Syllabi
MDM
Offered by
Electrical Department

Course Type	Course Code	Course Name	Credits
MDM	EEMDM301	INDUSTRIAL ELECTRONICS	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite :

1. ESC102: Basic Electrical Engineering

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO2: Problem analysis

Course Objectives:

1. To study the importance of industrial electronics in various mechanical domain industries.
2. To impart knowledge on fundamental concepts, applications and selection of Analog circuits, digital IC technologies, power electronic switches and circuits.
3. To comprehend fundamentals concepts of microcontrollers and familiarize with the Arduino, its hardware components and software tools.
4. To study comparison and selection of different motors to solve engineering problems within the realm of mechanical systems,

Module	Details	Hrs
	Course Introduction Industrial electronics play a crucial role in automation and robotics in manufacturing industries. Mechanical engineers need to understand the electronic components and systems that control robots and automated machinery to design, program, and maintain these systems efficiently. Mechanical engineers also need to comprehend the design and programming of embedded systems to develop intelligent machines and systems that meet industrial demands.	**01**
01.	**Introduction to Industrial Electronics:**	**3-5**
	Learning Objective: *Identify complex engineering applications of Mechanical Engineering in which Industrial Electronics is applicable.*	
	Content: Overview of industrial electronics, Importance and applications in various industries, Industrial electronics in Automotive sector, Components of typical Electric vehicle, Motor speed control drive	

	system for Electric vehicles, block diagram of CNC machine, Applications in Automation and robotics: Manufacturing (welding, painting, loading/unloading, machining, casting, forging etc.), Material Handling (Transport, pick and place, palletization)	
	Self-Learning Topics: *--*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Use the core applications of Mechanical engineering to understand Industrial electronics implemented in them. (P.I.1.3.1)* *LO 1.2: Apply the principles of automation and robotics in manufacturing processes to optimize production outcome, recognize the importance of industrial electronics in various industries and its impact on enhancing productivity and efficiency.(P.I.1.4.1)*	
02.	**Semiconductor Devices**	**6-8**
	Learning Objective: *Apply fundamentals concepts of power electronic devices to identify and select power electronic device for specific application.*	
	Content: Review of Construction, Working Principle, V-I Characteristics and Applications of: Rectifier Diode, Zener Diode, Zener diode as voltage regulator. SCR Construction, Operating Principle and V-I characteristics, Construction and working of MOSFET and IGBT, Comparison of MOSFET and IGBT, applications of MOSFET and IGBT.	
	Self-Learning Topics: *--*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply fundamental concepts of PN junction diodes and its type in different applications. (P.I.:1.3.1)* *LO 2.2: Apply concepts of semiconductor devices to find best suitable component for different applications. (P.I.1.4.1)* *LO 2.3: Identify suitable component for engineering system to solve the problem. (P.I. 2.1.2)* *LO 2.4: Compare performance characteristics of different power devices and use suitable one to solve engineering problems. (P.I. 2.2.4)*	
03	**Analog and Digital Circuits:**	**7-9**
	Learning Objective: *Apply fundamental knowledge of op-amp to identify suitable op-amp circuit in different applications.* *Application of Boolean algebra in different logic circuits and identify suitable gate/ digital circuit in different applications.*	
	Content: **Analog and Digital Circuits:** Analog circuits: Operational amplifier circuits, Ideal and Practical Op-	

