo applications.		
	3.2 Low cost brush less dc motor drives		
	3.4 Important features		
	3.5 Applications: Home appliances, EVs		
Self Learning Topic: Use of PMBLDC in aerospace systems.			
04	Permanent Magnet Synchronous Motors (PMSM)	07	CO4
	Construction and principle of operation		
	4.1 Types: Surface-mounted and Interior PMSMs		
	4.2 EMF and torque equations		
	4.3 Vector control (FOC) and direct torque control (DTC) principles		
Applications: Servo systems, robotics, aerospace, traction drives			
Self Learning Topic: comparison between synchronous motor and PMSM motor.			
05	Introduction to smart grid :	07	CO5
	5.1 Conventional power systems and Smart grid, definition of smart grid, need for smart grid,		
	5.2 Smart grid architecture, smart grid domains, enablers of smart grid, 5.3		
	Communication architecture and protocols for smart grid, smart grid priority standards and regulation.		
Self Learning Topic: smart-grid activities in India.			
06	Distributed Generation and communication in Smart Grid:	07	CO6
	6.1 Renewable-based Distributed generations, Introduction to energy storage devices,		
	6.2 Different types of energy storage technologies,		
	6.3 Battery management system (BMS): concept, types and applications,		
	6.4 smart grid communication technologies.		
Self Learning Topic: need of renewable energy sources.			

Text Books

1. K. Venkataratnam, *Special Electrical Machines*, Universities Press.
2. E. G. Janardanan, *Special Electrical Machines*, PHI Learning.
3. Microgrids architectures and control Edited by Nikos Hatziargyriou, Wiley, IEEE Press, 2014.
4. A. Keyhani, M. N. Marwali, M. Dai, *Integration of Green and Renewable Energy in Electric Power Systems*, Wiley, 2009.

5. Antonio Carlos Zambroni de Souza, Miguel Castilla, *Microgrids Design and Implementation*, Springer 2019.
6. James Momoh, —*Smart Grid: Fundamentals of Design and Analysis*, IEEE Press and Wiley Publications, 2015.
7. J. C. Sabonnadière, N. Hadjsaid, —*Smart Grids*, Wiley Blackwell.

References:

1. T. J. E. Miller, *Brushless Permanent Magnet and Reluctance Motor Drives*, Clarendon Press.
2. R. Krishnan, *Electric Motor Drives – Modeling, Analysis and Control*, Prentice Hall.
3. D. P. Kothari and I. J. Nagrath, *Electric Machines*, Tata McGraw Hill.
4. G. K. Dubey, *Fundamentals of Electrical Drives*, Narosa Publications
5. Yezdani, and Reza Iravani, *Voltage Source Converters in Power Systems: Modeling, Control and Applications*, John Wiley Publications, 2010.
6. Dorin Neacsu, *Power Switching Converters: Medium and High Power*, CRC Press, 2006.
7. J. Ekanayake, N. Jenkins, K. Liyanage, J. Wu, A. Yokoyama, *Smart Grid: Technology and Applications*, Wiley, 2012.
8. IEEE standards —IEEE-1547-2003: IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems IEEE standards 2003.
9. IEEE standards —IEEE 1547-4-2011: IEEE Guide for Design Operation & Integration of Distributed Resources Island System with Electric Power System.
10. Consortium for Electric Reliability Technology Solutions (CERTS) white paper on Integration of Distributed Energy Resources: The CERTS Microgrid Concept' 2002.
11. NPTEL Course: DC Microgrid and Control System, Prof. Avik Bhattacharya, IIT Roorkee.

Website Reference / Video Courses:

1. **NPTEL Course: Special Electromechanical Systems** By Prof. S. S. Murthy, Yogesh Hote, Dept. of Electrical Engineering, IIT Delhi.:- Web link- <https://nptel.ac.in/courses/108102156>
2. **NPTEL Course: Introduction to Smart Grid**, By Prof. N. P. Padhy & Prof. Premalata Jena, IIT Roorkee

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					
CEMDML501	Database Management System Lab	-	25	-	-	-	25	

Course Objectives: The course aims to

1	Explore design and develop of relational model 2 3
2	Present SQL and procedural interfaces to SQL comprehensively
3	Introduce the concepts of transactions and transaction processing
4	Design of different queries.

Course Outcomes: Learners will be able to

1	Design ER /EER diagram and convert to relational model for the real world application.
2	Apply DDL, DML, DCL and TCL commands
3	Apply simple and complex queries
4	Explore PL / SQL Constructs.
5	Learn simple and complex queries
6	Demonstrate the concept of Views, Trigger

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
1	Identify the case study and detail statement of problem. Design an Entity-Relationship (ER) / Extended Entity-Relationship (EER) Model	CO1
2	Mapping ER/EER to Relational schema model.	CO 1
3	Create a database using Data Definition Language (DDL) and apply integrity constraints for the specified System	CO 2
4	Apply DML Commands for the specified system	CO 2
5	Perform Simple queries, string manipulation operations and aggregate functions.	CO 3
6	Implement various Join operations.	CO 4
7	Perform Nested and Complex queries	CO 5
8	Perform DCL and TCL commands	CO 2
9	Implement procedure and functions	CO 5
10	Implementation of Views and Triggers	CO 6

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
ETMDML501	Digital Communication and Sensor Technology Lab	-	25	-	-	-	25	1

Prerequisite:

Course Objectives: The course aims to

1	To understand the fundamental concepts and components of digital communication systems and various digital modulation techniques.
2	To analyze and implement source coding, channel coding, and line coding techniques for efficient and reliable data transmission.
3	To study and perform signal conversion techniques such as Pulse Code Modulation (PCM) and digital modulation schemes like ASK, PSK, FSK, and QPSK.
4	To understand the working principles, characteristics, and applications of various sensors and transducers used for physical parameter measurement.

Course Outcomes: Learners will be able to

1	Identify and explain the basic elements, characteristics, and performance parameters of a digital communication system.
2	Demonstrate the process of Pulse Code Modulation (PCM), source coding (Huffman coding), and analyze information rate and entropy of a discrete source.
3	Design and implement error detection and correction codes such as linear block codes, cyclic codes, and convolutional codes.
4	Generate and compare different line coding and digital modulation schemes (ASK, FSK, PSK, QPSK) in terms of performance and bandwidth efficiency.
5	Experimentally analyze the characteristics and working principles of various displacement, pressure.
6	Demonstrate the operation of temperature, and light sensors and MEMS-based microsensors and understand their applications in modern measurement and control

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	To study and understand the basic elements of a digital communication system	CO1
02	To study and perform Pulse Code Modulation (PCM) and Demodulation of an analog signal.	CO1
03	To calculate the amount of information and entropy for a given discrete message source.	CO2
04	To design and implement Huffman coding for a given discrete source and calculate code efficiency and redundancy.	CO2
05	Linear block code generation and error detection	CO3
06	Cyclic code generation and error detection	CO3
07	Convolutional code generation	CO3
08	Line Codes generation and performance comparison	CO4
09	Generation (and detection) of Binary ASK, Binary PSK, and Binary FSK.	CO4
10	Generation (and detection) of QPSK	CO4
11	Study of Characteristics of a Potentiometer as a Displacement Sensor	CO5
12	Study of LVDT (Linear Variable Differential Transformer) Characteristics	CO5
13	Study of Capacitive Transducer for Displacement or Pressure Measurement	CO5
14	Study and Characterization of a Thermistor (Temperature Sensor)	CO6
15	Study of Photo-resistive Sensor (LDR) characteristics (Light intensity vs resistance)	CO6
16	Demonstration of MEMS-based sensors (e.g., accelerometer, pressure sensor using Arduino or NI-ELVIS)	CO6

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Course Code	Course Name	Examination Scheme					Total Marks	Practical
		Marks Distribution			Exam Duration (Hrs)			
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					
ARMDML501	Mechatronics Lab	-	25	-	-	-	25	

Prerequisite: Basic knowledge of electrical and mechanical systems, control theory, and microcontroller programming.

Course Objectives: The course aims to

1	Understand fundamentals of mechatronic systems, sensors, and actuators.
2	Interface and control electrical and mechanical devices using microcontrollers
3	Identify and analyze dynamic characteristics of actuators.
4	Apply automated controls using pneumatic and pneumatic. systems.
5	Implement PLC programs for automation applications.

Course Outcomes: Learners will be able to

1	Demonstrate the interfacing and control of sensors and actuators using microcontrollers.
2	Demonstrate the interfacing of different electrical/mechanical devices (motors, heaters, etc.) with microcontrollers.
3	Identify dynamic characteristics of an actuator through experimental system identification.
4	Demonstrate use of automated controls using pneumatic systems.
5	Demonstrate use of automated controls using hydraulic systems.
6	Implement a program on the PLC system and demonstrate its application.

Suggested List of Experiments (Any six)

Sr. No.	List of Experiments:	CO Mapping
1	Interfacing of Stepper Motor with microcontroller and its programming for Rotational or XY table (It is suggested to program to vary the position of the rotary or XY table and compare the positioning accuracy using a standard calibrated angular or linear sensor).	CO1
2	Interfacing of DC Motor with microcontroller and its programming for characterization of DC motor setup (It is suggested to program to vary the speed of DC motor and determine its load-speed)	CO2
3	Case study on System Identification with different sensors & actuators.	CO3
4	Designing a sequential operation for two cylinders using electro-pneumatic circuits.	CO4
5	Simulation of basic pneumatic and electro-pneumatic circuits (using software like Festo, AutoSim , etc.).	CO4
6	Simulation of hydraulic and electro-hydraulic circuits (using software like Festo, AutoSim, etc).	CO5

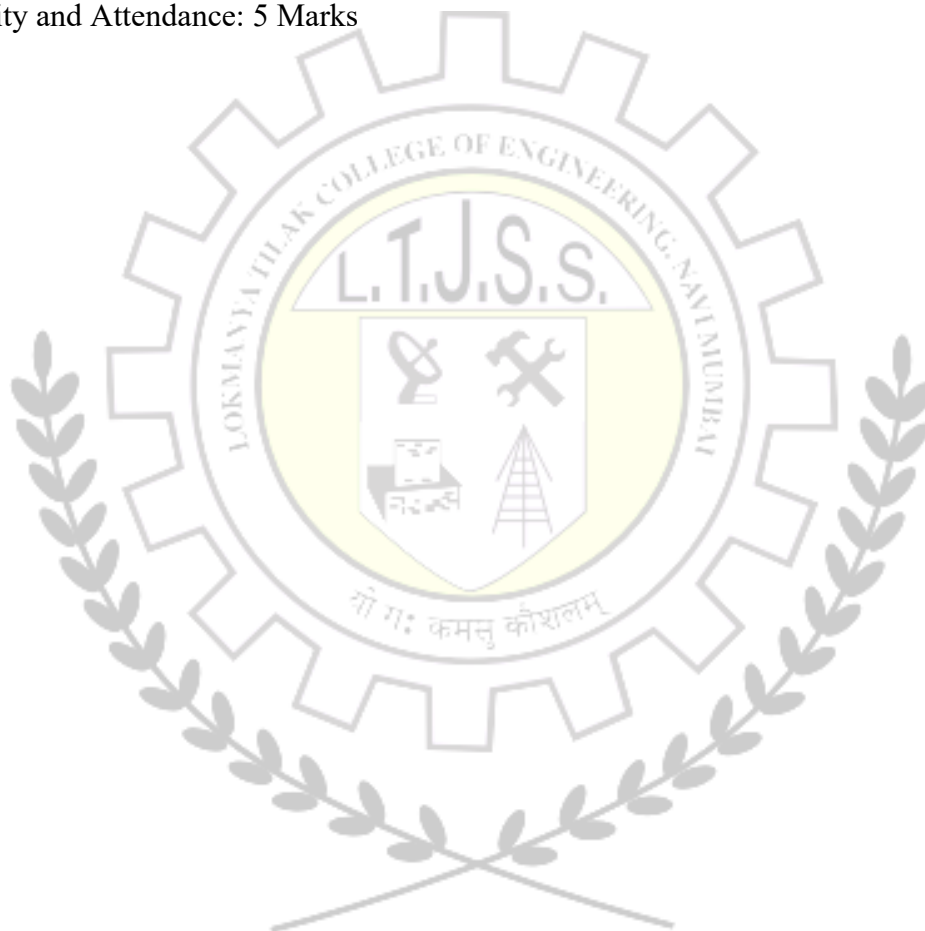
7	Designing a sequential operation for two cylinders using electro-hydraulic circuits.	CO5
8	Experiments on Ladder programming on PLC for simple on-off control, timers, counters, two motor system, and simple control applications with logic/ timers/counters.	CO6
9	Experiments on Ladder programming for Mechatronics systems (e.g. bottle filling plant, control of electro-pneumatic or electro-hydraulic systems).	CO6

Continuous Internal Evaluation (25 Marks)

1.Lab Performance: 10 Marks

2.In-Semester Practical Exam during lab session: 10 Marks

3.Regularity and Attendance: 5 Marks



Course Code	Course Name	Examination Scheme					Total Marks	Practical	
		Marks Distribution			Exam Duration (Hrs)				Total Credits
		Internal Assessment		Oral & Practical	MSE	ESE		1	
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)						
ITMDML501	Sensors, Actuators and Transducers Lab	-	25	-	-	-	25		

Prerequisite:

Course Objectives: The course aims to

- 1 Implement, test and characterize sensors (analog/digital/MEMS) used in IoT.
- 2 Design simple signal-conditioning circuits and ADC interfacing.
- 3 Control actuators (DC/stepper/servo/relay/solenoid) from microcontrollers.
- 4 Calibrate sensors, perform error analysis and document results.

Course Outcomes: Learners will be able to

- 1 Implement, test and characterize sensors (analog/digital/MEMS) used in IoT.
- 2 Implement, test and characterize transducers used in IoT.
- 3 Implement, test and characterize micro sensors used in IoT.
- 4 Implement, test and characterize actuators (DC/ stepper/servo/relay/solenoid) used in IoT.

Suggested List of Experiments

S. N	List of Experiments	CO Mapping
01	Study of analog and digital temperature sensors	CO1
02	Interfacing MEMS accelerometer (MPU6050) with Arduino	CO2
03	Interfacing servo and stepper motors using PWM	CO4
04	Interfacing DC motor with H-bridge driver circuit	CO4
05	Study of piezoelectric transducer	CO2
06	Signal conditioning for sensor data (amplifier + filter)	CO3
07	IoT data acquisition using ESP32/ESP8266 and cloud platform	CO3
08	Calibration and performance evaluation	CO2,3,4
09	Mini project using sensors and actuators	CO1,2,3,4
10	Measurement of temperature using DHT11, thermistor, thermocouple	CO2,
11	Measurement of pressure using Piezoelectric sensor, Bourdon tube, Strain-gauge pressure sensor, BMP180, MPX5010	CO2
12	Demonstration of IR sensor for proximity sensing	CO3
13	Automatic lighting system using LDR	CO3
14	Motion detection using MEMS Accelerometer (ADXL335, MPU6050), Gyroscope	CO3,4

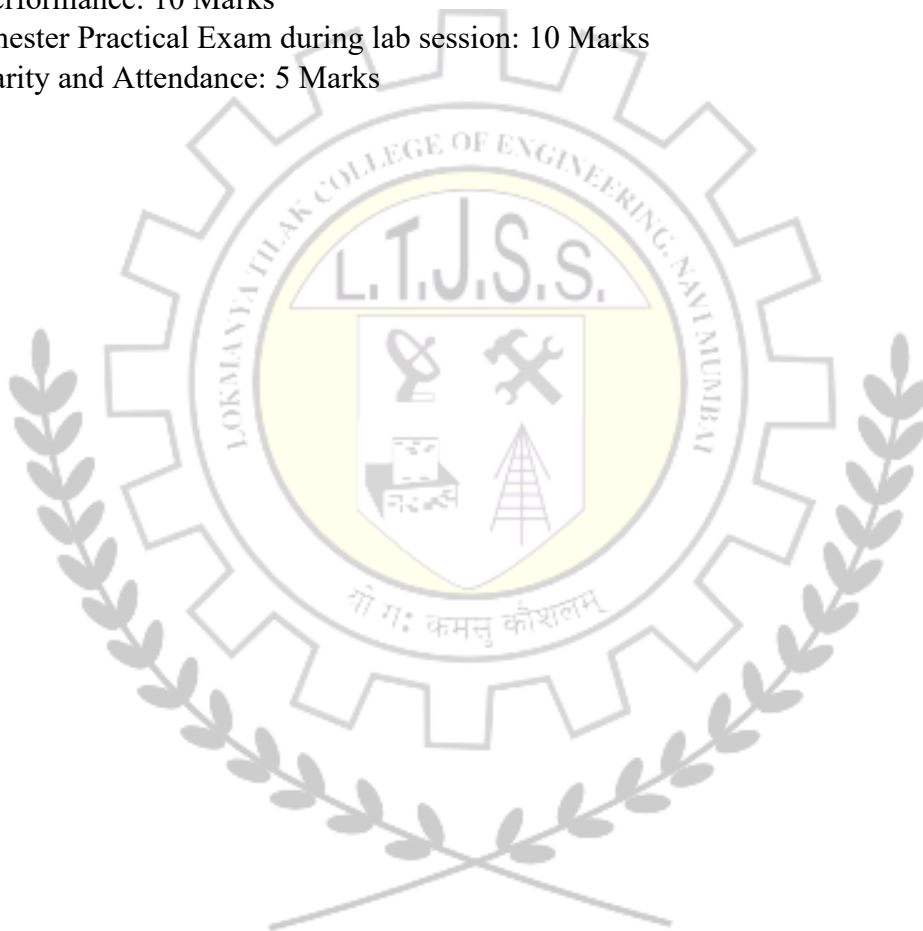
Reference Websites

- <https://www.arduino.cc>
- <https://randomnerdtutorials.com>
- <https://thingspeak.com>
- <https://blynk.io>
- <https://www.mems-exchange.org>

Lab performance: Minimum 8 experiments must be conducted to keep the term valid. Any other experiment may be conducted on the related topics of the theory course.