	Amp, common OPAMP ICs; Basic OPAMP circuits- Inverting amplifier, Non-inverting amplifier, adder, subtractor, comparator, voltage follower (Buffer), Instrumentation Amplifier. **Digital circuits:** Comparison of Analog and digital circuits, Review of Logic gates, Boolean algebra, universal gates, Flip flops: Set Reset (SR), Analog to digital converter, Counters: Synchronous and Asynchronous counters.	
	Self-Learning Topics: --	
	Learning Outcomes: *Learner will be able to* *LO 3.1: Apply basic mathematical techniques to find voltage gain equations of different op-amp circuits. (P.I.1.1.1)* *LO 3.2: Apply Kirchhoff's law to ideal Op-amp and find required equation of Analog circuit. (P.I. 1.4.1)* *LO 3.3: Identify suitable op-amp circuit and digital circuit to solve the problem. (P.I. 2.1.2)* *LO 3.4: Assuming op-amp as ideal one find necessary equations of different op-amp circuits with same accuracy of practical op-amp (P.I.2.3.2)*	
04.	**Microcontrollers and their applications**	**6-8**
	Learning Objective: *Identify features of different microcontrollers and apply suitable algorithm to complex engineering problem.*	
	Content: **Microcontrollers and their applications**: Introduction to Microprocessor and Microcontroller, comparison of Microprocessor and Microcontroller. Features, applications of general purpose 8 bit and 16 bit microcontrollers, Introduction to Arduino Uno board, ATmega328P microcontroller for Arduino board, Communication between Arduino and Software, Interfacing of Arduino board with Potentiometer, thermistor and servomotor, PWM generation, ADC using Arduino.	
	Self-Learning Topics: --	
	Learning Outcomes: *Learner will be able to* *LO 4.1: Identify the systems parameters and control it using microcontrollers. (P.I. 2.1.2)* *LO 4.2: Apply knowledge of programming to produce and validate results using microcontroller for specific application. (P.I.2.4.2)*	
05.	**Power Converters:**	**8-10**
	Learning Objective: *Apply fundamental knowledge of semiconductor devices and analyse performance of converters.*	
	Content: **DC-DC Converter:** Operation of Buck converter, Boost converter.	

	Inverters: Basic principle of single phase Inverter, Operation of Single phase half bridge voltage source inverter with R load, Operation of single phase full bridge inverter with R load, basic working principle of three phase inverter, Application of converters in EV and renewable applications.	
	Self-Learning Topics: --	
	Learning Outcomes: *Learner will be able to* *LO 5.1: Apply fundamental mathematical techniques to find equations of dc-dc converters. (P.I. 1.1.1)* *LO 5.2: Apply fundamental concepts of semiconductor devices to select suitable device in dc-dc converters and inverters. (P.I.1.4.1)* *LO 5.3: Identify suitable dc-dc converters and inverters for different engineering applications. (P.I.2.1.2)* *LO 5.4: Compare performance of different types of dc-dc converters and inverters and select suitable one for specific application. (P.I. 2.2.4)*	
06.	**Motors and their applications:**	**7-9**
	Learning Objective/s: *Identify different types of electric motors, their applications and sizing for specific applications.*	
	Content: **Motors and their applications**: Servomotors: types, construction, principle of operation, characteristics and control, Stepper motor: Construction, Working Principle, and Applications, BLDC Motor: construction, working, electronic commutation, control of BLDC motor, Selection and sizing of motors for Electric vehicles and Drones.	
	Self-Learning Topics: --	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply fundamental mathematics to determine sizing of motor for specific application. (P.I.1.1.1)* *LO 6.2: Apply fundamental knowledge of different motors to plot performance characteristics and select suitable motor for specific application. (P.I.1.4.1)* *LO 6.3: Identify variables and parameters to be controlled and find suitable motors for particular application. (P.I.2.1.2)* *LO 6.4: Compare performance characteristics of different motors and select suitable motor for a given application. (P.I.2.2.4)*	
	Course Conclusion:	**01**
	Students are expected to use knowledge of this subject to design, optimize, and maintain sophisticated mechanical systems in industrial environments.	
Total		**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply electrical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.3.2	Identify assumptions (mathematical and physical) necessary to allow modelling of a system at the level of accuracy required.
2.4.2	Produce and validate results through skilful use of contemporary engineering tools and models.

Course Outcomes: A learner will be able to -

1. Integrate principles and applications of mechanical engineering with industrial electronics across various industries. *(LO 1.1, LO 1.2)*
2. Apply fundamental concepts of power electronic switches and identify the suitable one for particular converter. *(LO 2.1, LO 2.2, LO 2.3, LO 2.4)*
3. Identify suitable Analog and Digital circuit for different applications. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4)*
4. Use appropriate Microcontroller to validate results of different applications. *(LO 4.1, LO 4.2)*
5. Determine relevant equations for the dc-dc converters and inverters. Also find their applications in EV and renewable sources. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4)*
6. Compare and analyse performance, characteristics of different motors to select the best in specific application. *(LO 6.1, LO 6.2, LO 6.3, LO 6.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EEMDM301.1	3	--	--	--	--	--	--	--	--	--	--
EEMDM301.2	3	3	--	--	--	--	--	--	--	--	--
EEMDM301.3	3	3	--	--	--	--	--	--	--	--	--
EEMDM301.4	--	3	--	--	--	--	--	--	--	--	--
EEMDM301.5	3	3	--	--	--	--	--	--	--	--	--
EEMDM301.6	3	3	--	--	--	--	--	--	--	--	--
Average	**3**	**3**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Power Electronics M.H. Rashid, Prentice-Hall of India
2. Electronic Devices and Circuits, Robert Boylestad and Louis Nashelsky, Prentice Hall
3. Modern Digitals Electronic, Jain R P, Tata McGraw Hill, 1984

4. Programming Arduino, Dr.Simon Monk, McGraw-Hill Education 2012

5. Electric Machinery, Bimbhra P.S., Khanna Publisher

Reference Books :

1. Power Electronics, Ned Mohan, Undeland, Robbins, John Wiley Publication

2. Special Electrical Machine, E. G. Janardanan, PHI publication

Other Resources :

1. NPTEL Course: Fundamentals of semiconductor devices, Prof. Digbijoy N. Nath, IISc Bangalore
   Web link- https://nptel.ac.in/courses/108/108/108108122/
2. NPTEL Course: Power Electronics Prof. D.Prasad, Prof. N.K. De, Dr. D.Kastha, Prof. Sabyasachi Sengupta, IIT Khragpur
   Web link- https://nptel.ac.in/courses/108/105/108105066/
3. NPTEL Course: Basic Electronics By Prof. Mahesh B. Patil, IIT Bombay
   Web link- https://nptel.ac.in/courses/108101091
4. NPTEL Course: Digital Electronics By Prof. N.J.Rao, IISc Bangalore
   Web link- https://nptel.ac.in/courses/106108099
5. NPTEL Course: Electrical Machines By Prof. G.Bhuvaneshwari, IIT Delhi
   Web link- https://nptel.ac.in/courses/108102146

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

Two Class test	:	05 Marks each
Open book test/ Open notes test	:	05 Marks
Regularity and active participation	:	05 Marks

2. Mid Semester Exam (30 Marks)

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

END SEMESTER EXAMINATION (50 MARKS)

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

Course Type	Course Code	Course Name	Credits
MDM	EEMDM402	MEASUREMENT AND CONTROL	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. BSC204: Engineering Mathematics II

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO4: Conduct Investigations of Complex Problems

Course Objectives:

1. To familiarize measuring instruments.
2. To acquaint with various measurement system.
3. To acquaint with control system.
4. To familiarize with stability analysis of control system.

Module	Details	Hrs.
	Course Introduction The significance measurement system. Automation and control systems are pivotal across numerous industries, with smart manufacturing and IoT-enabled processes being essential in industrial settings. Within automated systems, the critical process of collecting data from various sensors and transmitting signals to different entities is imperative. It is crucial to comprehend the types and characteristics of sensors utilized in the development of automated systems. The significance of accurate measuring instruments becomes apparent in the design of control systems, where identifying and integrating key elements is essential. The foundational components of a control system are fundamental to its operational efficacy in real-world applications.	**01**
01.	**Generalized Measurement System** ***Learning Objective:*** *Learner will be able to apply engineering and mathematical knowledge to analyze the different characteristics of measuring instruments.*	**3-5**