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks



Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
MEMDML501	Renewable Energy Sources Lab	-	25	--	-	-	25	

Prerequisite: Thermal Engineering

Course Objectives: The course aims to

1	To study working principles of various renewable energy sources and their utilities
2	To study working principles of various Thermal & Hydro Electric Power plants.
3	To study economics of harnessing energy from renewable energy sources

Course Outcomes: Learners will be able to

1	Analyze the various energy sources & its availability in India & world.
2	Describe the operating principle of Thermal & hydel power plants.
3	Describe the operating principle of nuclear power plants.
4	Analyze different solar collectors using geometrical parameters and photovoltaics for generation of solar energy & its application
5	Identify and analyze various wind turbine energy harnessing techniques.
6	Identify various Mini & Micro Hydro Electric Plants & wind turbine energy harnessing techniques

Suggested List of Experiments (Any six)

Sr. No.	List of Experiments	CO Mapping
01	Demonstration on Solar Cooker	CO4
02	Demonstration on Solar Panel Test Rig.	CO4
03	Case Study on Wind Mill.	CO5
04	Study of Components of Wind Mill.	CO5
05	Study of Component & layout of thermal power plant.	CO2
06	Study of Component & layout of hydroelectric power plant.	CO2
07	Study of Mini & Micro Hydro Electric Plants	CO6
08	Case study on Energy Scenario & pattern of consumption of fossil fuel in Indian	CO1
09	Study of Component & layout of nuclear power plant.	CO3
10	Compulsory Visit to Any Renewable Source installation or conventional power plant.	CO1-6

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Course Code	Course Name	Examination Scheme						Practical	
		Marks Distribution				Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits	
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1	
EEMDML501	Special Machines and smart grid Lab	-	25	-	-	-	25		

Prerequisite: Students know the construction, working principle and operation of DC machines, transformers and Induction motors

Course Objectives: The course aims to

1	Introduce various special electrical machines beyond conventional DC and AC machines.
2	Explain the construction, working principles, and control techniques of stepper, reluctance, and permanent magnet motors.
3	Highlight applications of special motors in industrial automation, robotics, and electric vehicles.
4	To explore various control implementation incorporated in smartgrid in simulation or with hardware.

Course Outcomes: Learners will be able

1	To exemplify the working of Stepper motor and its control.
2	To demonstrate the functioning of SRM motor and its control
3	To illustrate the working of BLDC motor and its control
4	To illustrate the operational features of PMSM motor and its control
5	To Identify and study the various smart grid components.
6	To understand the modelling of renewable resources such as PV, Wind, and fuel cell.

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	Study of Smart Grid components.	CO5
02	Simulation on Modelling of PV system using MATLAB.	CO6
03	Simulation on Modelling of DFIG based wind power system.	CO6
04	Simulation of Grid connected PV MPPT single stage. CO1	CO6
05	To measure and analyze the power quality parameters with and without compensation. (voltage, THD, pf and current)	CO5
06	Simulation/Emulation of DC Microgrid with steady state/transient performance analysis	CO5
07	Simulation/ Emulation of AC Microgrid with steady state/transient performance analysis.	CO5
08	Study of solar PV characteristics	CO6
09	Study of constructional features and working principle of different special motors (Stepper, SRM, BLDC, PMSM, LIM).	CO1 to CO4

10	Speed control of a Stepper Motor using Arduino or Microcontroller Interface.	CO1
11	Determination of Step Angle and Resolution of Stepper Motor.	CO1
12	Characteristics of Switched Reluctance Motor (SRM).	CO2
13	Speed control of SRM using a power converter.	CO2
14	Study of Permanent Magnet Synchronous Motor (PMSM).	CO4
15	Experimental setup of PMSM drive using inverter and controller.	CO4
16	Study of BLDC motor and its characteristics.	CO3
17	Integration of special motor with sensor and control module for application (e.g., robotic arm / conveyor).	CO3

Virtual Lab Website Reference:

1. <http://vlab.co.in/broad-area-electrical-engineering>
2. <https://www.vlab.co.in/broad-area-mechanical-engineering> - Energy Storage Labs, Solar Energy lab, Wind Energy Lab

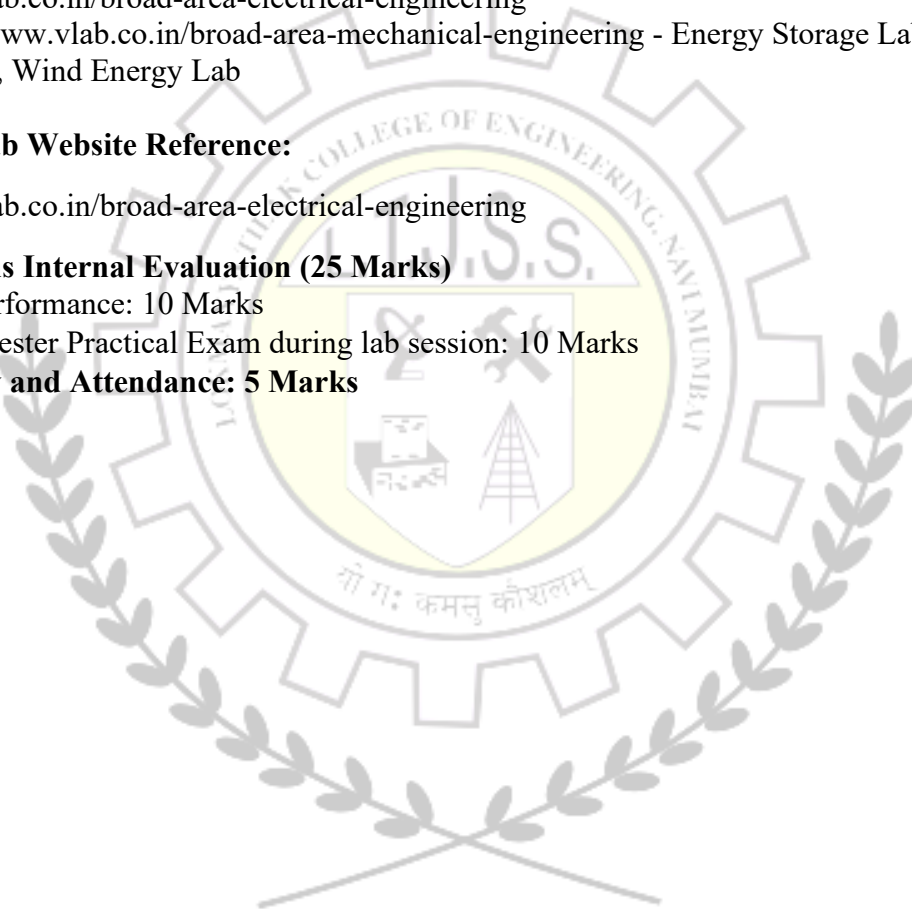
Virtual Lab Website Reference:

1. <http://vlab.co.in/broad-area-electrical-engineering>

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks

Regularity and Attendance: 5 Marks





Department of Mechanical Engineering

Third Year Engineering Curriculum

Semester VI

Course Code	Course Name	Examination Scheme					Total Marks	Lecture	
		Marks Distribution			Exam Duration (Hrs)				Total Credits
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE			
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)						
MEPCC601	Design of Machine Elements	20	20	60	1	2	100	3	

Prerequisite: Engineering Mechanics, Strength of Materials, Material Technology, Theory of Machines

Course Objectives: The course aims to

1	Acquaint the students with the fundamental principles of machine design and with design considerations
2	Familiarize the students with functional and strength design principles of machine elements
3	Guide the students through the design calculation, preparation of working drawings based on designs
4	Familiarize students to the use of design data books & various codes of practice for the design/selection of standard machine elements

Course Outcomes: Learners will be able to

1	Select the suitable factor of safety identifying the mode of failure satisfying design considerations
2	Design the machine components under static loading conditions
3	Design the machine components under fluctuating loading conditions
4	Select bearings for a given applications from the manufacturers catalogue
5	Design the Shaft, key and coupling under various loading conditions
6	Select and/or design belts and chain for given applications

Module	Detailed Contents	Hrs.	CO Mapping
01	Mechanical Engineering Design Fundamentals 1.1 Mechanical Engineering Design and Machine design. 1.2 Aesthetic and Ergonomics consideration in design. 1.3. Material properties and their uses in design. 1.4. Manufacturing consideration in design, Design consideration of casting and forging. 1.5 DFMA 1.6 Basic principle of Machine Design 1.7 Modes of failures 1.8 Factor of safety, Design stresses, 1.9 Theories of failures (Selection in the process of designing) 1.10 Standards, I.S. Codes, Preferred Series and Numbers.	04	CO1
	Self-Learning Topic: Industrial design principles and considerations		

02	Design against static loads	08	CO2
	2.1 Design of Socket and Spigot Cotter joint. 2.2 Design of Bolted joints under eccentric loading. 2.3 Design of leaf springs.		
	Self-Learning Topic: Industrial Examples of static loading		
03	Design against fluctuating loading	08	CO3
	3.1 variables stresses, reversed, repeated, fluctuating stresses. 3.2 Fatigue failure: static and fatigue stress concentration factors, 3.3 Endurance limit- estimation of endurance limit, Soderberg and Goodman design criteria. 3.4 Design of helical coil springs under fluctuating loading		
	Self-Learning Topic: Examples and applications of fluctuating loading.		
04	Design of Bearings	06	CO4
	4.1 Types of bearing and designation, functions of bearings, applications of bearings 4.2 selection of rolling contact bearings based on constant / variable load & speed conditions (includes deep groove ball bearing, cylindrical roller, spherical roller, taper roller, self-aligning bearing and thrust bearing) 4.3 Comparison of rolling and sliding contact bearings		
	Self-Learning Topic: Bearing catalogue		
05	Design of Shaft, Key and Couplings	10	CO5
	5.1 Design of Shaft: power transmitting, under static and fatigue criteria 5.2 Design of Keys: Types of keys and their selection based on shafting condition. 5.3 Couplings: Classification of coupling, Difference between rigid and flexible coupling 5.4 Selection and design of Bush pin type flexible coupling		
	Self-Learning Topic: Types of industrial couplings		
06	Design of Power transmitting elements	06	CO6
	6.1 Design and selection of Belts: Design and Selection of Flat and V-belts. 6.2 Selection of standard roller chains		
	Self-Learning Topic: Industrial Designation of belt and chains		

Reference Books :-

1. Machine Design, R S Khurmi, J K Gupta, 14th Edition, Eurasia Publishing House (Pvt.) Ltd, 2005
<https://drive.google.com/drive/u/1/folders/1a754pH7b53Pplm7vgERgw85Fuit7l25Z>
2. Design of Machine Elements, V B Bhandari, 3rd Edition, Tata McGraw Hill Company Publication
<https://drive.google.com/drive/u/1/folders/1a754pH7b53Pplm7vgERgw85Fuit7l25Z>
3. PSG Design Data Book
<https://drive.google.com/drive/u/1/folders/1a754pH7b53Pplm7vgERgw85Fuit7l25Z>

Web Material: -

Module	Text Books	References/links
1	Mechanical Engineering Design Fundamentals	https://drive.google.com/drive/u/1/folders/1a754pH7b53Pplm7vgERgw85Fuit7l25Z
2	Design against static loads	https://drive.google.com/drive/u/1/folders/1a754pH7b53Pplm7vgERgw85Fuit7l25Z
3	Design against fluctuating loading	https://drive.google.com/drive/u/1/folders/1a754pH7b53Pplm7vgERgw85Fuit7l25Z
4	Design of Rolling Contact Bearings	https://drive.google.com/drive/u/1/folders/1a754pH7b53Pplm7vgERgw85Fuit7l25Z
5	Design of Shaft, Key and Couplings	https://drive.google.com/drive/u/1/folders/1a754pH7b53Pplm7vgERgw85Fuit7l25Z
6	Design of Power transmitting elements	https://drive.google.com/drive/u/1/folders/1a754pH7b53Pplm7vgERgw85Fuit7l25Z

Links for online NPTEL/SWAYAM courses:

1. <https://nptel.ac.in/courses/112105125>
2. <https://nptel.ac.in/courses/112105124>
3. <https://nptel.ac.in/courses/112106137>

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)				3	
MEPCC602	Refrigeration and Air conditioning	20	20	60	1	2	100	

Prerequisite: Applied Thermodynamics	
Course Objectives: The course aims to	
1	Learning the fundamental principles and different methods of refrigeration and air Conditioning
2	Study of various refrigeration cycles and evaluate performance of each cycle.
3	Study of components of refrigeration and air-conditioning systems along with the applications.
Course Outcomes: Learners will be able to	
1	Understand the fundamental principles of refrigeration and air conditioning systems.
2	Identify various components of vapour compression refrigeration system
3	Understand working performance of various other refrigeration system.
4	Estimate cooling and heating loads for an air-conditioning system.
5	Select and analysis the components of Air distribution system.
6	Apply the knowledge of RAC for the sustainable development of refrigeration and airconditioning systems.

Module	Detailed Contents	Hrs.	CO Mapping
01	<p>Introduction</p> <p>1.1 Basic Knowledge Carnot refrigerator, Carnot heat pump, Refrigeration effect, Coefficient of performance, Effect of temperature and pressure on COP of the cycle.</p> <p>1.2: Air Refrigeration System: Bell Coleman cycle, Necessity of air cooling, Factors considered for the selection of air refrigeration system, Types of air refrigeration system with schematic and T-Sdiagram, Numerical based on simple and bootstrap air refrigeration system.</p>	6	CO1

	Self-Learning Topic: Second law of thermodynamics, Carnot Cycle		
02	Vapour Compression Refrigeration System	10	CO2
	<p>2.1 Refrigerants: Classification of refrigerant, ASHRAE Numbering system for refrigerant. Selection of refrigerant, Physical and chemical properties of refrigerants, Secondary refrigerants. Common Detection methods for Refrigerant Leakages in RAC Systems.</p> <p>2.2 Vapour Compression Refrigeration System: Simple system on P-h and T-s diagrams, analysis of the simple cycle, factors affecting the performance of the cycle, actual cycle, Multistage compression system. Numerical based on standard vapour compression system by using P-h chart and refrigerant table. Comparison between water cooled and air cooled condenser, Types of condensers, evaporators, and compressors, Expansion devices</p>		
	Self-Learning Topic: Properties of Steam and Vapour Cycles		
03	Other refrigeration systems:	6	CO3
	<p>3.1 Vapour absorption refrigeration system: Simple vapour absorption system, Refrigerant-adsorbent properties, COP of ideal vapour absorption system, Domestic Electrolux refrigerator,</p> <p>3.2 Non-conventional Refrigeration System: Steam Jet Refrigeration System, Thermoelectric Refrigeration Systems, Vortex tube Refrigeration system. Cascading refrigeration system</p> <p>3.3 Evaporative cooling System: Direct evaporative cooling and indirect evaporative cooling.</p>		
04	Psychrometry of Air Conditioning Processes	10	CO4
	<p>4.1 Thermal Comfort Conditions: thermal comfort, heat balance equation for a human being, factors affecting thermal comfort, Effective temperature, comfort chart and factors governing effective temperature, Selection of inside & outside design conditions</p> <p>4.2 Psychrometry of Air Conditioning Processes: Psychrometry properties, relations and processes, Adiabatic air mixing process, Psychrometric chart, RSHF, GSHF, ERSHF, Bypass factor,</p>		

	Apparatus dew point, Numerical based on psychrometric chart and relations, Classification of air conditioning system. 4.3 Cooling Load Estimation: Introduction, Components of cooling load, Different heat sources, various load Estimation, Design of air conditioning system, Building survey and economic aspect used in design.		
05	Air Distribution System	6	CO5
	5.1 Duct: Classification of ducts, duct material, pressure in ducts, Flow through duct, pressure losses in duct, Air flow through simple duct system, equivalent diameter, Methods of duct system design, Factors consider in air distribution system, Air distribution system for heating and cooling,		
06	Controls and Industrial Applications	4	CO6
	6.1 Controls: LP/HP Cutoffs, Thermostat, Humidistat, Electronics controls. 6.2 Industrial Application Ice plant, Food storage plants, dairy and food processing plants, freeze drying, A/c in textile, Printing, Pharmaceutical industry and Hospitals ,Cold chain Technology,		

Text Books/ References Books:

1. Refrigeration and Air Conditioning by C.P. Arora, McGraw Hill education (India) (P) limited, New Delhi
2. Principles of Refrigeration by Roy J. Dossat, Pearson education, New Delhi
3. Refrigeration and Air Conditioning by Manohar Prasad, New age international (P) limited, New Delhi
4. Refrigeration and Air Conditioning by S. C. Arora and S. Domkundwar, Dhanpatrai and sons, Delhi
5. Khurmi R.S. and Gupta J.K., Refrigeration and Air conditioning, Eurasia Publishing House Pvt. Ltd, New Delhi
6. Refrigeration and Air conditioning by R K Rajaput
7. ISHRAE Air Conditioning Handbook
8. ISHRAE Refrigeration Handbook
9. ASHRAE Handbook of Fundamentals
10. ASHRAE Handbook of Equipment
11. Open-Source Software/learning website
12. https://onlinecourses.nptel.ac.in/noc19_cs47/preview

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

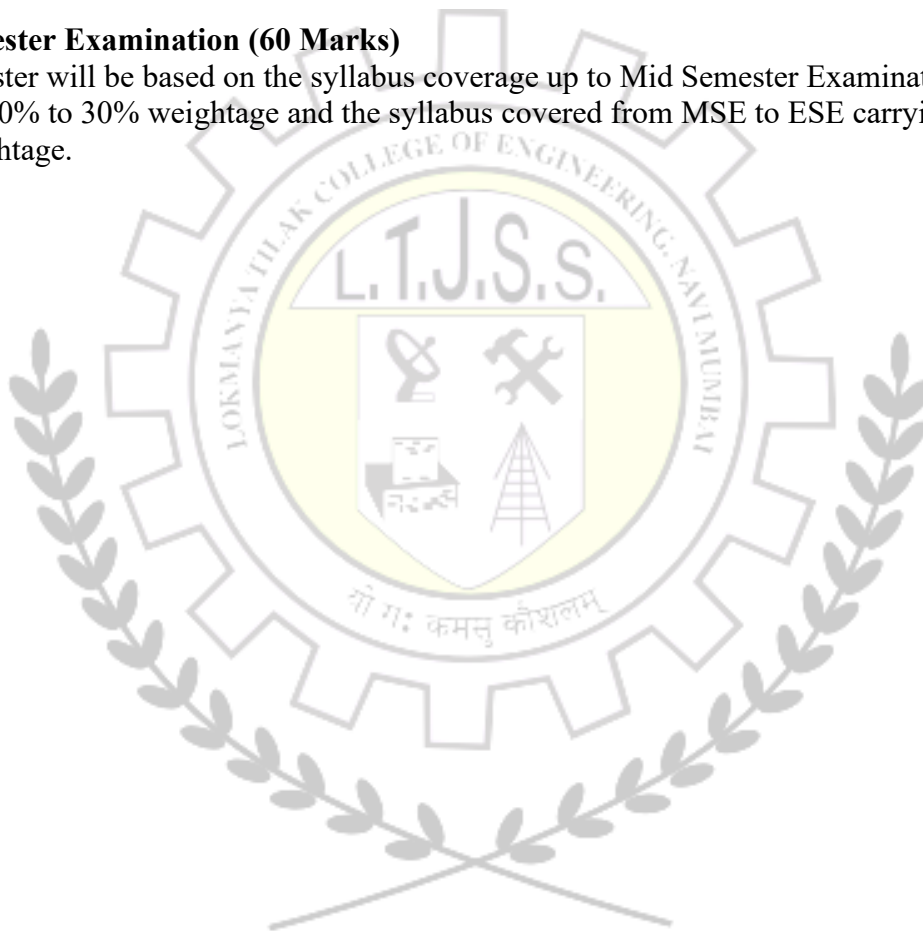
Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.