	Contents: Aim of measurement, methods and techniques of measurement, generalized measurement systems. Instruments & its classifications, performance characteristics of instruments, Statistic & dynamic characteristics, analysis of experimental data, Regression analysis, correlation, estimation of uncertainty and presentation of data. Errors in measurements**.**	
	Self-Learning Topics: *Identify measuring instruments come across in our day life*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply engineering knowledge to select appropriate measurement technique for real life applications. (P.I.-1.4.1)* *LO 1.2: Apply mathematical knowledge in estimation of uncertainty in measurement (P.I.-1.1.2).* *LO 1.3: Apply mathematical concepts for analyzing static and dynamic characteristics of measuring instruments. (P.I.-2.1.3)* *LO 1.4: Apply engineering systems and variables for analyzing characteristics of measuring instruments (2.1.2).*	
02.	**Temperature Measurement, Pressure Measurement, Flow Measurement and Strain Measurement** ***Learning Objective:*** *Learner will be able to apply knowledge in selecting different instrumentation tools to measure various physical quantities as per sensor characteristics.*	**7-9**
	Contents: **Temperature Measurement:** Electrical resistance thermometer, Thermistors and thermocouples, Laws of thermocouples and their applications, Construction and calibration of thermocouples, Radiation pyrometers, total radiation pyrometer. Input output characteristics. Application based on sensor characteristics. **Pressure Measurement:** Bourdon tube pressure gauge, Diaphragms and bellows, Low pressure measurement, McLeod gauge, Pirani& thermal conductivity gauge. Ionization gauge, Piezo electric transducer. Selection of pressure measuring devices for specific applications. Calibration of pressure measuring devices. Range and span of the pressure measuring devices. **Flow Measurements:** Types of flow measuring devices, Coriolis flow meter, vortex shedding flow meter, Hot wire anemometers, Magnetic flow Meters, Flow visualization Techniques, Shadowgraph, Interferometer, Laser Doppler, Ultra sonic flow meter, PIV (Particle Image Velocimetry). Input output characteristics. Application based on sensor characteristics. **Strain Measurement:** Strain Gauges, Construction, Types and sensitivity of strain gauges, Digital Image Correlation Techniques, DAQ System for strain measurements. Signal conditioning of sensor signals.	

	Self-Learning Topics: *Range and span of the pressure measuring devices*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply mechanical engineering knowledge and fundamental engineering knowledge for understanding different characteristics of sensors used for temperature, pressure, flow and strain measurement(P.I.-1.3.1).* *LO 2.2: Apply mechanical engineering knowledge for using appropriate measuring instruments based on sensor characteristics (P.I.-1.4.1).* *LO 2.3: Identify engineering systems and variables for establishing relationship between measured data and output of measuring instruments(P.I.-.2.1.2).* *LO 2.4: Apply mathematical and engineering knowledge to categorize different measuring instruments based on its span and range for real life applications(P.I.-2.1.3).*	
03.	**Smart Sensors and Technologies** ***Learning Objective:*** *Learner will be able to demonstrate the ability to explore technological advancement in sensor technology.*	**9-11**
	Contents: **Smart Sensors and Technologies** - Smart Sensors, Accelerometers, Force Sensors, Load Cells, Torque Sensors, Pressure Sensors Microphones, Impact Hammers and Fiber Optic Sensors. Smart Actuator and its Techniques – Role of Actuators and Actuator materials, Piezoelectric and Electrostrictive Materials, Magneto-structural Materials, Shape Memory Alloys, Electro rheological fluids, Electromagnetic actuation. MEMS Accelerometer, Air bag sensor, Bio –Medical sensor, Gas sensor, Chemical sensor, Micro motor, micro channel. Micro cantilever beam	
	Self-Learning Topics: *MEMS sensors for real applications*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply fundamental engineering knowledge for understanding different characteristics of micro-sensors (P.I.-1.3.1).* *LO 3.2: Apply mechanical engineering concepts in selecting appropriate measurement techniques using smart sensor and actuation technique for specific applications. (P.I.1.4.1).* *LO 3.3: Identify engineering systems and variables for establishing relationship between measured data and output of micro-sensors(P.I.-.2.1.2).* *LO 3.4: Apply mathematical and engineering knowledge to categorize different micro-measuring instruments for real life applications(P.I.-2.1.3).*	
04.	**Control System** ***Learning Objectives:*** *Learner will be able to apply mathematical knowledge to build and analyze the data for control purpose.*	**6-8**
	Contents:	