Course Code	Course Name	Examination Scheme					Total Marks	Lecture		
		Marks Distribution			Exam Duration (Hrs)				3 Hrs	
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE				Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)							
MEPEC6011	Finite Element Analysis	20	20	60	1	2	100	3		

Prerequisite: Applied Math's courses, Basics of mechanical engineering including SOM, FM, ATD, HT.	
Course Objectives: The course aims to	
1	Understand the concepts of FEA and its applicability to different engineering field problems.
2	Understand the representation of the physical model into an equivalent FEA model and steps to solve it.
3	Acquaint with application of numerical techniques for solving problems.
Course Outcomes: Learners will be able to	
1	Solve differential equations using weighted residual methods.
2	Develop the finite element equations to model engineering problems governed by second order differential equations.
3	Apply the basic finite element formulation techniques to solve engineering problems by using one dimensional element.
4	Apply the basic finite element formulation techniques to solve problems on Truss and beams
5	Develop shape functions for 2D elements and understand sources of error and convergence.
6	Apply the basic finite element formulation techniques to solve engineering problems on two-Dimensional Vector Variable Problems.

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction	06	CO1
	1.1 Introductory Concepts: Introduction to FEM, Historical Background, General FEM procedure, Applications of FEM in various fields Advantages and disadvantages of FEM		
	1.2 Mathematical Modelling of field problems in engineering, Governing Differential equations, primary/secondary variables, boundary conditions- types-essential/natural etc.		
	1.3 Approximate solution of differential equations, Weighted residual techniques (Galerkin , Subdomain method)		
	Self-Learning Topic: Differential equations, Matrix algebra		

02	FEA Procedure:(Pre-processing, Processing, Post-processing):	08	CO2
	2.1 Discrete and Continuous Models, Weighted Residual Methods - Ritz Technique- Basic Concepts of the Finite Element Method.		
	2.2 Definitions of various terms used in FEM like element, order of the element, internal and external node/s, degree of freedom. 2.3 Minimization of a functional, Principle of minimum total potential, Piecewise Rayleigh-Ritz method, Formulation of 'stiffness matrix', assembly concepts to develop system equation.		
03	One Dimensional Problems:	08	CO3
	3.1 One dimensional second order equations - discretization-element types- linear and higher order elements -derivation of shape functions and stiffness matrices and force vectors.		
	3.2 Assembly of Matrices- solution of problems in one dimensional structural analysis, heat transfer and fluid flow (stepped and taper bars, fluid network, spring-Cart Systems)		
	Self-Learning Topic: Basics of the core field (Governing laws, relationship between the various variables and constants –like in structural field stress-strain, Thermal field-temp, heat transfer rate etc.		
04	Trusses & Beams:	08	CO4
	4.1 Analysis of Plane trusses: Development of Element metrics equation EME for truss element & analysis of truss problems. 4.2 Analysis of Beams: Development of Element metrics equation EME for Beam element & analysis of Beam problems.		
05	Two-Dimensional Finite Element Formulations:	06	CO5
	5.1 Shape functions: Introduction, three node triangular element, four node rectangular element		
	5.2 Natural coordinates and coordinates transformations: serendipity and Lagrange's methods for deriving shape functions for triangular element. 5.3 Convergence criterion, sources of errors		
06	Two-Dimensional Vector Variable Problems:	06	CO6
	6.1 Equations of elasticity - Plane stress, plane strain and axisymmetric problems 6.2 Jacobian matrix, stress analysis of CST.		
	Self-Learning Topic: Stress strain relations in 2D.		

Text Books:

- 1.Textbook of Finite Element Analysis by Seshu P, Prentice Hall of India
- 2.Finite Element Method by J N Reddy, TMH
- 3.'Introduction to Finite Elements in Engineering, Chandrupatla and Belegundu, Pearson Education
- 4.Finite Element Methods by R Dhanraj and K Prabhakaran Nair, Oxford University Press
- 5.A first course in Finite Element Method by Logan D L, Thomson Asia PvtLtd

References:

1. Concepts and Applications of Finite Element Analysis by Cook R D, Malkus D S, Plesha ME, John- Wiley Sons
2. The Finite Element Method in Engineering by S. S. Rao, Butter Worth Heinemann
3. Fundamental Finite Element Analysis and Application with Mathematica and MATLAB Computations by M. Asghar Bhatti, Wiley India Pvt. Ltd.

Internal Assessment (40 Marks)**A. Mid Semester Exam (20 Marks)**

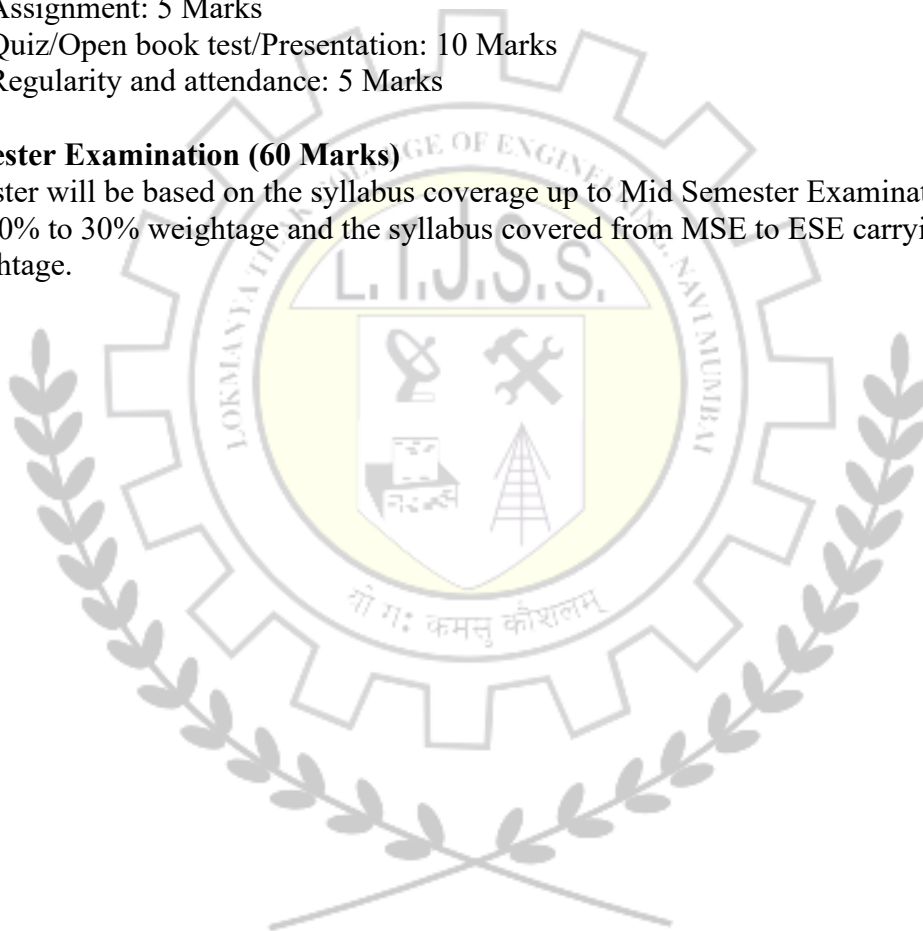
Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.



Course Code	Course Name	Examination Scheme					Total Marks	Lecture	
		Marks Distribution			Exam Duration (Hrs)				Total Credits
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE			
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)						
MEPEC6012	Computational Fluid Dynamics	20	20	60	1	2	100	3	

Prerequisite: Thermal Engineering, Fluid Mechanics and Hydraulic Machinery, FEA

Course Objectives: The course aims to

1	Acquaint with the fundamentals and applications of Computational Fluid Dynamics (CFD) in engineering.
2	Inculcate the significance of governing equations like the Navier-Stokes equations and numerical methods (FVM, FDM, FEM).
3	Impart skills in pre-processing, solver setup, and post-processing within the CFD workflow
4	Inculcate the usage of CFD tools like ANSYS Fluent/CFX for practical and research-oriented applications.

Course Outcomes: Learners will be able to

1	Understand the fundamentals and applications of Computational Fluid Dynamics (CFD) in engineering.
2	Develop the ability to use industry-standard CFD tools .
3	Set up solver configurations for steady and unsteady flow simulations by selecting suitable physical and turbulence models
4	Impart knowledge of post-processing techniques for visualization and quantitative evaluation of CFD results
5	Understand the multiphase and transient flow simulations using models such as Volume of Fluid (VOF) and Eulerian approaches
6	Provide exposure to combustion modeling and design optimization using commercial CFD tools

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction to Computational Fluid Dynamics	06	CO1
	Basics of CFD and its Applications, Governing Equations of Fluid Flow: Navier-Stokes Equations, Numerical Methods in CFD (Finite Volume, Finite Difference, Finite Element Methods), Role of Pre-processing, Solvers, and Post-processing in CFD Workflow.		
02	Essentials of CFD Tools	07	CO2
	Introduction to Computational tools and Design Modeller/Space Claim, Types of Elements (1D, 2D, 3D and surface), Selection of elements according to specific application, Grid Generation and Mesh Types (Structured, Unstructured, Hybrid), Mesh Quality Metrics and Refinement Techniques, Introduction to Boundary		

	Conditions and Initial Conditions.		
03	Solver Setup and Solution Techniques	07	CO3
	Selection of Physical Models (Single-phase, Multiphase, Heat Transfer, etc.), Turbulence Models (k-epsilon, k-omega, SST) and Their Applications, Pressure and Velocity Coupling Schemes (SIMPLE, PISO), Convergence Criteria and Residual Monitoring.		
04	Post-Processing Techniques	07	CO4
	Visualization Tools: Contours, Streamlines, and Vectors, ISO-Surface and Cut Plane Visualization, Quantitative Analysis: Force, Drag, Lift, and Heat Transfer Coefficients, Data Export and Comparison with Experimental Results.		
05	Multiphase and Transient Analysis in ANSYS Fluent	08	CO5
	Multiphase Flow Simulation: Volume of Fluid (VOF) and Eulerian Models, Transient Analysis for Unsteady Flow Problems, Free Surface Flow and Phase Change Simulations, Applications: Bubble Dynamics, Sloshing, and Phase Change		
06	Combustion and Optimization in Computational Tool	07	CO6
	Combustion Modelling: Premixed, Non-Premixed, and Partially Premixed Models, Chemical Reaction Mechanisms and Species Transport, Parametric Studies and Optimization using Design-Explorer in ANSYS, Automation of CFD Workflows with User-Defined Functions (UDFs)		

Text Books:

1. Introduction to Computational Fluid Dynamics by H.K. Versteeg and W. Malalasekera.
2. Numerical Heat Transfer and Fluid Flow by S.V. Patankar, Hemisphere Publishing Company.
3. Computational Fluid Dynamics by T.J. Chung, Cambridge University Press 2003
4. Computational fluid flow and heat transfer by K. Murlidhar and T. Sounderrajan, Narosa Publishing Co.
5. An Introduction to Computational Fluid Dynamics by Versteeg, H.K. and Malalasekera, W, Pearson Education, 2010.

References:

1. Computational fluid dynamics by J.A. Anderson, McGraw-Hill Publications 1995
2. Computational fluid mechanics and heat transfer by D. A. Anderson, J. C. Tannehill, R.H. Pletcher, Tata McGraw-Hill Publications 2002
3. An Introduction to Computational Fluid Dynamics: The Finite Volume Method by H. Versteeg and W. Malala Sekera
4. Computational Fluid Dynamics by T.J. Chung. 2002

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Quiz/Open book test/Presentation: 15 Marks
2. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.



Course Code	Course Name	Examination Scheme					Total Marks	Lecture		
		Marks Distribution			Exam Duration (Hrs)				3 Hrs	
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE				Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)							
MEPEC6013	Computer Aided Engineering	20	20	60	1	2	100			

Prerequisite: Knowledge of Engineering Mathematics-I &II, Thermal Engineering, Fluid Mechanics	
Course Objectives: The course aims to	
1	Familiar to the basics of CAE, different types of analysis, and apply mesh quality metrics and adaptive meshing techniques.
2	Select element types, mesh refinement methods, and solvers to ensure convergence and optimize computational performance in FEA
3	Apply post processing tools to analyze displacement, stress, and strain contours, evaluate design reliability, assess convergence
4	Apply pressure-based and density-based solvers, select turbulence models, and set convergence criteria for flow simulations.
5	Ability to set up, solve, and analyze heat transfer problems using appropriate numerical methods.
6	Ability to solve thermomechanical problems using appropriate numerical methods
Course Outcomes: Learners will be able to	
1	Apply the fundamental principles of Computer-Aided Engineering (CAE) to evaluate their application in engineering design.
2	Apply the fundamental principles of static and linear analysis in structures using the theory of elasticity
3	Apply the significance and fundamental concepts of Modal, Harmonic, and Transient analysis, including natural frequencies and mode shapes in dynamic systems
4	To apply pressure-based and density-based solvers, select turbulence models, and set convergence criteria for flow simulations
5	Demonstrate the ability to set up, solve, and analyse heat transfer and thermomechanical problems using appropriate numerical methods
6	Demonstrate the thermos-mechanical behavior in engineering applications.

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction to Computer-Aided Engineering (CAE)	07	CO1
	Overview of different types of analysis like Structural Analysis (e.g., stress, strain, fatigue), Thermal Analysis (e.g., heat transfer, conduction), Fluid Dynamics (CFD) (e.g., airflow, turbulence) Geometry: 1D, 2D & 3D elements, Geometry creation/import & simplification Material properties: Modulus of Elasticity, Modulus of Rigidity, Poisson's Ratio Meshing: Element types, mesh quality, and convergence		

	Mesh Quality Metrics: Aspect Ratio, Jacobian Ratio, Skewness, warping, Adaptive Meshing Use of Symmetry, Planar Symmetry, Axial Symmetry, Cyclic Symmetry		
02	Structural Analysis (Static and Linear) Introduction: Basics of static and linear analysis, Theory of elasticity and stress-strain relationships Types of elements: Solid Elements, Shell Elements, Beam Elements, Tetrahedral Elements (Different types of elements and element selection to be covered from FEA perspective.) Boundary Conditions: Forces, Pressures, Fixed Support, Displacement Support, Frictionless Support, Cylindrical Support, Compression Only Support Post-Processing: Stress Contours, Deformation Plots, Safety Factors.	07	CO2
03	Dynamic and Modal Analysis Introduction Significance and basics of Modal, Harmonic and Transient Analysis, Natural Frequencies and Mode Shapes Modal Analysis: Element Types: Solid, Shell, Beam Boundary Conditions: Fixed Support, Displacement Support Post-Processing: Mode Shapes, Natural Frequencies Harmonic and Transient Analysis Element Types: Solid, Shell, Beam Boundary Conditions: Harmonic Loads, Transient Loads Solver: Full Method, Reduced Method (CMS), Mode Superposition Solver Settings: Damping, Time Step, Load Frequency	06	CO3
04	Fluid Analysis Pressure-Based Solver for Incompressible Flows, Density-Based Solver for High-Speed Compressible Flows, Time Stepping (Steady vs. Transient), Turbulence Modelling Settings, RANS Models, k- ϵ , k- ω (Standard, SST), LES (Large Eddy Simulation) & DES (Detached Eddy Simulation), Convergence Criteria & Residual Controls, Residual Convergence Criteria. Post Processing: Visualization Tools: Contours, Streamlines, and Vectors, ISO-Surface and Cut Plane Visualization, Quantitative Analysis: Force, Drag, Lift, Data Export.	07	CO4
05	Thermal Analysis Different modes of heat transfer: Conduction, Convection, and Radiation Steady-State and Transient Thermal Analysis: Elements: Solid, Shell, Line Material Properties: Thermal Conductivity, Specific Heat Capacity, Density, Emissivity Boundary Conditions: Convection, Radiation, Temperature, Heat Flux, Adiabatic Post-Processing: Temperature Contours, Heat Flux Vectors, Thermal Gradients	06	CO5

06	Thermo-Mechanical Coupling:	06	CO6
	Thermal Stresses and Expansion Elements: Solid, Shell Material Properties: Modulus of Elasticity, Modulus of Rigidity, Poisson's Ratio, Thermal Conductivity, Specific Heat Capacity, Density, Thermal Expansion Coefficient, Emissivity Boundary Conditions: Thermal Loads, Mechanical Loads Post-Processing: Thermal Stress Contours, Displacement Plots, Thermal Strain		

Text Books:

1. S. S. Rao, The Finite Element Method in Engineering, 6th Edition, Butterworth-Heinemann, 2018.
2. T. J. R. Hughes, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Dover Publications, 2000.
3. R. K. Mittal, Computational Fluid Dynamics, 1st Edition, Cengage Learning India, 2015.
4. M. D. Raisinghani, Computational Fluid Dynamics, 1st Edition, Narosa Publishing House, 2007.
5. John D. Anderson Jr., Computational Fluid Dynamics: The Basics with Applications, 1st Edition, McGraw-Hill, 1995.
6. Rainald Löhner, Applied Computational Fluid Dynamics Techniques, 1st Edition, Springer, 2008.
8. Olek C. Zienkiewicz, Robert L. Taylor, Jianzhong Zhu, The Finite Element Method: Its Basis and Fundamentals, 7th Edition, Butterworth-Heinemann, 2013.
9. J. N. Reddy, An Introduction to the Finite Element Method, 4th Edition, McGraw-Hill Education, 2019

NPTEL Course:

1. Finite Element Analysis Web link: <https://nptel.ac.in/courses/112/101/112101115/>
2. NPTEL Course: Introduction to Computational Fluid Dynamics Web link: <https://nptel.ac.in/courses/101/104/101104013/>
3. NPTEL Course: Computer Methods in Mechanics Web link: <https://nptel.ac.in/courses/112/106/112106317/>

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Quiz/Open book test/Presentation: 15 Marks
2. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme					Total Marks	Lecture		
		Marks Distribution			Exam Duration (Hrs)				3 Hrs	
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE				Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)							
MEPEC6021	Dynamics of Machinery	20	20	60	1	2	100			

Prerequisite: Engineering Mechanics, Strength of Material, Theory of Machines

Course Objectives: The course aims to

- | | |
|---|---|
| 1 | Understand working principles and applications of Governors and Gyroscope |
| 2 | Understand static and dynamic force analysis in the mechanisms |
| 3 | Understand Mechanical vibrations |
| 4 | Understand the balancing of mechanical systems |

Course Outcomes: Learners will be able to

- | | |
|---|--|
| 1 | Demonstrate working Principles of different types of governors and Gyroscopic effects on the mechanical systems. |
| 2 | Determine static and dynamic forces and dynamically equivalent system |
| 3 | Determine natural frequency of Mechanical system |
| 4 | Determine vibration response of mechanical elements / systems |
| 5 | Design vibration isolation system for a specific application |
| 6 | Demonstrate basic concepts of balancing of forces and couples |