	Open loop and Closed loop system. Automatic Control System. Mathematical modelling of mechanical, fluid system and thermal systems. Transfer Function. Block diagram reduction techniques, signal flow graphs. Modes of control. Proportional, Integral, Derivative, Proportional Plus Integral plus Derivative controls, examples from mechanical and electrical systems. Fuzzy logic – Fuzzy set – Fuzzy control.	
	Self-Learning Topics: *Real life examples of open loop and closed loop control system.*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Formulate the transfer function model for mechanical, fluid and thermal systems by applying basic concepts in mechanical engineering (P.I.-1.3.1.)* *LO 4.2: Reframe the complex systems into interconnected subsystems, construct transfer function for each subsystem, then to reduce to a single transfer function model for the entire system. (P.I.-1.4.1)* *LO 4.3: Apply skill in framing complex problems in to sub problems for development of mathematical model of control system (P.I.-2.2.1).* *LO 4.4: Apply mathematical and engineering knowledge to devise transfer function of a system (P.I.-2.1.3).*	
05.	**Time response of control system** ***Learning Objective/s:*** *Learner will be able to analyze the data for reframing complex problems for finding possible static and dynamic error coefficients of control system.*	**7-9**
	Contents: Time response of control system, analysis of steady state error. Standard test signals and transient response of first and second order systems. Sources of errors, static and dynamic error constants.	
	Self-Learning Topics: *Significance of time and frequency response of control system.*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply mathematical concept for analyzing transient state analysis of control system (P.I.-2.1.3).* *LO 5.2: Analyze the system for steady state error (P.I.-2.2.1).* *LO 5.3: Analyze the given data for static and dynamic error coefficients (P.I.-4.3.2).* *LO 5.4: Solve the given transfer function to determine the damping ratio, natural frequency and static error coefficients of a system and use this information to analyze the transient and steady state behavior of the system. (P.I.-4.3.3).*	
06.	**Stability of Control System** ***Learning Objective/s:*** *Learner will be able to apply the skill for analyzing data for prediction of system stability.*	**5-7**

	Contents: State variables, state space representation, Routh Hurwitz stability criteria, Root locus. Frequency response: Bode plot, Polar plot, Stability analysis, Relative stability. Control system design.	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Analyze system stability criteria using Routh's criteria method (P.I.-2.1.3).* *LO 6.2: Use engineering mathematics and computations to sketch the root locus from the given transfer function model. (P.I.-2.1.2).* *LO 6.3: Analyze the transfer function to convert T.F. in to state space model of control system(P.I.-4.3.2).* *LO 6.4: Plot frequency response cure for a control system for predicting system stability (P.I.-4.3.3.).*	
	Course Conclusion Upon completing the course, the learner will have the capability to choose suitable instruments based on sensor characteristics for typical applications. Additionally, they will gain familiarity with diverse control systems and methods for ensuring system stability.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.2	Apply advanced mathematical techniques to model and solve mechanical engineering problems.
1.3.1	Apply fundamental engineering concepts to solve engineering problems
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2.1	Reframe complex problems into interconnected sub problems.
4.3.2	Analyze data for trends and correlations, stating possible errors and limitations
4.3.3	Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and drawing of conclusions.

Course Outcomes: A learner will be able to

1. Categorize a generalized measurement system and identify the various static characteristics associated with measuring instruments. (*LO 1.1, LO 1.2, LO 1.3, LO 1.4*)
2. Learner will be able to develop the skill for selection of sensors for specific applications as per sensor characteristics (*LO 2.1, LO 2.2, LO 2.3, LO 2.4)*
3. Learner will be able to develop the skill for selection of micro sensors for specific applications. (*LO 3.1, LO 3.2, LO 3.3, LO 3.4)*
4. The learner will gain the ability to comprehend different types of control systems. (*LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 5.1, LO 5.2, LO 5.3, LO 5.4)*

5. The learner will acquire the capability to apply skills in predicting the stability of a control system. (*LO 6.1, LO 6.2, LO 6.3, LO 6.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEMDM503.1	3	3	--	--	--	--	--	--	--	--	--
MEMDM503.2	3	3	--	--	--	--	--	--	--	--	--
MEMDM503.3	3	3	--	--	--	--	--	--	--	--	--
MEMDM503.4	3	3	--	3	--	--	--	--	--	--	--
MEMDM503.5	--	3	--	3	--	--	--	--	--	--	--
Average	**3**	**3**	--	**3**	--	--	--	--	--	--	--

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books:

1. Measurement Systems: Applications and Design, by EO Doebelin,5th Edition, McGraw Hill
2. Mechanical Engineering Measurements, A. K. Sawhney, Dhanpat Rai & Sons, New Delhi
3. Control System Engineering by Nagrath I.J. and Gopal M, Wiley Eastern Ltd
4. Modem Control engineering: by K. Ogata, Prentice Hall
5. Control systems by Dhanesh Manik, Cengage Learning

Reference Books :