Module	Detailed Contents	Hrs.	CO Mapping
01	Governors and Gyroscopes 1.1 Governors: Introduction to Centrifugal governors, Study and Force analysis of Porter and Hartnell governors including Performance characteristics, Governors effort and power. 1.2 Gyroscope: Introduction, Gyroscopic couple and its effect on spinning bodies, naval ships during steering, pitching, rolling and their stabilization.	08	CO1
	Static and Dynamic force analysis and dynamically equivalent systems 2.1 Static and Dynamic force analysis of Slider crank mechanism (neglecting mass of connecting rod and crank), Turning moment on crank shaft 2.2 Dynamically equivalent systems to convert rigid body into two mass with and without correction couple(Case study- Connecting rod)		
02		06	CO2
03	Free Undamped Single Degree of Freedom Vibration System 3.1 Basic Concepts of Vibration: Vibration and oscillation, causes and effects of vibrations, Importance of study of vibrations, Vibration parameters - springs, mass, damper, Motion- periodic, non-periodic,	07	CO3

	degree of freedom, static equilibrium position, vibration classification, steps involved in vibration analysis 3.2 Free Undamped Single Degree of Freedom Vibration System: Longitudinal, transverse, torsional vibration system, Methods for formulation of differential equations by Newton, Energy, and Rayleigh's method.		
04	Free Damped Single Degree of Freedom Vibration System 4.1 Free Damped Single Degree of Freedom Vibration System: Introduction to different methods of damping, Study and analysis of 1) Viscous damped system (under damped, critically damped, over damped; Logarithmic decrement) 2) Coulomb's damping (Combined Viscous and Coulomb damping excluded) 4.2 Equivalent Single Degree of Freedom Vibration System: Conversion of multi springs, multi masses, multi-dampers into a single spring and damper with linear or rotational co-ordinate system,	06	CO4
05	Forced Single Degree of Freedom Vibratory System 5.1 Forced Single Degree of Freedom Vibratory System: Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (excluding elastic damper) 5.2 Vibration Isolation and Transmissibility: Force Transmissibility, motion transmissibility, typical isolators & mounts. 5.3 Vibration Measuring instruments: Principle of seismic instruments, vibrometer, accelerometer, Introduction to conditioning monitoring and fault diagnosis.	08	CO5
06	Balancing of masses 6.1 Rotor Dynamics: Critical speed of single rotor, undamped and damped. 6.2 Balancing: Static and Dynamic balancing of multi rotor system (up to four rotors), balancing of reciprocating masses in In-line engines (up to four cylinders) , Introduction to V-engines (excluding other radial engines)	07	CO6

Text Books:

1. Theory of Machines Thomas Bevan CSB Publishers & Distributors
2. Theory of Machines by Jagdishlal Metropolitan Book New Delhi,
3. Theory of Machines by S.S.Ratan Tata McGraw Hill , New Delhi
4. Theory of Machines by P.L.Bellaney Khanna publication, New Delhi
5. Theory of Machines and Mechanisms by John J Uicker, Gordon R Pennock and Joseph E Shigley, Oxford University Press
7. Theory of Vibration with Applications, by W. Thomson, 2nd edition, Pearson Education
8. Mechanical Vibrations by S. S. Rao, fourth edition, Pearson Education
9. Mechanical Vibrations by G. K. Grover
10. Fundamentals of Mechanical Vibration by S. Graham Kelly, Tata McGraw Hill
11. Principles of Vibration by Benson H Tongue, 2nd Edition, Oxford University Press
12. Vibration Analysis by P. Srineevasan, TMH
13. Mechanical Vibrations- Schaum's outline series, William W. Seto, McGraw Hill
14. Theory and Practice of Mechanical Vibrations by J S Rao and K Gupta, New Age International
15. Elements of Vibration Analysis by Leonard Meirovitch, McGraw- Hill, New York

References:

1. <https://nptel.ac.in/courses/112/101/112101096/> - Dynamics of Machines, IIT Bombay
2. <https://nptel.ac.in/courses/112/107/112107212/> - Introduction to Mechanical Vibration, IIT Roorkee

Internal Assessment (40 Marks)**A. Mid Semester Exam (20 Marks)**

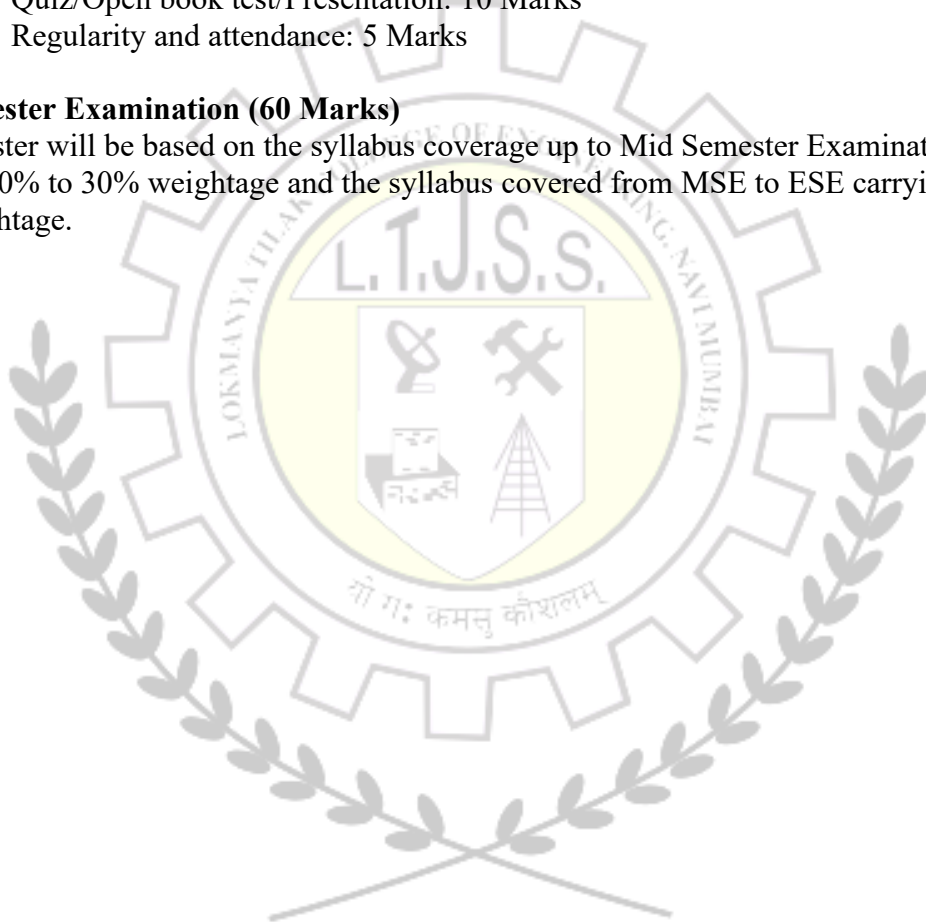
Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.



Course Code	Course Name	Examination Scheme					Total Marks	Lecture		
		Marks Distribution			Exam Duration (Hrs)				3 Hrs	
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE				Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)							
MEPEC6022	Vibration Control	20	20	60	1	2	100	3		

Prerequisite: Engineering Mechanics, Strength of Materials, Theory of Machines

Course Objectives: The course aims to

1 Study Vibration Absorbers.

2 Study Vibration Isolators.

3 Study Vibration Control.

Course Outcomes: Learners will be able to

1 Apply basic concepts of Vibration Isolation and Damping.

2 Identify suitable Vibration Absorber

3 Identify suitable Vibration Isolator

4 Apply suitable method to Control the vibrations to the acceptable level

5 Identify suitable adaptive vibration absorber

6 Identify suitable Active and semi-active vibration isolators

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction to vibration control Vibration reduction at source, factors affecting vibration level, isolation of the source, methods of vibration control, dynamic properties and selection of materials.	06	CO1
	Dynamic vibration absorbers Dynamic vibration neutralizers, self-tuned pendulum neutralizer, optimum design of damped absorbers, absorber with ideal spring and viscous dashpot, gyroscopic vibration absorbers, impact absorbers, absorbers attached to continuous systems.		
02	Vibration isolation of single degree of freedom systems Isolators with complex stiffness, Isolators with Coulomb damping, Three element isolators, Two-stage isolators, Pneumatic suspension, Concept of negative stiffness in vibration isolation	08	CO3
	Active and semi active vibration control 4.1 Active vibration control: Classification and modeling, actuators and sensors for active vibration control, Active vibration absorption and damping, classical control, optimal control, Piezoelectric transducers for active vibration control 4.2 Semi-active vibration control: Introduction, Magneto-rheological fluids, MR models and devices, semi-active suspension, narrowband disturbance.		

05	Active, semi-active, and adaptive dynamic vibration absorbers	06	CO5
	Active tuned vibration absorber, active mass damper, adaptive vibration absorber, semi-active tuned vibration absorber.		
06	Active and semi-active vibration isolation	06	CO6
	Active single-axis base isolation, active force isolation system, isolator based on piezoelectric stack actuator, semi-active isolation, Adaptive-passive vibration isolation, active control of vehicle suspensions		

Text Books:

1. A.K. Mallik and A. Chatterjee, “Principles of Active and Passive Vibration Control”, East-West- Press 2014, ISBN: 9788176710985
2. A. Preumont, “Vibration Control of Active Structures”, Springer 2018, ISBN: 9783319722962
3. S.S. Rao, “Mechanical Vibrations”, 5th Edition 2004, Pearson Publications
4. Clarence de Silva, “Vibration: Fundamentals and Practice”, 1st Edition 2000, CRC Press, ISBN:0849318084

References:

Links for online NPTEL/SWAYAM courses:

- <https://nptel.ac.in/courses/112104211>– Principles of Vibration Control, IIT Kanpur
<https://nptel.ac.in/courses/112107088>– Vibration control, IIT Roorkee

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme					Total Marks	Lecture		
		Marks Distribution			Exam Duration (Hrs)				3 Hrs	
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE				Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)							
MEPEC6023	Mechanical Vibrations	20	20	60	1	2	100	3		

Prerequisite: Engineering Mechanics, Strength of Materials, Theory of Machines	
Course Objectives: The course aims to	
1	Study undamped Mechanical vibrations
2	Study damped Mechanical vibrations
3	Study undamped multi dof Mechanical vibrations
4	Study the balancing of mechanical systems and condition monitoring
Course Outcomes: Learners will be able to	
1	Determine natural frequency of undamped Mechanical system
2	Determine natural frequency of damped Mechanical system
3	Determine vibration response of mechanical elements / systems
4	Determine natural frequency of Multi dof Mechanical systems
5	Understand Machine condition monitoring and diagnosis
6	Demonstrate basic concepts of balancing of forces and couples

Module	Detailed Contents	Hrs.	CO Mapping
01	Free Undamped Single Degree of Freedom Vibration System 1.1 Basic Concepts of Vibration: Vibration and oscillation, causes and effects of vibrations, Importance of study of vibrations, Vibration parameters - springs, mass, damper, Motion- periodic, non-periodic, degree of freedom, static equilibrium position, vibration classification, steps involved in vibration analysis 1.2 Free Undamped Single Degree of Freedom Vibration System: Longitudinal, transverse, torsional vibration system, Methods for formulation of differential equations by Newton, Energy, and Rayleigh's method.	07	CO1
	Free Damped Single Degree of Freedom Vibration System 2.1 Free Damped Single Degree of Freedom Vibration System: Introduction to different methods of damping, Study and analysis of 1) Viscous damped system (under damped, critically damped, over damped; Logarithmic decrement) 2) Coulomb's damping (Combined Viscous and Coulomb damping excluded) 2.2 Equivalent Single Degree of Freedom Vibration System: Conversion of multi springs, multi masses, multi-dampers into a single spring and damper with linear or rotational co-ordinate system.		
02		06	CO2

03	Forced Single Degree of Freedom Vibratory System	07	C03
	3.1 Forced Single Degree of Freedom Vibratory System: Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (excluding elastic damper) 3.2 Vibration Isolation and Transmissibility: Force Transmissibility, motion transmissibility, typical isolators & mounts. 3.3 Vibration Measuring instruments: Principle of seismic instruments, vibrometer, accelerometer, Introduction to conditioning monitoring and fault diagnosis.		
04	Multi Degree of Freedom System:	08	C04
	4.1 Undamped free vibration: Free vibration equation of motion, Influence coefficients (stiffness and flexibility), Reciprocity theorem, Generalized Coordinates, and Coordinate Coupling, Lagrangian equations, Rayleigh and Dunkerley method, two rotor and geared systems 4.2 Eigen Values and Eigen vectors: for translatory and torsional two d.o.f. systems, Matrix method, Holzer's method (translatory and torsional unbranched systems)		
05	Modal analysis and Condition Monitoring	06	C05
	Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine condition monitoring and diagnosis		
06	Balancing of masses	08	C06
	6.1 Rotor Dynamics: Critical speed of single rotor, undamped and damped 6.2 Balancing: Static and Dynamic balancing of multi rotor system (up to four rotors), balancing of reciprocating masses in In-line engines (up to four cylinders) , Introduction to V-engines (excluding other radial engines)		

Text Books:

1. Theory of Machines Thomas Bevan CSB Publishers & Distributors
2. Theory of Machines by Jagdish Lal Metropolitan Book New Delhi,
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13. Mechanical Vibrations- Schaum's outline series, William W. Seto, McGraw Hill
14. Theory and Practice of Mechanical Vibrations by J S Rao and K Gupta, New Age International
15. Elements of Vibration Analysis by Leonard Meirovitch, McGraw- Hill, New York

References:

- <https://nptel.ac.in/courses/112107212> – Introduction to Mechanical Vibration, IIT Roorkee
<https://nptel.ac.in/courses/112103111> – Mechanical Vibrations, IIT Guwahati
<https://nptel.ac.in/courses/112103022> – Nonlinear Vibration, IIT Guwahati
<https://nptel.ac.in/courses/112104211> – Principles of Vibration Control, IIT Kanpur

Internal Assessment (40 Marks)**A. Mid Semester Exam (20 Marks)**

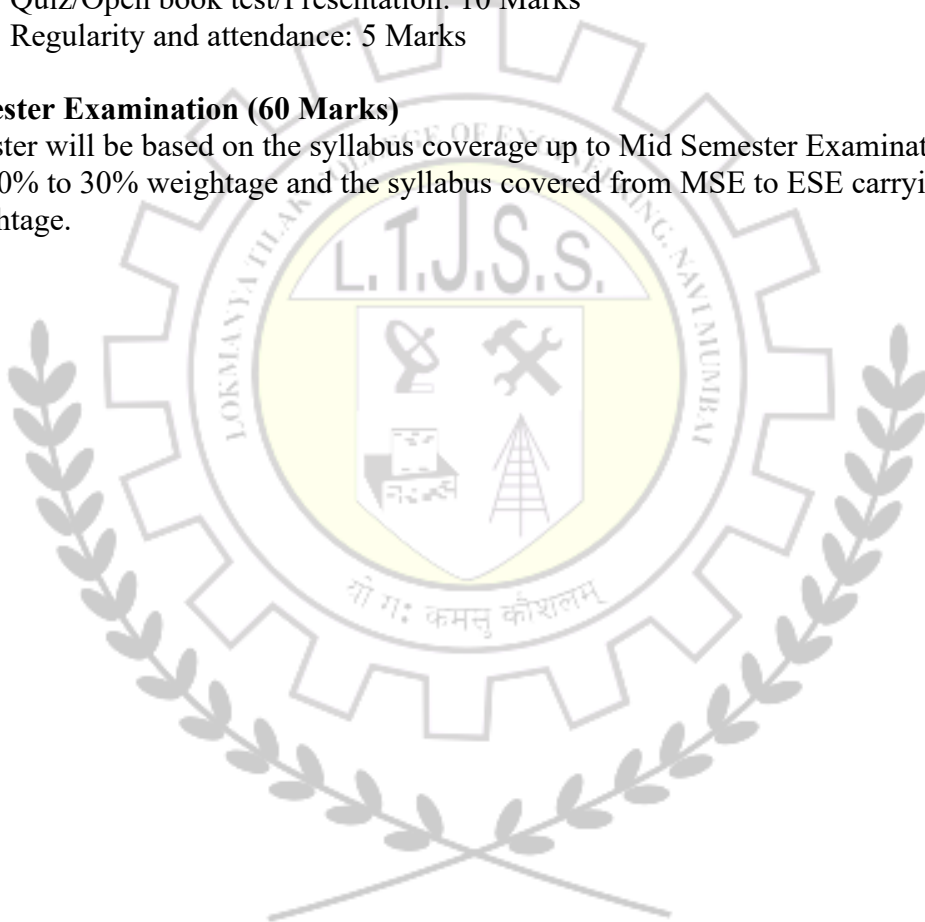
Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.



Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
MEPCL601	Refrigeration and Air conditioning Lab	-	25	25	-	-	50	

Prerequisite: Applied thermodynamics, Thermal engineering

Course Objectives: The course aims to

1	Study working and operating principle of vapour Compression and vapour absorption system.
2	Study Controls and Components of refrigeration and Airconditioning system.
3	Design air conditioning systems using cooling load calculation.

Course Outcomes: Learners will be able to

1	Evaluate the performance of Refrigeration and Airconditioning system
2	Analyse design aspects of Refrigeration and Airconditioning in various application
3	Develop awareness of the engineering and technological aspects in the of Refrigeration and Airconditioning industries
4	Aware of the roles and ethics of refrigeration and Airconditioning engineers in related industries.
5	Communicate effectively through the preparation of report and practical presentation
6	Present the impact of professional engineering solutions in societal and environmental contexts

Suggested List of Experiments (Performance on Any Six)

Sr. No.	List of Experiments	CO Mapping
01	Study and performance on simple vapour compression test rig.	CO1
02	Study and performance on Multistage evaporator vapour compression test rig.	CO1
03	Study and performance on Vapour absorption refrigeration test rig.	CO1

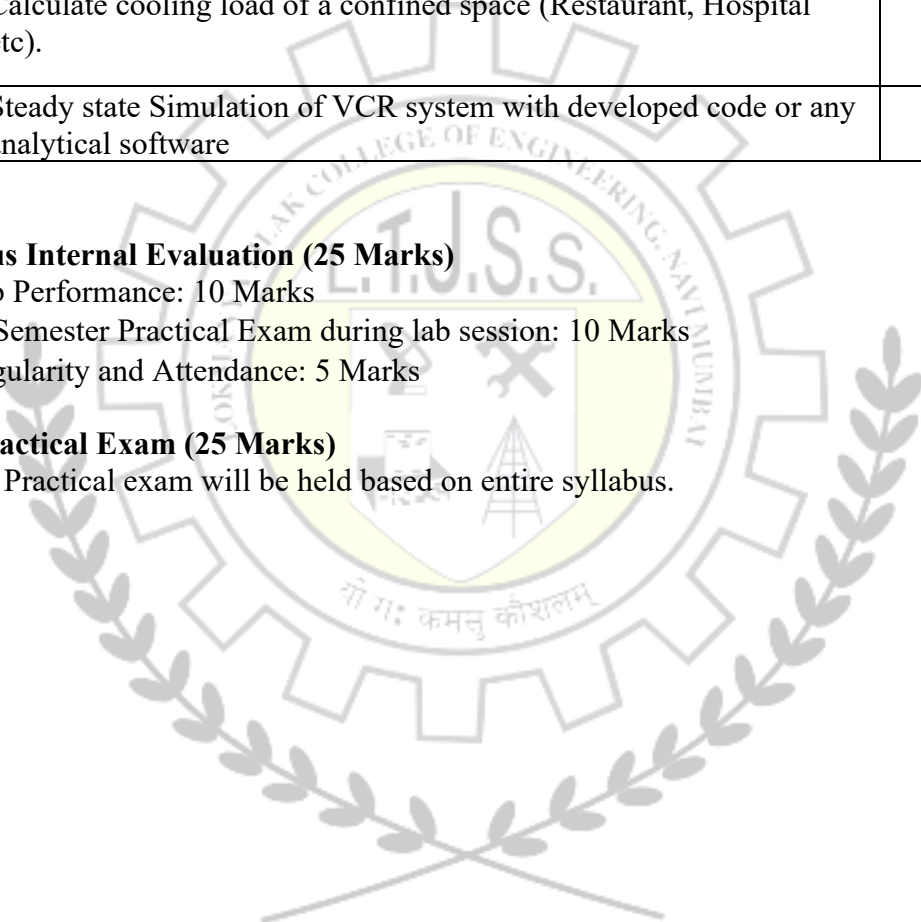
04	Study and performance of Hybrid refrigeration system test rig.	CO2
05	Humidification and Dehumidification air conditioning process on air conditioning test rig.	CO1, CO2
06	Study and performance of refrigeration cycle on Ice plant (Brine/ Ethelyn glycol)	CO4, CO6
07	Cooling capacity analysis of the direct & indirect evaporative cooling system.	CO4
08	Industrial visit on any Rrefrigeration plant (Ice plant, Cold Storage, Dairy plant etc.) or any Manufacturing plant (Compressor, condenser/ evaporator).	CO3, CO4, CO5,
09	Calculate cooling load of a confined space (Restaurant, Hospital etc).	CO2, CO6
10	Steady state Simulation of VCR system with developed code or any analytical software	CO6

Continuous Internal Evaluation (25 Marks)

7. Lab Performance: 10 Marks
8. In-Semester Practical Exam during lab session: 10 Marks
9. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

An Oral & Practical exam will be held based on entire syllabus.



Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
MEPCL602	Dynamics of Machinery & Vibration Lab	-	25	25	-	-	50	

Prerequisite: Engineering Mechanics	
Course Objectives: The course aims to	
1	Acquaint with working principles and applications of governors
2	Acquaint with working principles and applications of Gyroscope
3	Acquaint with the principles of Mechanical Vibration systems
4	Study balancing of mechanical systems
Course Outcomes: Learners will be able to	
1	Plot and analyze governor characteristics
2	Analyze gyroscopic effect on laboratory model
3	Estimate natural frequency of mechanical systems
4	Analyze damped vibratory system and vibration isolation
5	Determine Whirling speed of shaft
6	Balance the rotating masses

Suggested List of Experiments (Any six)

Sr. No.	List of Experiments	CO Mapping
01	Experiment on Porter Governor	CO1
02	Experiment on Hartnell Governor	CO1
03	Experiment on Gyroscope	CO2
04	Experiment on Transverse vibrations	CO3
05	Experiment on Longitudinal vibrations	CO3
06	Experiment on Torsional vibrations	CO3
07	Experiment on damped vibrations	CO4
08	Experiment on Whirling speed of shaft	CO5
09	Experiment on balancing of masses	CO6
10	Experiment on Active/semi active vibration isolation	CO4

11	Experiment on Whirling speed of shaft	CO5
12	Experiment on balancing of masses	CO6

Continuous Internal Evaluation (25 Marks)

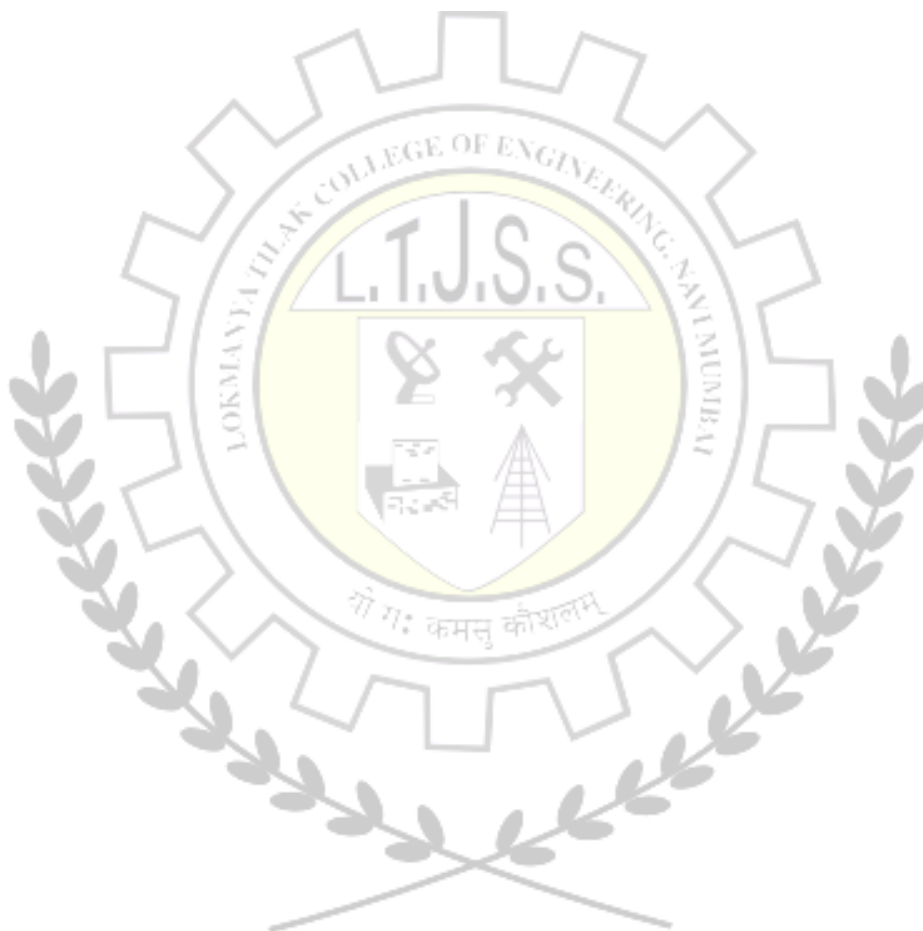
1.Lab Performance: 10 Marks

2.In-Semester Practical Exam during lab session: 10 Marks

3.Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

An Oral & Practical exam will be held based on entire syllabus.



Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
MEPEL6011	Finite Element Analysis Lab	-	25	--	-	-	25	

Prerequisite:

Course Objectives: The course aims to

1	Familiarize FEA concept for practical implementation
2	Acquaint with FEA application software
3	Use commercial FEA software, to solve problems related to mechanical engineering.

Course Outcomes: Learners will be able to Apply the basic finite element formulation techniques & simulate

1	1D structural problems by using Ansys APDL/Workbench.
2	1D thermal problems by using Ansys APDL/Workbench.
3	Truss problems by using Ansys APDL/Workbench.
4	Beam problems by using Ansys APDL/Workbench.
5	2D structural problems by using Ansys APDL/Workbench.
6	3D problems (structural thermal/fluid/ coupled field/considering symmetry, different fields/multifield etc. by using Ansys Workbench.

Suggested List of Experiments

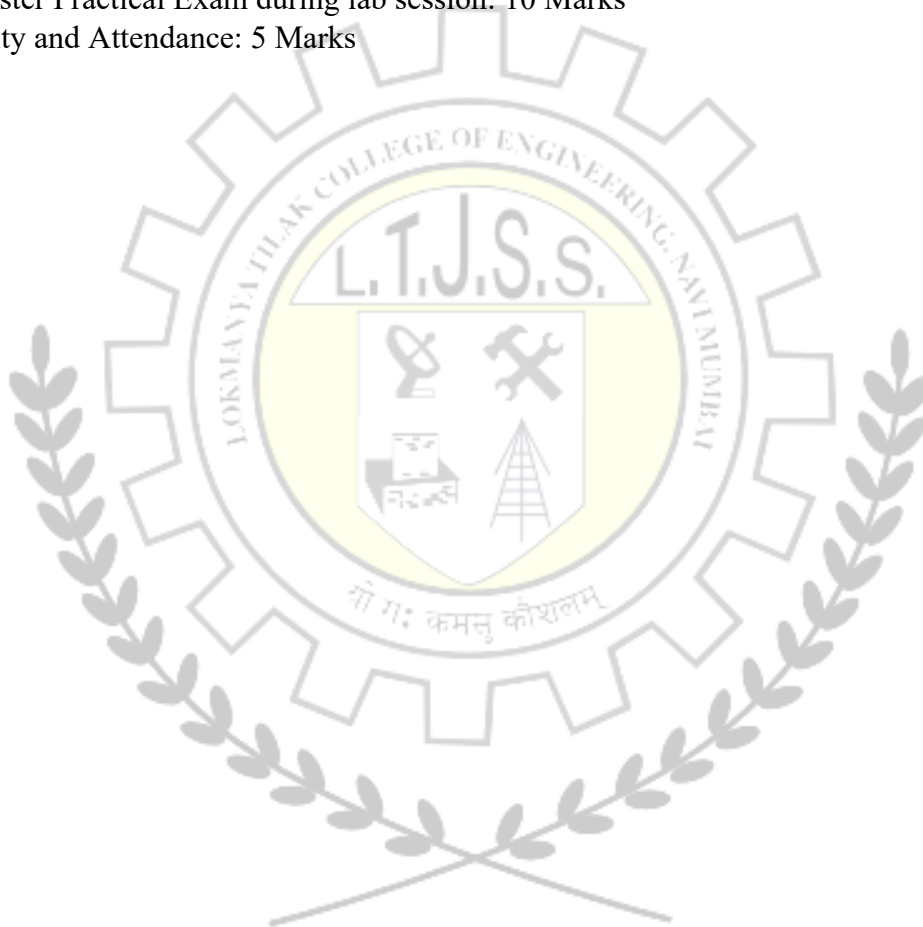
Sr. No.	List of Experiments	CO Mapping
01	Any two problems using bar element-Structural application	CO1
02	Any two problems using bar element-Thermal application	CO2
02	Any two problems for analysis of truss.	CO3
03	Any one problem for analysis of Beams.	CO4
04	Any two problems using CST element.	CO5
05	Any two problem using axisymmetric element.	CO5
06	Finite Element Analysis of any mechanical engineering element /system, which involves element selection, assigning properties, meshing, assigning loads, and boundary conditions, analysis and result interpretation.	CO6
07	Develop the program to verify the results obtained by manual calculations for simple 1D/2D problems using Python, MATLAB programming platform etc.	CO6

08	Simulate a problem and validate the results with experimental results (the test rigs from Strength of material /Heat transfer/Dynamics of machine/fluid lab etc may be used for obtaining the experimental results)	CO6
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Note: Students should use the commercial software (Ansys APDL/ Workbench) or open source application programs, to verify the results obtained by manual calculations. The input data and output results of the problem solved using the computer programs (Minimum 8 expt., from Expt.01 to 06) and a course project (group of 4 student) like Expt. 7 & 8.

Continuous Internal Evaluation (25 Marks)

- 1.Lab Performance: 10 Marks
- 2.In-Semester Practical Exam during lab session: 10 Marks
- 3.Regularity and Attendance: 5 Marks



Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
MEPEL6012	Computational Fluid Dynamics Lab	-	25	--	-	-	25	

Prerequisite:

Course Objectives: The course aims to

1	Acquaint with the fundamentals and applications of Computational Fluid Dynamics (CFD) in engineering.
2	Inculcate the significance of governing equations like the Navier-Stokes equations and numerical methods (FVM, FDM, FEM).
3	Impart skills in pre-processing, solver setup, and post-processing within the CFD workflow
4	Inculcate the usage of CFD tools like ANSYS Fluent/CFX for practical and research-oriented applications.

Course Outcomes: Learners will be able to

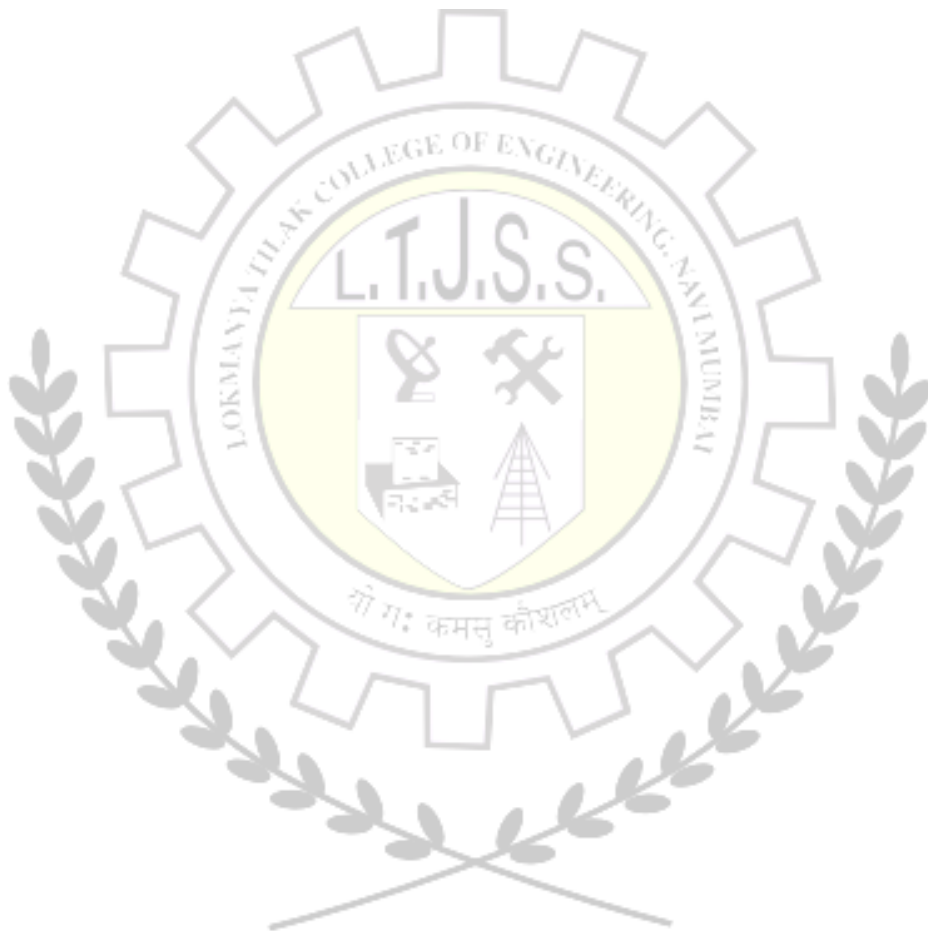
1	Familiarization with CFD software interface, geometry modelling, and meshing.
2	Generate structured and unstructured meshes, evaluate mesh quality metrics.
3	Apply boundary conditions and solver settings for laminar and turbulent flow.
4	Conjugate heat transfer, apply temperature and heat flux boundary conditions
5	Apply turbulence models, post-processing, and transient flow studies.
6	Visualize and export CFD results for reporting and validation.

Suggested List of Experiments (Any six)

Sr. No.	List of Experiments	CO Mapping
01	Creating simple geometries (pipe, nozzle, or flat plate).	CO1
02	Create 2D/3D geometries using Design Modeler <i>or</i> Space Claim.	CO1
03	Import CAD geometry, repair and simplify it for meshing.	CO1
04	Structured Mesh Generation for External Flow	CO2
05	Unstructured Mesh Generation for Internal Flow	CO2
06	Computation and Validation of Velocity and Pressure Distribution for Laminar Flow in a Circular Pipe	CO3
07	Computation and Validation of Velocity and Pressure Distribution for Turbulent flow in a Circular Pipe	CO3
08	Simulation of Natural and Forced Convection over a Flat Plate Using CFD	CO4
09	CFD Analysis of a Shell and Tube Heat Exchanger under Steady-State Conditions	CO4
10	Transient CFD Simulation of Phase Change during Melting of an Ice Block	CO5
11	CFD Analysis of Flow around a Bluff Body (Cylinder / Car Model)	CO5
12	Post-Processing and Visualization of CFD Simulation Results	CO6

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks



Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
MEPEL6013	Computer Aided Engineering Lab	-	25	--	-	-	25	

Prerequisite:

Course Objectives: The course aims to

1	Acquaint with the fundamentals and applications of computer aided Engineering.
2	Impart skills in pre-processing, solver setup, and post-processing within the application (Software Environment)
3	Inculcate the usage of Analysis tools for practical and research-oriented applications.

Course Outcomes: Learners will be able to

1	Apply CAD/CAE tools to create, analyze, and evaluate mechanical components using structural, thermal, fluid, and motion simulations.
2	Perform finite element meshing, apply boundary conditions, and interpret stress, deformation, and safety-factor results for static structural problems.
3	Analyze dynamic behavior of components by conducting modal, buckling, and fatigue analyses to determine natural frequencies, critical loads, and life expectancy.
4	Simulate and evaluate thermal and fluid-flow phenomena (steady-state, transient, external flow) to determine heat transfer, pressure distribution, and aerodynamic performance.
5	Integrate multi-physics and optimization techniques (thermal-structural coupling, FSI, topology optimization) to improve product performance and reduce weight.
6	Demonstrate proficiency in virtual prototyping and mechanism simulation, including motion analysis, design for additive manufacturing, and performance validation through CAE tools.

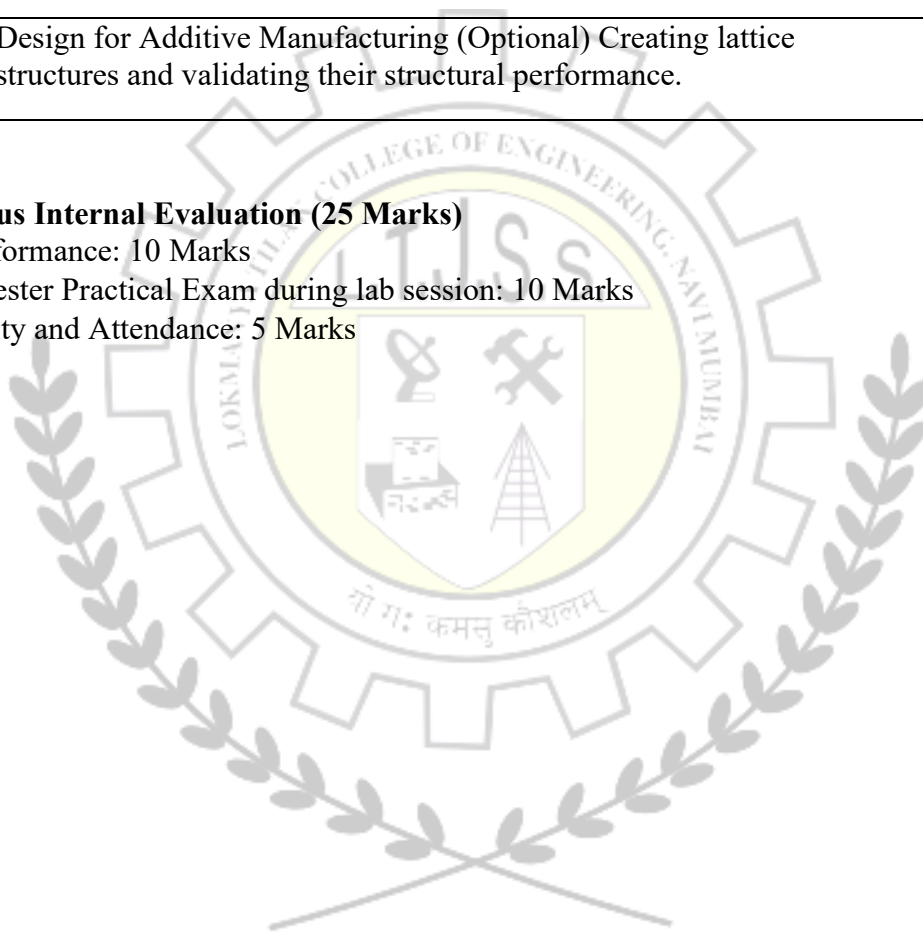
Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	Static Structural Analysis Meshing, applying boundary conditions, and evaluating stresses on a simple bracket.	CO 1
02	Modal (Vibration) Analysis of Mechanical Components Determining natural frequencies and mode shapes.	CO 3
03	Thermal Analysis (Steady-State & Transient)	CO 4
04	Heat distribution across fins or a plate under different thermal loads.	CO 2
05	Buckling Analysis of Columns or Plates Determining the critical load and buckling mode shapes.	CO 2

06	Fatigue Life Prediction Stress-life and strain-life fatigue analysis on components under cyclic loading.	CO1, CO5
07	External Flow Simulation Aerodynamic analysis around a cylinder/aerofoil and drag coefficient estimation.	CO1, CO2
08	Multi-Physics Coupled Analysis Thermal-structural coupling or fluid-structure interaction (FSI) demonstration.	CO1, CO3
09	Topology Optimization Optimizing the weight and stiffness of a component using design constraints.	CO4
10	Motion/Mechanism Simulation Simulating linkages, gears, cam & follower systems using motion analysis tools.	CO5
11	Design for Additive Manufacturing (Optional) Creating lattice structures and validating their structural performance.	CO6

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks



Course Code	Course Name	Examination Scheme					Total Marks	Practical
		Marks Distribution			Exam Duration (Hrs)			2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
MECEP601	Mini Project II	-	25	25	-	-	50	

Program Outcomes addressed:

PO1 Engineering knowledge
 PO2 Problem Analysis
 PO3 Design/Development of Solutions
 PO4 Conduct investigations of complex problems
 PO5 Engineering Tool Usage
 PO6 The Engineer & the world
 PO7 Ethics
 PO8 Individual and Collaborative Team work
 PO9 Communication
 PO10 Project Management & Finance
 PO11 Life-long learning

Course Objectives:

- 1.To familiarize students about available infrastructure at Department/Institute level, online resources, plagiarism, expectations from Mini Project 1, etc.
- 2.To guide students in identifying societal needs and formulating them into problem statements.
- 3.To facilitate problem-solving in group settings.
- 4.To apply basic engineering principles to address identified problems.
- 5.To foster self-learning and research skills.

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

1. Identify problems based on societal or research needs and methodology for solving them.
2. Apply knowledge and skills to solve societal and environmental problems collaboratively.
3. Develop interpersonal skills necessary for teamwork.
4. Analyze, verify, and validate results and the impact effectively through various tools
5. Excel in written and oral communication by technical report writing, oral presentation, technical papers.
6. Demonstrate lifelong learning capabilities through self-directed group projects.

Guidelines for the Mini Project

At the beginning of semester-VI, project coordinators are required to conduct orientation sessions including following topics: -

- Acquainting students about infrastructure available at Department/Institute level and its utilization.
- How to identify societal problems and formulate project problem statements.
- How to carry out literature surveys.
- What is plagiarism and what care needs to be taken while writing a report.
- What is the project report template and how should it be used?

Expectations from mini-project II.

Mini project may be carried out in one or more form of the following:

Product preparations, prototype development model, fabrication of set-ups, laboratory experiment development, process modification/development, simulation, software development, integration of software (frontend-backend) and hardware, statistical data analysis, creating awareness in society/environment etc.

Students must form groups of 2 to 4 members either from the same departments.

Groups should conduct surveys to identify needs and develop problem statements in consultation with faculty.

An implementation plan covering weekly activities must be submitted to the faculty supervisor.

Each group must maintain a logbook to record weekly progress, to be verified by the faculty supervisor.

The solution to be validated with proper justification and report to be compiled in standard format of the Institute. Research papers, competition certificates may be submitted as part of annexure to the report.

With the focus on self-learning, innovation, addressing societal/research/innovation problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students.

In-Semester Continuous Assessment and End-Semester Examination Guidelines

- The Head of the Department & Project coordinator will assign a guide to each of the mini-projects and shall form a progress monitoring committee. The guide will carry out weekly monitoring of the project's progress. The committee shall carry out in-semester project evaluation based on presentations with a minimum of two evaluations per semester.
- Assessment will be based on individual contributions, understanding, and responses to questions asked.

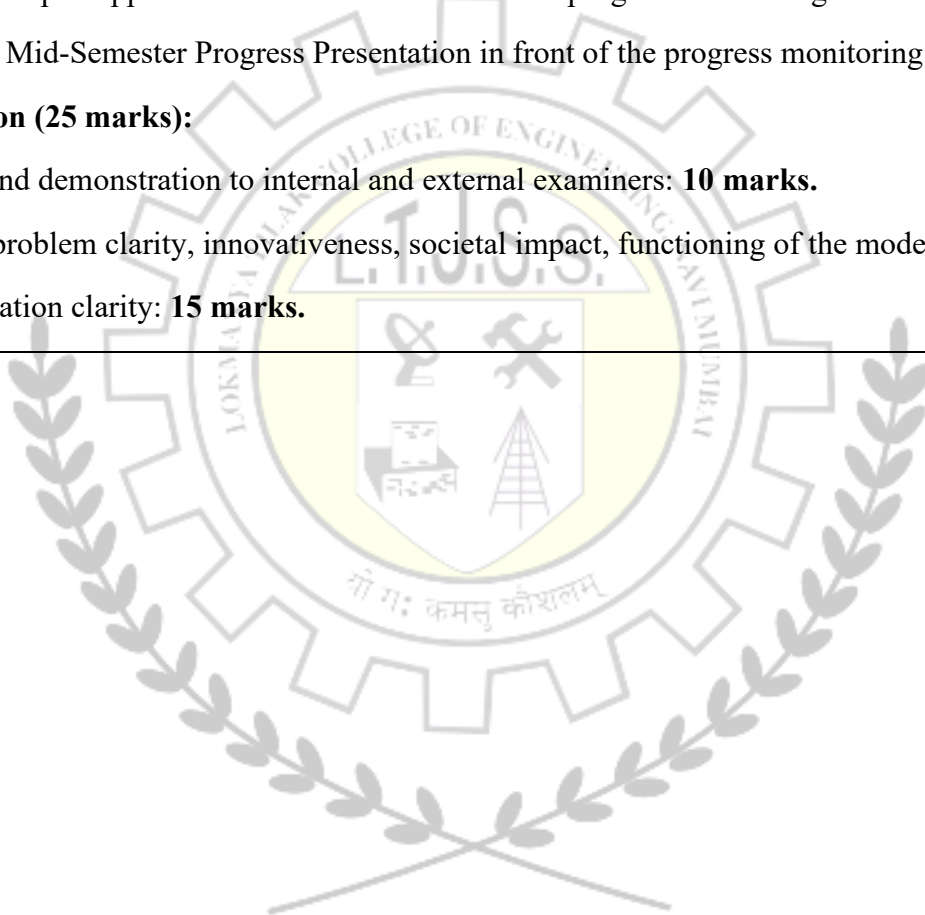
Continuous Assessment marks distribution in semester VI (25 marks): -

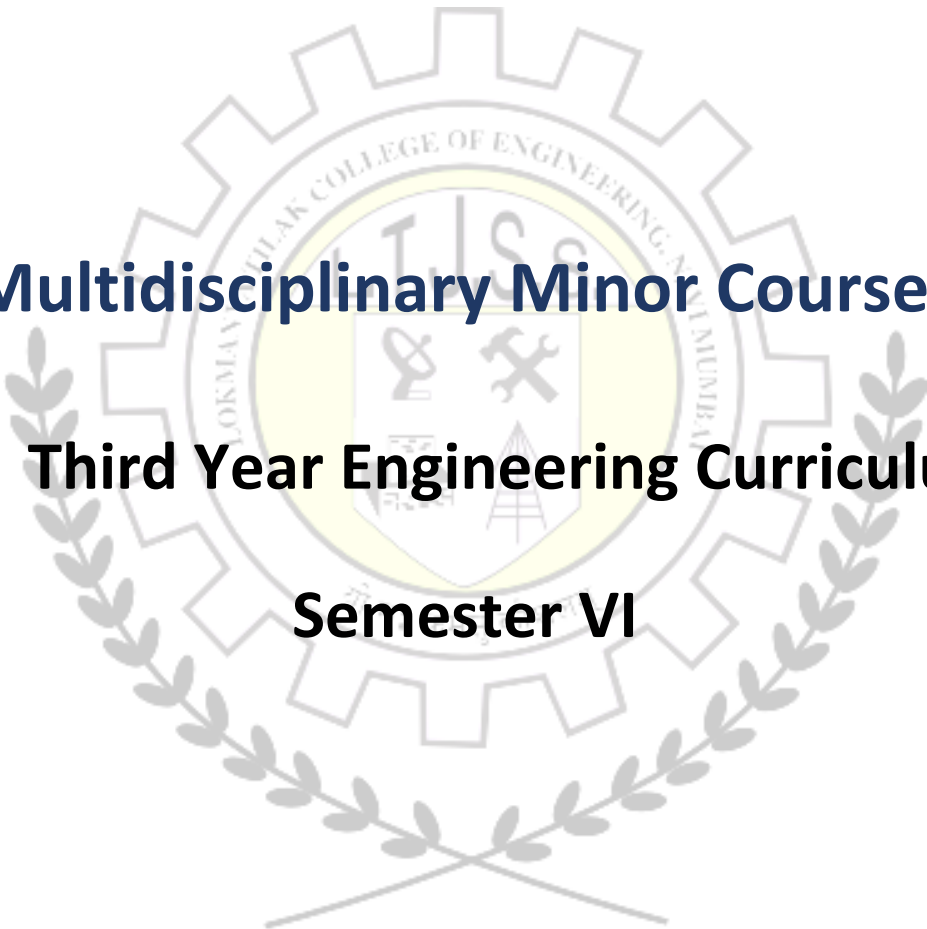
05 marks for the Topic Approval Presentation in front of the progress monitoring committee.

20 marks for the Mid-Semester Progress Presentation in front of the progress monitoring committee

Oral Examination (25 marks):

1. Presentation and demonstration to internal and external examiners: **10 marks.**
2. Emphasis on problem clarity, innovativeness, societal impact, functioning of the model, skill utilization, and communication clarity: **15 marks.**





Multidisciplinary Minor Course III
Third Year Engineering Curriculum
Semester VI

The logo of Lokmanya Tilak College of Engineering, Navi Mumbai, is a circular emblem. It features a gear-like outer border. Inside the gear, there is a central shield containing various engineering symbols: a microscope, a hammer and wrench, and a tower. The text 'LOKMANYA TILAK COLLEGE OF ENGINEERING, NAVI MUMBAI' is written around the inner circle of the gear. The entire logo is rendered in a light gray color.

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
CEMDM601	Big Data Computing	20	20	60	1	2	100	

Prerequisite: Data base management system

Course Objectives: The course aims to

1	Describe an Overview of an exciting growing field of Big Data Analytics.
2	Discuss the tools required to manage and analyze big data like Hadoop, NoSQL, Map Reduce.
3	Apply the fundamental techniques in achieving big data analytics with scalability and streaming capability
4	Discuss the several types of big data like social media, web graphs and data streams.

Course Outcomes: Learners will be able to

1	Describe the key issues in big data management and its associated applications in intelligent business and scientific computing
2	Outline fundamental enabling techniques and scalable algorithms like Hadoop, MapReduce and NoSQL in big data analytics.
3	Predict the business models and scientific computing paradigms, and apply software tools for big data analytics
4	Describe adequate perspectives of big data analytics in various applications like recommender systems, social media applications etc
5	Develop applications for Big Data analysis using Hadoop and NoSQL etc.
6	Design and implement successful Recommendation engines for enterprises.

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction to Big data Analytics	2	CO1
	Introduction to Big Data, Big Data characteristics, Types of Big Data, Traditional vs. Big Data a business approach, Traditional vs. Big Data business approach, Big Data Challenges, Examples of Big Data in Real Life, Big Data Applications		
02	Hadoop	6	CO2
	Introduction to Hadoop. Core Hadoop Components, Hadoop Ecosystem-Apache HBase, Hive, HCatalog, Pig, Mahout, Oozie, Zookeeper, Sqoop, Physical Architecture, Hadoop limitations.		
03	NoSQL	7	CO3
Introduction to NoSQL, NoSQL business drivers, NoSQL database case studies. NoSQL data architecture patterns: Key-value stores, Graph stores, Column family (Bigtable) stores, Document stores, Variations of NoSQL architectural patterns Using NoSQL to manage big data: What is a big data NoSQL solution? Understanding the types of big data problems; Analysing big data with a shared-nothing architecture; Choosing distribution models: master-slave versus peer-to-peer; Four ways that NoSQL systems handle big data problems, Managing MongoDB database with CRUD operations			
04	Map Reduce	6	CO4
	MapReduce and The New Software Stack: Distributed File Systems, Physical Organization of Compute Nodes, Large Scale File-System Organization. MapReduce: The Map Tasks, Grouping by Key, The Reduce Tasks, Combiners, Details of MapReduce Execution, Coping with Node Failures Algorithms Using MapReduce: MapReduce Wordcount Program, Matrix-Vector Multiplication by MapReduce, Relational-Algebra Operations by MapReduce, Matrix Operations, Matrix Multiplication by MapReduce .		
05	Techniques in Big Data Analytics	14	CO5
Finding Similar Item: Nearest Neighbour Search, Similarity of Documents, Distance Measures: Euclidean, Jaccard, Cosine , Edit and Hamming Distance with its Examples Mining Data Streams: Data Stream Management Systems, Data Stream Model, Examples of Data Stream Applications: Sensor Networks, Network Traffic Analysis Filtering streams: The Blooms filter.			

	Link Analysis: PageRank Definition, Structure of the web, dead ends, Using Page rank in a search engine, Efficient computation of Page Rank: Page Rank Implementation Using MapReduce Frequent Itemset Mining: Market-Basket Model, Apriori Algorithm, Algorithm of Park-Chen-Yu		
06	Big Data Analytics Applications Recommendation Systems: Introduction, A Model for Recommendation Systems: Collaborative-Filtering System, Content based system and its Examples Mining Social-Network Graphs: Social Networks as Graphs, Types of Social-Networks. Clustering of Social Graphs: Applying Standard Clustering Techniques, counting triangles using Mapreduce.	7	CO6

Text Books:

1. Radha Shankarmani and M Vijayalakshmi —Big Data Analytics, Wiley
2. Alex Holmes —Hadoop in Practice, Manning Press, Dreamtech Press.
3. Dan McCreary and Ann Kelly —Making Sense of NoSQL – A guide for managers and the rest of us, Manning Press.

References:

1. Bill Franks, —Taming The Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, Wiley
2. Chuck Lam, —Hadoop in Action, Dreamtech Press
3. Analytics in a Big Data World: The Essential Guide to Data Science and its Applications, Bart Baesens, WILEY Big Data Series
4. https://onlinecourses.nptel.ac.in/noc25_cs131/preview

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)				3	
ETMDM601	Digital Image Processing	20	20	60	1	2	100	

Prerequisite: Basic concepts of Mathematics and Digital Communication	
Course Objectives: The course aims to	
1	Familiarize fundamental concepts of Digital Image Processing
2	Learn Spatial and Frequency domain Image enhancement techniques
3	Gain knowledge of Image Segmentation and Image Compression
4	Understand Image Morphology, Restoration, Descriptors and Object recognition applications
Course Outcomes: Learners will be able to	
1	Understand the fundamentals of Digital Image Processing and perform basic operations on image.
2	Analyze and apply Spatial and Frequency domain Image enhancement techniques.
3	Illustrate image segmentation techniques based on principle of discontinuity and similarity using various algorithms.
4	Describe and analyze various digital image compression techniques.
5	Demonstrate morphological operations, image restoration model and various shape descriptors
6	Apply image processing algorithms for object recognition applications.

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction	06	CO1
	Fundamental steps in Digital Image Processing, Representation of a Digital Image, Tonal and Spatial Resolutions, Pixel relationships - neighbors, adjacency, connectivity, distance measures, Basic image operations - arithmetic, logical, geometric transformations, Image File Formats: BMP, TIFF and JPEG, RGB Color model. Self Learning Topic: Sampling and Quantization		
02	Image Enhancement	09	CO2
	Spatial domain enhancement techniques – Image Negative, Contrast Stretching, Thresholding, Gray level transformation, Histogram Equalization, Histogram Specification. Spatial filtering – Smoothing, Sharpening, Highboost and Median Filters. Frequency domain enhancement techniques - Introduction to 2-D DFT and IDFT, Frequency domain filtering - Low pass, High pass and Homomorphic filtering.		
03	Image Segmentation	08	CO3
	Fundamentals of segmentation and edge detection, Thresholding techniques - global, local, and adaptive thresholding, Edge based segmentation- Robert, Sobel, Prewitt, Laplacian, and Canny operators, Region-based segmentation - region growing, splitting, and merging.		
04	Image Compression	08	CO4
	Fundamentals of image compression, Types of redundancy, Fidelity criteria, Lossless compression techniques: Runlength coding, Huffman coding, Bitplane coding, Arithmetic coding, Introduction to DCT, Wavelet transform, Lossy compression techniques: Transform coding, Image and Video Compression Standards – JPEG, MPEG.		
05	Morphological Operations, Image Restoration and Description	07	CO5
	Introduction to mathematical morphology, Erosion and Dilation, Opening and Closing operations, Hit-or-Miss transform, Boundary Extraction and Region Filling, Thinning and Thickening, Image Restoration Models, Boundary and Region Descriptors, Shape descriptors, Fourier descriptors, Moments, Skeletons.		