1. Control systems by Dhanesh Manik, Cengage Learning.
2. Mechanical Measurements by S P Venkateshan, John Wiley & Sons.

Other Resources :

1. NPTEL Course: Principles of measurement by Prof. Dipankar N Basu Department of Mechanical Engineering, IIT Guwahati.
   Web link- https://nptel.ac.in/courses/112/103/112103261/
2. NPTEL Course: Control Engineering By Prof. Ramkrishna Pasumarthy, Department of Electrical Engineering, IIT Madras.
   Web link- https://nptel.ac.in/courses/108/106/108106098/
3. NPTEL Course: Mechanical Measurement System By Prof. Ravi Kumar, Department of Mechanical & industrial Engineering, IIT Roorkee.
   Web link- https://nptel.ac.in/courses/112/107/112107242/

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment – Theory (20 Marks)

Suggested breakup of distribution

MCQ test strictly as per GATE exam pattern / level)	:	05 Marks
Test will be conducted in offline mode		
Class Test	:	05 Marks
Open book Test	:	05 Marks
Regularity and active participation	:	05 Marks

2. Mid Semester Exam (30 Marks)

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

END SEMESTER EXAMINATION (50 MARKS)

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

Course Type	Course Code	Course Name	Credits
MDM	EEMDM503	ELETCRICAL DRIVES AND CONTROL	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ESC102: Basic Electrical Engineering
2. ESC203: Basic Electronics Engineering

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO4: Conduct investigations of complex problems:
4. PO6: The Engineer and The World
5 PO11: Life-Long Learning

Course Objectives:

1. To familiarize various electrical drives
2. To acquaint with electronic control of electric motors
3. To acquaint with various control techniques for AC drives
4. To familiarize with four quadrant operation of DC drives

Module	Details	Hrs.
	Course Introduction The significance of electric dives and systems Electric drives and systems are integral to modern technology and play a pivotal role in various industries. Their significance stems from their ability to control and optimize the operation of electric motors, which are used in numerous applications.	**01**
01.	**Introduction to Electric Motors** ***Learning Objective:*** *Learner will be able to apply engineering and mathematical knowledge to analyze the different characteristics of electrical drives.*	**7-9**

	Contents: Electric drives, advantages of electrical drives, parts of electrical drives, choice of electrical drives, status of ac and dc drives. Types of load, fundamental of torque equation, speed-torque convention and multi quadrant operation, selection of power rating.	
	Self-Learning Topics: --	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply engineering knowledge to identify different parts of electrical drives. (P.I.-1.1.2)* *LO 1.2: Apply engineering knowledge for selection of appropriate given drives for specific application. (P.I.1.1.3)* *LO 1.3: Apply mathematical concepts for torque- speed characteristics of electrical drives. (P.I.-2.1.3)* *LO 1.4: Apply engineering systems and variables for analyzing power rating of electrical drives (P.I.2.1.2)*	
02.	**Electrical Motors** ***Learning Objective:*** *Learner will be able to apply engineering knowledge to understand various characteristics of electric drives.*	**8-10**
	Contents: DC Motors – Permanent magnet, field wound, series, shunt compound - constructional features, principle of operation, torque equation, speed torque characteristics AC Motors – Induction Motor. Synchronous motor, brushless DC Motor. Permanent magnet synchronous motor. Switched reluctance motor, stepper motor. Universal motor, hysteresis motor, servo motor. Constructional features, principle of operation, torque equation, speed torque characteristics. Selection criterion of electric motors for specific applications based on its characteristics.	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply fundamental engineering knowledge for understanding constructional features of various electrical drives(P.I.-1.3.1).* *LO 2.2: Apply electrical engineering knowledge for classifying different electrical drives for appropriate usages. (P.I.-1.4.1).* *LO 2.3: Identify engineering systems and variables for establishing relationship between various performance characteristics of electrical drives in the context of sustainable development to an engineering activity. (P.I.- 2.1.2, 6.2.2).* *LO 2.4: Apply mathematical and engineering knowledge to analyze speed- torque characteristics of electrical drives in the context of sustainable development to an engineering activity (P.I.- 2.1.3,6.2.2).*	
	Electronics Control of Electrical Motors	