06	Object Recognition and Applications	04	CO6
	Feature extraction, Patterns and Pattern Classes, Representation of Pattern classes, Types of classification algorithms. Applications- Biometric Authentication, Character Recognition, Content based Image Retrieval, Remote Sensing.		
	Self Learning Topic: Medical application of Image processing		

Text Books:

1. Gonzales and Woods, “Digital Image Processing”, Pearson Education, India, Fourth Edition 2018
2. Anil K. Jain, “Fundamentals of Image Processing”, Prentice Hall of India, Second Edition 2004
3. Pratt W.K, “Digital Image Processing”, Third Edition, John Wiley, New York, 2002

References:

1. Kenneth R. Castleman, Digital Image Processing, Pearson, 1996.
2. B. Chanda and D. Dutta Majumder, Digital Image Processing and Analysis, PHI, 2011.
3. S. Jayaraman, E. Esakkirajan and T. Veerkumar, “Digital Image Processing”, Third Edition, Tata McGraw Hill Education Private Ltd, 2009
4. Digital Image Processing, IIT Kharagpur, Prof. P.K. Biswas Link:
<https://nptel.ac.in/courses/117105079>

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme					Total Marks	Lecture		
		Marks Distribution			Exam Duration (Hrs)				3 Hrs	
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE				Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)							
ARMDM601	Robotics	20	20	60	1	2	100	3		

Prerequisite: Engineering mechanics, Electrical engineering

Course Objectives: The course aims to

1	Acquaint with significance of robotic system in agile and automated manufacturing processes.
2	Make conversant with robotic elements/ peripherals, their selection and interface with manufacturing equipment's
3	Study the basics of robot kinematics

Course Outcomes: Learners will be able to

1	Understand the basic components and types of robots.
2	Analyze and model robotic arms, manipulators, and end-effectors.
3	Acquire skills in image processing and object recognition for robotic applications.
4	Apply kinematic and dynamic analysis to robotic systems
5	Acquire skills of robot intelligence and its role in autonomous decision-making.
6	Understand social, ethical, and economic impacts of robotics on labour, productivity, and society.

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction: Automation & its Overview, Introduction to robotics: Robotic system & Anatomy, Classification of robots and Robot degrees of freedom (DoF) and joint & joint types.	04	CO1
	Drives & Peripherals End Effectors: Drives Control Loops, Basic Control System Concepts & Models, Control System Analysis, Robot Activation & Feedback Components, Position & Velocity Sensors, Actuators and Power Transmission system. Robot & its Peripherals End Effectors: Type mechanical and other grippers, Tool as end effector. Sensors: Sensors in Robotics, Tactile Sensors, Proximity & Range Sensors, Sensor Based Systems, Vision systems and Equipment		
03	Machine vision & Programming for Robots: Machine vision Introduction, Low level & High-level Vision, Sensing & Digitizing, Image Processing & analysis, Segmentation, Edge detection, Object Description & recognition, interpretation and Applications. Programming for Robots Method, motion & task	09	CO3

	level Languages, Robot languages, Programming in suitable languages and characteristics of robot.		
04	Robot Kinematics & Robot Dynamics:	08	CO4
	Robot Kinematics Forward, reverse & Homogeneous Transformations, Manipulator Path control and Robot Dynamics. Introduction to wheeled and legged robots including humanoids.		
05	Robot Intelligence & Task Planning:	07	CO5
	Robot Intelligence & Task Planning Introduction, State space search, Problem reduction, use of predictive logic, Means Ends Analysis, Problem solving, Robot learning and Robot task planning.		
06	Robot application:	06	CO6
	Robot application in manufacturing Material transfer, machine loading & un loading, processing operation, Assembly & inspectors, robotic Cell design & control, social issues & Economics of Robotics. Introduction to AI in Robotics industrial safety standards in robotics, Recent trends in robotics like service, Medical, humanoid robot, Soft robotics		

Text Books:

- 1.Fundamentals of Robotics, Larry Health
- 2.Robotics for Engineers, Yoram Koren , Mc Graw hill.
- 3.Industrial Robotics, Technology, Programming & Applications, Grover, Weiss, Nagel, Ordey, Mc Graw Hill.
- 4.Robotic technology & Flexible Automation, S R Deb. TMH.
- 5.Robot Analysis & Control, H Asada, JJE Slotine.
- 6.Robot Technology, Ed. A Pugh, Peter Peregrinus Ltd. IEE, UK.
- 7.Handbook of Industrial Robotics, Ed. Shimon. John Wiley
- 8.Roland Siegwart, Illah Reza Nourbakhsh, and Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", Bradford Company Scituate, USA

References:

- 1.https://onlinecourses.nptel.ac.in/noc23_me07/preview
- 2.https://onlinecourses.nptel.ac.in/noc25_me166/preview
- 3.https://onlinecourses.nptel.ac.in/noc19_cs47/preview

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

- 1.Assignment: 5 Marks
- 2.Quiz/Open book test/Presentation: 10 Marks
- 3.Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
ITMDM601	Microcontrollers and Application	20	20	60	1	2	100	

Prerequisite: Digital Electronics, Number system

Course Objectives: The course aims to

1	understand the features and architecture of PIC 18 microcontroller and Arduino UNO
2	Introduce assembly programming knowledge for PIC 18 microcontroller
3	Impart embedded programming knowledge for PIC 18 microcontroller using C
4	Introduce various applications using microcontroller-based system

Course Outcomes: Learners will be able to

1	Explain difference between microprocessor and microcontroller architecture and memory
2	Understand PIC 18 instruction and assembly level Programming
3	Describe the timer, counter and interrupt module of PIC 18 with assembly program
4	Explain the serial and parallel I/O with simple assembly program
5	Understand the Arduino UNO programming
6	Write C program for various application of microcontroller.

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction to Microcontroller	6	CO1
	Block diagram of generic microcontroller, Microcontroller versus Microprocessor, A brief history of PIC microcontroller, Overview of PIC 18 family and features, Internal Bus structure of PIC microcontroller, Clock frequency, machine cycle and instruction cycle PIC18 microcontroller programming model, Bus architecture, program		

	memory and data memory organization, Special Function Registers (SFRs), General Purpose Registers (GPRs) <i>CPU registers:</i> Working Register (Wreg), Status Register, Bank Select Register (BSR), Instruction Decoder <i>Memory Pointers:</i> Program ROM and Program Counter (PC), Data ROM		
02	PIC18F Instruction Set	9	CO2
	Pipelining. (conceptual overview only) <i>Instructions and Assembly Programs:</i> Instruction Set, Instruction formats, Addressing modes, Assembler Directives, Assembly programs. (Assembly programs are restricted to basic arithmetic, logical and data transfer operations only)		
03	PIC 18 Timer/counters and interrupt	6	CO3
	<i>Timer Module:</i> Basic Concept of Timers and counters, Timer Registers, Control Registers, 8 bit and 16 bit operation (only for Timer 0), CCP module (Capture, Compare and PWM), Watch dog Timer. <i>Interrupt Module:</i> Basic concept of Interrupt, PIC 18 Interrupts, Interrupt versus polling, Interrupt sources, Interrupt vector, Interrupt service routine, Interrupt process, RCON, INTCON, IPR1 and PIE1.		
04	Parallel Ports and Serial Communication	9	CO4
	IO PORT Module: Basic concept of I/O interfacing, PORT Registers, TRIS Registers, LAT Registers, Simple input /output peripheral interfacing (switches & LEDs). Serial communication: Basics of serial communication, Data framing, USART module, SPBRG, TXREG, RCREG, TXSTA, RCSTA, PIR1.		
05	Introduction to Arduino	6	CO5
	Introduction to Arduino -UNO board, Analog and digital Pins, Programming structure of Arduino, basics of C programming, programming Arduino with sensor interfacing, LED blinking, LCD interfacing.		
06	Application of Microcontroller	6	CO6
	Interfacing matrix keyboard and Seven segments LED display, LCD Interfacing, ADC Interfacing, Traffic signal controller, DC motor interfacing, Stepper motor interfacing, PWM signal generation.		

Text Books:-

1. Ramesh Gaonkar, "Fundamentals of Microcontrollers and Applications in Embedded Systems (with the PIC 18 Microcontroller Family)", Penram International publications (Ind) Pvt. Ltd.
2. Ali Mazidi, Rolind D Mckinlay and Danny Causey, "PIC Microcontroller and Embedded Systems", Pearson Education ltd., 2015
3. Robert B. Reese, "Microcontroller from Assembly Language to C using PIC18FXX2", Davinici Engineering press.
4. Simon Monk, "Programming Arduino: Getting started from Sketches, second Edition,

Reference Books:-

1. Han Way Huang, "PIC Microcontroller: An Introduction to Software and Hardware Interfacing", Cengage Learning, 2005.
2. NPTEL Course: **Microprocessors And Microcontrollers** By Prof. Santanu Chattopadhyay, Dept. of Electrical Engineering, IIT Kharagpur:- Web link- <https://nptel.ac.in/courses/108/105/108105102/>
3. <https://www.arduino.cc/education/certification/>

Internal Assessment (40 Marks)**A. Mid Semester Exam (20 Marks)**

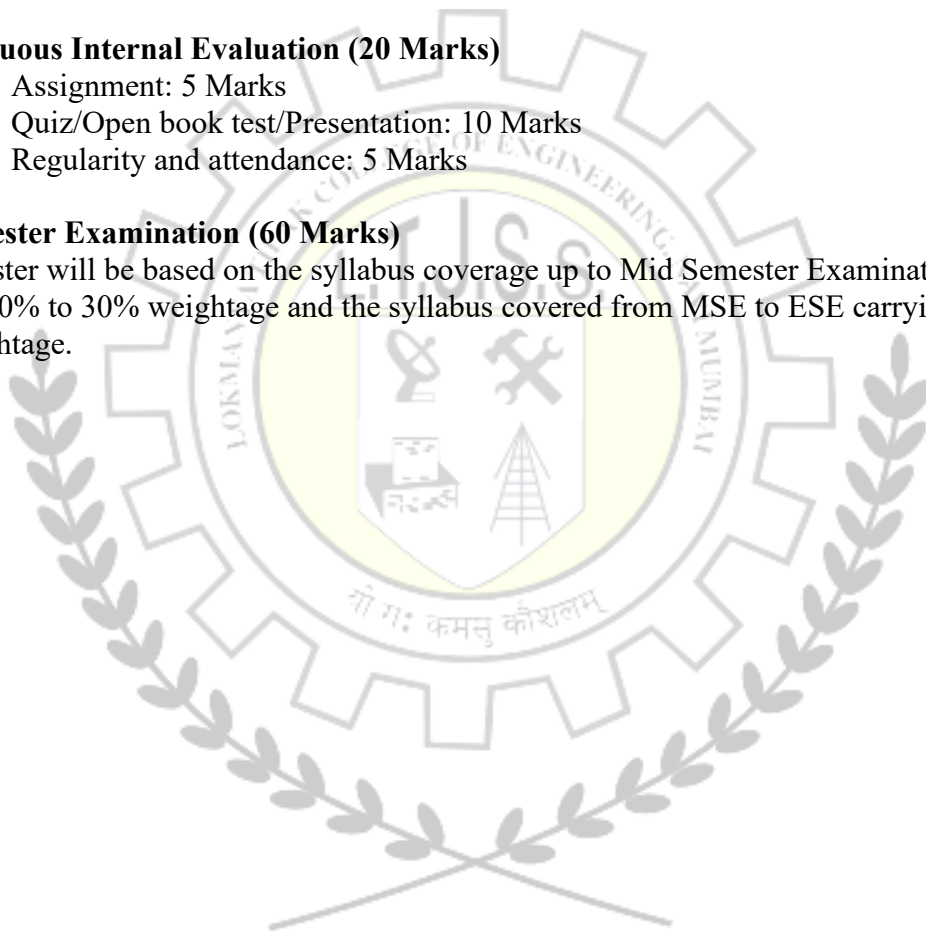
Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.



Course Code	Course Name	Examination Scheme						Lecture	
		Marks Distribution				Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE	Total Credits		
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)						
MEMDM601	Automobile Systems	20	20	60	1	2		100	3

Prerequisite: Engineering Mechanics	
Course Objectives: The course aims to	
1	Understand the major systems and subsystems in modern automobiles.
2	Analyse the working principles of vehicle drivetrain, chassis, braking, steering and suspension systems.
3	Apply mechanical engineering fundamentals (mechanics, strength of materials, kinematics) to vehicle systems.
4	Understand the fundamentals of electric/hybrid vehicle (EV) systems and how they differ from conventional vehicles.
5	Select appropriate components/materials for automotive applications and appreciate trends in automotive technology (EV, ADAS).
Course Outcomes: Learners will be able to	
1	Identify and classify automotive clutches and transmission systems.
2	Demonstrate the working of Driveline, Final Drive & Differential.
3	Demonstrate Steering mechanisms, Wheels, Tyres & Suspension.
4	Identify and classify Braking Systems & Chassis Layout in Automobile.
5	Identify and classify Vehicle Body, Aerodynamics, Materials for Automobile.
6	Relate emerging technologies (electric/hybrid vehicles, regenerative braking, ADAS) to conventional systems.

Module	Detailed Contents	Hrs.	CO Mapping
01	Clutch and Transmission Systems	07	CO1
	Purpose of clutch & transmission in a vehicle, Single-plate, multi-plate clutches, centrifugal clutches, Manual transmissions: sliding mesh, constant mesh, synchromesh Automatic transmissions: torque converter, fluid coupling Continuously Variable Transmission (CVT), Introduction to EV / hybrid transmission layouts.		
02	Driveline, Final Drive & Differential	08	CO2
	Driveline components: propeller shaft, universal joints, driveshafts Final drive gears & bearings Differential: open, limited slip, locking types, Rear axle construction for different vehicles (2WD, 4WD) Introduction to EV/Hybrid drivetrain configurations (e.g., single motor, dual motor, hub motors)		
03	Steering, Wheels, Tyres & Suspension	08	CO3
	Steering geometry, types of steering mechanisms (rack & pinion, recirculating ball), Power steering systems, steer-by-wire, Tyre construction, types, loads; wheel & hub assembly. Suspension systems: leaf, coil, air, independent suspension Vehicle dynamics basics: camber, toe, roll, pitch EV/HV implications: regenerative braking effect on suspension, weight distribution, hub motors		
04	Braking Systems & Chassis Layout	07	CO4
	Braking fundamentals: friction brakes, drum vs disc, Hydraulic and pneumatic braking systems. ABS, EBD, regenerative braking (in EV/HV) Chassis types: ladder, monocoque, space-frame Vehicle layouts: FR, FF, MR, RR, 4WD, AWD Impact of EV architecture on chassis-body design (battery placement, low centre of gravity)		
05	Vehicle Body, Aerodynamics, Materials	05	CO5
	Vehicle body structures, loads, crashworthiness, Aerodynamics basics: drag, lift, side-wind, airflow Materials in automotive industry: steels, aluminium, composites		

	Integration of thermal management systems for EV		
06	Electric & Hybrid Vehicle Systems	07	C06
	Overview of electric vehicle (EV) and hybrid architectures, Batteries: types, performance metrics, Electric motors / motor drives: types (DC, AC, PMSM, etc.) Power electronics: inverters, converters, charger systems, Charging infrastructure, vehicle-to-grid (V2G) & future trends. Comparison of conventional vs EV systems: lifecycle, maintenance, Sustainability.		
	c)		

Text Books:

1. A Textbook of Automobile Engineering by S. K. Gupta.
2. A Textbook of Automobile Engineering by R. K. Rajput.
3. Automobile Engineering by G. B. S. Narang
4. Automobile Engineering Vol I and II by Kirpal Singh.

References:

1. Heitner, J. J., *Fundamentals of Vehicle Dynamics and Driveline Systems*.
2. Heldt, P. M., *Automotive Chassis & Body*.
3. Crouse, W. H. & Anglin, D. L., *Automotive Mechanics*.
4. Ganesan, V., *Electric Vehicles and Hybrid Vehicles*.
5. Husain, I., *Electric and Hybrid Vehicles: Design Fundamentals*.

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Visit/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EEMDM601	Electric Vehicle Technology	20	20	60	1	2	100	

Prerequisite: Sustainability and environment, Electrical Machine.	
Course Objectives: The course aims to	
1	Describe the history and evolution of electric & hybrid electric vehicles to emphasize on the need and importance of EV/HEV for a sustainable future.
2	Identify and describe the principles of various EV/HEVs drive train topologies.
3	Develop an understanding of EV/HEV Electric Machines drives for Propulsion Applications and Energy Sources.
4	Model, analyze and design electric and hybrid electric vehicles drive train and to understand energy management strategies.
Course Outcomes: Learners will be able to	
1	Identify and describe the history and evolution of electric & hybrid electric vehicles.
2	Identify and describe the principles of various EV/HEVs drive train topologies.
3	Select electric propulsion system components for EV/HEV drives for the desirable performance and control.
4	Compare and evaluate various energy sources and energy storage components for EV/HEV
5	Model, analyze and design EV/HEV drive train with energy management
6	Recognize the need to adapt and engage in operations EV/HEV with the absolute technological change in the transportation system for a sustainable future.

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction	07	CO1
	1. Basics of vehicle mechanisms, history of Electric vehicles (EV) and hybrid electric vehicles (HEV), importance of EV and HEV. 2. Power/Energy supplies requirements for EV/HEV applications, transmission characteristics. 3. State of the art and Indian and global scenario in EV/HEV.		
	Self Learning Topic: Basics of vehicle parts, Bharat standard for vehicle emission.		
02	Drive train Topologies	07	CO2
	2.1 Common parts in ICE drive train and EV/ HEV electric drive train topologies, Classification of HEV (Micro, Mild and Full hybrid) 2.2 basics of hybrid traction system, various hybrid drive-train topologies 2.3 fuel efficiency analysis for series and hybrid drive train, comparison.		
	Self Learning Topic: Electric motor, single and multi drive system,		
03	DC and AC machines and Drives for propulsion application	07	CO3
	3.1 DC and AC machines used in EV/HEV, Electrical system components. 3.2 Features of DC and AC Motors for EV/HEV propulsion. 3.3 Permanent magnet(BLDC) and switch reluctance machines, configuration and control of drives.		
	Self Learning Topic: comparison of DC and AC machines, induction motor drive characteristics.		
04	Energy sources for EV and HEV	07	

	4.1 Requirements of energy storage in EV/HEV: batteries, fuel cells, flywheels and ultra-capacitors as energy sources for EV/HEV 4.2 characteristics and comparison of energy sources for EV/HEV 4.3 hybridization of different energy sources. Self-learning Topic: Basics of cell, overview of battery.		CO4
05	Drive train modeling in EV/HEV	07	CO5
	5.1 Modeling and analysis of EV/HEV drive train: Total tractive force calculation, sizing of motor 5.2 Power electronics drive used in EV/HEV		
	Self Learning Topic: Basic electronic components guidelines.		
06	Energy management strategies in EV/HEV	07	CO6
	6.1 EV/HEV energy management strategies, classification of various energy management strategies. Rule based EMS, optimization methods of EMS. 6.5 Standards for EV and HEV. Case studies.		
	Self Learning Topic: 2w and 3w EV/HEV vehicles.		

Text Books:

1. I. Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003.
2. M. Ehsani, Y. Gao, S.E. Gay and Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press. 2005
3. Sheldon Williamson, *Energy Management Strategies for Electric and Plug-in Hybrid Vehicles*, Springer 2013
4. J. Larminie and J. Lowry, *Electric Vehicle Technology Explained*, Wiley, 2003
5. C. MI, M. Abul and D. W. Gao, *Hybrid Electrical Vehicle Principles and Application with Practical Perspectives*, Wiley 2011

Reference Books:

1. N.Mohan, T.M.Undeland, and W.P Robbins, *Power Electronics, Converters, Applications & Design*, Wiley India Pvt. Ltd., 2003
2. B. K Bose, *Modern Power Electronics and AC Drives*, Pearson Education 2002
3. Robert A. Huggins, *Energy Storage*, Springer 2010

NPTEL/ Swayam Course:

1. Course: Intro. to Hybrid and Electric Vehicles - Prof. Praveen Kumar & Prof. S. Majhi (IIT Guwahati): <https://nptel.ac.in/courses/108/103/108103009/>

2. Course: Electric Vehicles - Part 1 By Prof. Amit Kumar Jain (IIT Delhi)
<https://nptel.ac.in/courses/108/102/108102121/>

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

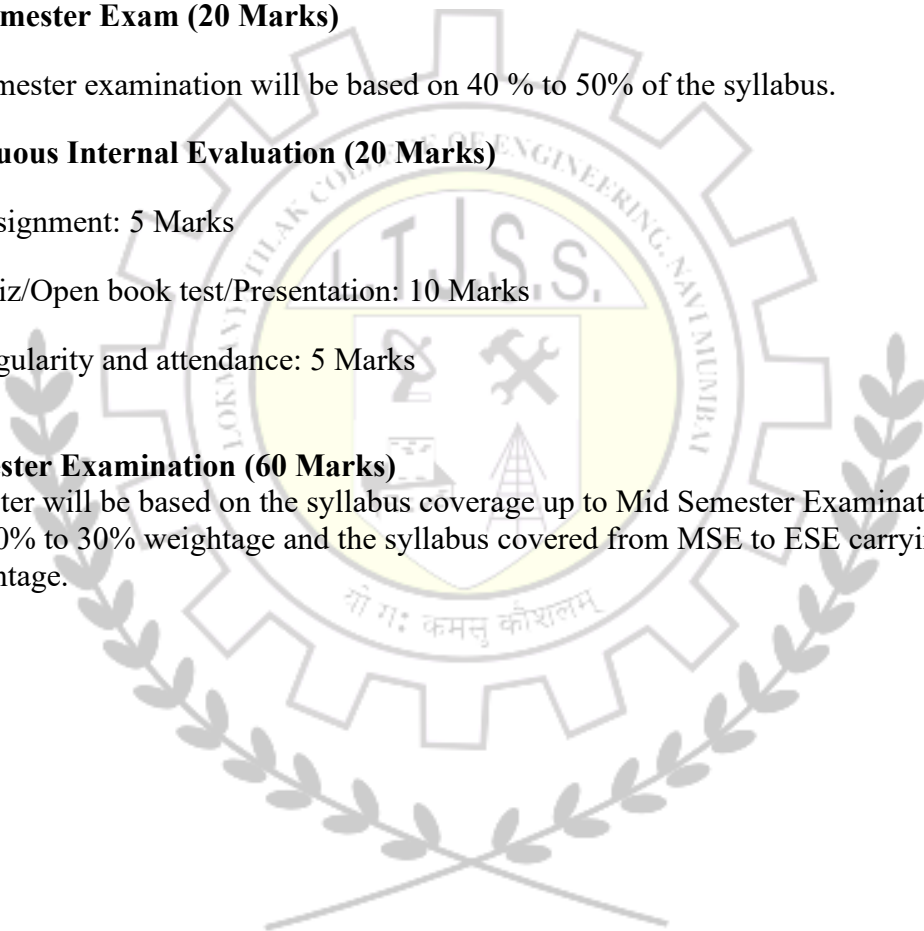
Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.



Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)				1	
CEMDML601	Big Data Computing Lab	-	25	-	-	-	25	

Prerequisite: DBMS

Course Objectives: The course aims to

1	Describe an overview of an exciting growing field of Big Data analytics.
2	Discuss the challenges traditional data mining algorithms face when analyzing Big Data.
3	Explain the tools required to manage and analyze big data like Hadoop, NoSql MapReduce.
4	Tell the tools that will help them to solve complex real-world problems in decision support.

Course Outcomes: Learners will be able to

1	Explain the motivation for big data systems and identify the main sources of Big Data in the real world.
2	Demonstrate an ability to use frameworks like Hadoop, NOSQL to efficiently store, retrieve and process Big Data for Analytics.
3	Build several Data Intensive tasks using the Map Reduce Paradigm
4	Apply several newer algorithms for Clustering Classifying and finding associations in Big Data
5	Design algorithms to analyze Big data like streams, Web Graphs and Social Media data.
6	Design and implement successful Recommendation engines for enterprises.

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	Case Study: on Study of Hadoop ecosystem	CO1
02	Programming exercises on Hadoop Using Hive, Pig, Hbase, Sqoop NOSQL, MongoDB	CO2
03	Implementing simple algorithms in MapReduce Matrix, multiplication, Aggregates, joins, sorting, searching etc.	CO3
04	Implementing Algorithms using MapReduce (Any 2)	CO3
05	Implementing Frequent Item set Mining	CO4
06	Implementing Clustering algorithms Implementing Classification Algorithms	CO5

07	Big Data Applications (Any 2) <ul style="list-style-type: none"> • Implementing Analytics on data streams • Implementing Social Network Analysis Algorithms 	CO6
08	Implementing Web Graph Algorithms Implementing recommendation Engines	CO6
09	Mini Project: One real life large data application to be implemented (Use standard Datasets available on the web) a) Twitter data analysis b) Fraud Detection c) Text Mining d) Recommendation Engines (list of datasets also given in the text book)	CO5,CO6

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Useful Links:

- 1 <https://www.coursera.org/learn/hadoop#syllabus>
- 2 <https://www.coursera.org/learn/introduction-mongodb#syllabus>
- 3 <https://www.coursera.org/learn/data-visualization-tableau?specialization=data-visualization#syllabus>
- 4 <https://www.coursera.org/learn/introduction-to-big-data-with-spark-hadoop#syllabus>

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
ETMDML601	Digital Image Processing Lab	-	25	-	-	-	25	

Prerequisite: Python Programming Skill Lab

Course Objectives: The course aims to

1	Gain practical experience with various operations on digital image.
2	Apply Image enhancement, Image Segmentation, and Image Compression techniques on digital image.
3	Perform morphological operations and compute region and shape descriptors.
4	Strengthen the ability to apply image processing techniques for the given real-world problem.

Course Outcomes: Learners will be able to

1	Demonstrate basic operations on Image.
2	Implement Spatial and Frequency domain Image enhancement techniques.
3	Perform various image segmentation techniques.
4	Implement and analyze various digital image compression techniques.
5	Demonstrate morphological operations, region and shape descriptors.
6	Apply image processing algorithms for object recognition and applications.

Suggested List of Experiments

Implementation can be carried out in MATLAB / Scilab /c / Python (OpenCV)

Sr. No.	List of Experiments	CO Mapping
01	Perform Image reading, displaying, and writing	CO1
02	Perform Image transformations like rotation, scaling, and translation	CO1

03	Implement Histogram equalization	CO2
04	Implement Spatial Domain Filtering: Smoothing and Sharpening Filters	CO2
05	Implement Frequency domain filtering: Low-pass and High-pass Filters	CO2
06	Implement Edge based segmentation- Sobel, Prewitt, Laplacian, and Canny operators	CO3
07	Implement region growing and watershed segmentation	CO3
08	Image segmentation using global Thresholding Algorithm	CO3
09	Implement RLE and Huffman coding for images	CO4
10	Implement Discrete Cosine Transform	CO4
11	Implement Wavelet transform	CO4
12	Implement Morphological operation – Erosion and Dilation, Opening and Closing operations, Hit-or-Miss transform, Boundary Extraction and Region Filling, Thinning and Thickening	CO5
13	Compute region and shape descriptors for given images	CO5
14	Perform object detection	CO6
15	Case Study on applications of Image Processing	CO6

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Course Code	Course Name	Examination Scheme					Total Marks	Practical	
		Marks Distribution			Exam Duration (Hrs)				Total Credits
		Internal Assessment		Oral & Practical	MSE	ESE			
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)						
ARMDML601	Robotics Lab	-	25	-	-	-	25	1	

Prerequisite: Mechatronics, Theory of Machines, Dynamics of Machinery	
Course Objectives: The course aims to	
1	To acquaint with programming of robots.
2	To learn the implementation of image processing algorithms.
3	To demonstrate the working of machine learning algorithms for data prediction
Course Outcomes: Learners will be able to	
1	Identify and describe the main components and Apply principles of sensors, actuators, and embedded systems to enable real-time decision-making in robots.
2	Obtain the tool to base transformations using software simulations.
3	Program a robotic arm to perform pick-and-place tasks with forward (direct) and inverse kinematics
4	Apply image processing techniques to perform edge detection
5	Implement image segmentation algorithms to isolate and recognize objects
6	Develop and simulate trajectory generation and path planning algorithms for robotic manipulators

Suggested List of Experiments

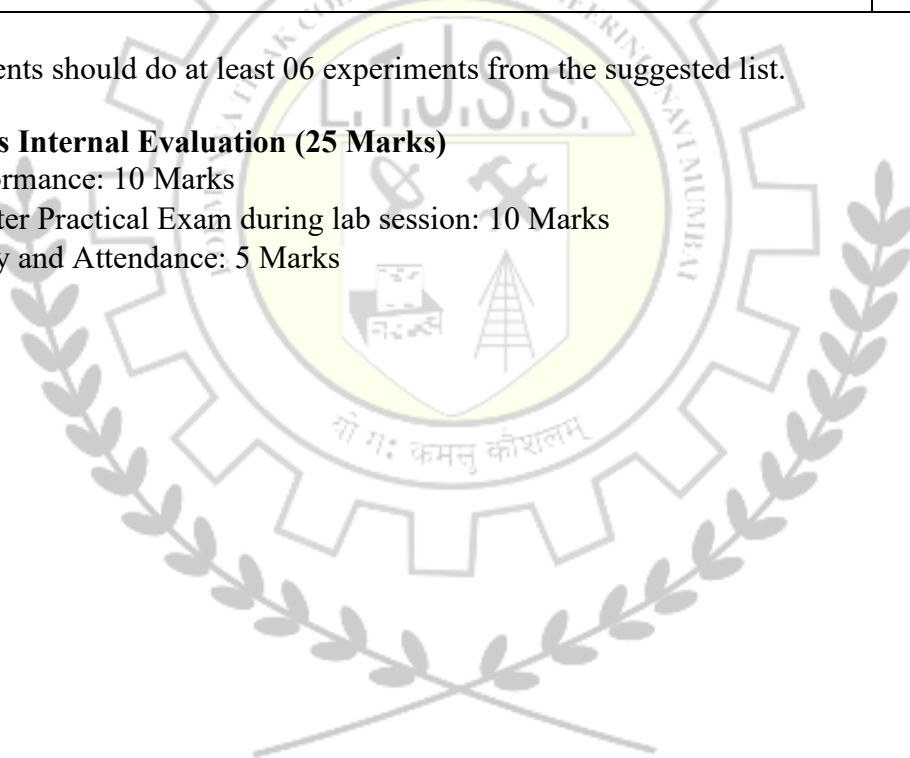
Sr. No.	List of Experiments	CO Mapping
01	Robot Components and Configuration: Understanding robot types, configurations, and components. using educational robotic arm, open Ware robotic simulator. Procedure: Identify the components of a robot. Classify robots based on their configuration. Observe actuators, sensors, and controllers. Results: Document robot types and components.	CO1
02	Study different coordinate frames and transformations. Using Open Ware simulation software. Steps: Define the base and tool coordinate frames. Perform homogeneous transformations. Visualize transformed points in Open Ware. Results: Record transformed coordinates.	CO2
03	Program a robotic arm to perform pick-and-place tasks. Apparatus: Educational robotic arm with Open Ware interface. Procedure: Identify pick and place coordinates. Write program using Open Ware commands. Execute and observe operation. Results: Successful pick-and-place operation	CO3

03	Edge detection using image processing (simulation/hardware) Result: Edges in the image successfully detected using gradient-based algorithms.	CO4
04	Segmentation using image processing (simulation/hardware)	CO5
05	Trajectory Generation and Path Planning(simulation/hardware)	CO6
06	Programming the robots to solve direct and inverse kinematics problems	CO4
06	Acquisition of sensor data over cloud using microcontroller (simulation/hardware)	CO5
07	Implementation of Clustering algorithm (K-means / K-medoids)	CO6
08	A Lab course project such as Mobile Robot Line Following, Obstacle Avoidance for Mobile Robot, surveillance robots etc to be developed in a batch of 4 students.	CO1, CO4

Note: Students should do at least 06 experiments from the suggested list.

Continuous Internal Evaluation (25 Marks)

- 1.Lab Performance: 10 Marks
- 2.In-Semester Practical Exam during lab session: 10 Marks
- 3.Regularity and Attendance: 5 Marks



Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hours
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
ITMDML601	Microcontrollers and Application Lab	-	25	-	-	-	25	

Course Objectives: The course aims to

- | | |
|---|--|
| 1 | Impart assembly programming of PIC microcontroller |
| 2 | Impart assembly programming for I/O interface and timer, counter |
| 3 | Impart knowledge of Arduino programming |
| 4 | Impart skill of application based microcontroller programming. |

Course Outcomes: Learners will be able to

- | | |
|---|---|
| 1 | Write and debug simple assembly programs on data transfer |
| 2 | Write and debug simple assembly programs on arithmetic and logical instructions |
| 3 | Write and debug simple assembly programs on Timers and counters |
| 4 | Write and debug Arduino programs |
| 5 | Write and debug I/O programming of Arduino and PIC |
| 6 | Make system using microcontroller |

Suggested List of Experiments

Minimum three experiments must be done from each group

Sr. No.	List of Experiments	CO Mapping
Group A	Use at least 3 programs <ol style="list-style-type: none">1. Data transfer2. Group of data transfer3. Addition, Subtraction, Multiplication4. Time delay5. Conditional and unconditional tasks	CO1
Group B	<ol style="list-style-type: none">1. Square wave generation2. LED inter facing3. Blinking LED4. Serial port programming5. Counter programming	CO1
Group C	<ol style="list-style-type: none">1. Simple Arduino programming for addition subtraction2. Arduino programming for LED blinking3. PIC 18 programming for LCD interface4. PIC 18/Arduino programming for DC motor interface5. Any other application of Microcontroller	CO2

Minimum 9 experiments and case study hardware project and one assignment are compulsory for the term work.

Continuous Internal Evaluation (25 Marks):

1. Lab Performance: 10 Marks
2. Mid Semester Oral & Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution				Exam Duration (Hrs)		2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE	Total Marks	Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
MEMDML601	Automobile Systems Lab	-	25	-	-	-	25	

Prerequisite: Thermal engineering, Machine Design

Course Objectives: The course aims to

1	Study construction, working and performance of key automobile subsystems.
2	Gain hands-on experience with vehicle transmission, steering, suspension, braking, and driveline systems.
3	Introduce modern EV and hybrid powertrain components through simulation and hardware demonstrations.
4	Correlate theoretical concepts with practical automotive systems and diagnostics.

Course Outcomes: Learners will be able to

1	Identify and explain the construction and working principle of single-plate and multi-plate clutch mechanisms used in vehicles.
2	Compare the working and torque transmission characteristics of manual (synchromesh) and automatic (torque converter/CVT) transmissions.
3	Demonstrate the function and interaction of propeller shaft, universal joint, and differential gear in the driveline system using models.
4	Examine different suspension systems (leaf, coil, air, independent) and analyze their impact on vehicle ride comfort.
5	Distinguish between chassis frame constructions (ladder, monocoque, space-frame) and identify vehicle layouts (FR, FF, 4WD, etc.).
6	Illustrate the architecture and components of Electric Vehicles, including battery, motor, inverter, and charging system.

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	Study and demonstration of single-plate and multi-plate clutch mechanisms.	CO1
02	Comparative study of manual (synchromesh) and automatic transmission (torque converter / CVT).	CO2
03	Study and demonstration of propeller shaft, universal joint, and differential gear using cut section models.	CO3
04	Demonstration of suspension systems.	CO4

05	Analysis of chassis frames (ladder, monocoque, space-frame) and vehicle layout identification.	CO5
06	Study of EV architecture – components like battery, motor, inverter, and charging systems.	CO6

Continuous Internal Evaluation (25 Marks)

1.Lab Performance: 10 Marks

2.In-Semester Practical Exam during lab session: 10 Marks

3.Regularity and Attendance: 5 Marks



Course Code	Course Name	Examination Scheme						Total Marks	Practical
		Marks Distribution			Exam Duration (Hrs)				2 Hrs
		Internal Assessment		Oral	MSE	ESE	01		
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)						
EEMDML601	Electric Vehicle Technology Lab	-	25	-	-	-		25	

Prerequisite: Renewable Energy System and Energy Storage System, Electrical Machines, Power Electronics

Course Objectives: The course aims to

- 1 Study the fundamental concepts and principles of electric and hybrid electric vehicles Drive train topologies
- 2 Develop a thorough understanding of the key elements of EV/HEV: Electric Machines For Propulsion Applications and Energy Sources
- 3 Model, analyze and design electric and hybrid electric vehicles drive train and to Understand energy management strategies

Course Outcomes: Learners will be able to

- 1 Explore EV and HEV and convention vehicle performance
- 2 Interpret the salient features and components of Electric and Hybrid electric vehicles
- 3 Test and analyze various propulsion motor loading under variable speed and torque conditions.
- 4 Observe and analyze the charging and discharging characteristics of electric vehicle batteries.
- 5 Describe about the applications of power electronics in electrical vehicles
- 6 Explore the transportation sustainability

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	Basic vehicle simulations on MATLAB or any other vehicle simulation software	CO1
02	Study of transmission system through simulation/ experiment	CO1
03	Emission test of conventional vehicle, electric vehicle and hybrid electric vehicle	CO2
04	Develop schematic diagram of hybrid electric vehicle and identify its parts in MATLAB simulation	CO2
05	Load test of DC series Motor	CO3
06	Testing and analysis of induction motor loading at different speed and torque conditions.	CO3
07	Connect and run the three phase squirrel cage induction motors (in both directions) using the DOL starter/ autotransformer starter.	CO3

08	Rechargeable lithium-ion battery SOC test and other performance	CO4
09	Design and testing of controlled rectifier circuit for battery charging	CO4
10	Prepare a report on batteries used from market survey	CO4
11	study of battery management system through simulation/experiment	CO5
12	Design and testing of battery connected buck / boost converter	CO5
13	List safety procedures and schedule for handling HEVs and EVs	CO6
14	Case study- Compare minimum four vehicles for economic and environmental analysis	CO6
15	Visit to EV/Battery/Motor/Capacitor manufacturing Plant	All COs

Any experiment or simulation related to EV and HEV that helps the students understand the course should be included and added other than the suggested list.

Plant Visit:

Visit to existing EV charging station/ battery manufacturing unit/ EV manufacturing unit.

Term Work: Minimum 8 experiment/simulation must be done for satisfactory completion of the term.

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