03.	***Learning Objective:*** *Learner will be able to demonstrate the ability to explore electronics control of electrical motors.*	
	Contents: Power electronics control - scope and applications. Types of power electronics circuits and their applications in drives. Speed and current sensors. Open-loop and closed-loop control, position control and practical applications	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply fundamental engineering knowledge for understanding different characteristics of power electronics control (P.I.-1.3.1).* *LO 3.2: Apply electrical engineering concepts in understanding different power electronics circuits and its applications. (P.I.1.4.1).* *LO 3.3: Identify engineering systems and variables for establishing relationship between measured data and output of speed and current sensors (P.I.-.2.1.2).* *LO 3.4: Apply mathematical and engineering knowledge to develop different control techniques and appropriate procedures for controlling electrical drives (P.I.-2.1.3,4.3.1).*	**8-10**
04.	**Various Control Techniques for AC Drives** ***Learning Objectives:*** *Learner will be able to apply mathematical knowledge to build and analyze various control techniques for AC drives.*	**6-8**
	Contents: Scalar control, concept of space vector. Field oriented control and direct torque control. Soft computing techniques and adaptive controllers.	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Formulate the concept of space vector and scalar control of AC drives (P.I.-1.3.1.)* *LO 4.2: Reframe the complex systems into interconnected subsystems, construct space vector of electrical systems. (P.I.-1.4.1)* *LO 4.3: Apply skill in framing complex problems in to sub problems for development of appropriate procedures for field oriented control and direct torque control of various drive systems (P.I.-2.2.1,4.3.1).* *LO 4.4: Apply mathematical and engineering knowledge to devise optimal engineering design solutions to develop adaptive controllers (P.I.-2.1.3,4.3.1).*	
05.	**Control of Induction Motor Through Stator Voltage and Frequency** ***Learning Objective/s:*** *Learner will be able to analyze the data for variable frequency control of induction motor.*	**5-7**

	Contents: Variable voltage characteristics control of induction motor by using AC voltage controllers, waveforms, speed torque charactestics. Variable frequency characteristics, variable frequency control of induction motor by voltage source and current source inverter..	
	Self-Learning Topics:	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Formulate the concept of variable voltage characteristics of induction motor (P.I.-1.3.1.)* *LO 5.2: Analyze the speed torque characteristics (P.I.-2.2.1).* *LO 5.3: Analyze variable frequency characteristics and control of induction motor in the context of technological advance in the domain of electrical engineering(P.I.-4.3.2,11.2.1).* *LO 5.4: Use appropriate procedures for variable frequency control of motor by voltage and current source inverter in the context of technological advance in the domain of electrical engineering (P.I.-4.3.1,11.2.1).*	
06.	**Four Quadrant Operations of AC Drives** ***Learning Objective/s:*** *Lerner will be able to apply the skill for understanding the principle of four quadrant operation of AC Drives.*	**3-5**
	Contents: Introduction to four quadrant operation of AC drives, electrical braking, plugging, dynamic regenerative plugging operation. Four quadrant operation of DC motors by dual converters.	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Formulate the concept of four quadrant operation of AC Drives (P.I.-1.3.1.)* *LO 6.2: Analyze electrical braking and dynamic regenerative plugging operation (P.I.-4.3.2).* *LO 6.3: Develop four quadrant operation of DC motors by dual converters.(P.I.-4.3.3.).*	
	Course Conclusion Upon completing the course, the learner will have the capability to understand various characteristics of AC/DC drives and their control techniques	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.2	Apply advanced mathematical techniques to model and solve mechanical engineering problems.
1.3.1	Apply fundamental engineering concepts to solve engineering problems
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.2.1	Reframe complex problems into interconnected sub problems.
4.3.2	Analyse data for trends and correlations, stating possible errors and limitations
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data
4.3.3	Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and drawing of conclusions.
6.2.2	Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline.
11.2.1	Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current

Course Outcomes: A learner will be able to -

1. Learner will be able to apply skill to categorize different electrical drives. (*LO 1.1, LO 1.2, LO 1.3, LO 1.4)*
2. Learner will be able to develop the skill for selection of electric motors for specific application as per its characteristics. (*LO 2.1, LO 2.2, LO 2.3, LO 2.4).*
3. Learner will be able to develop various control technique for electric drive systems. (*LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 4.1, , LO 4.2, , LO 4.3, , LO 4.4, , LO 5.1, LO 5.2, LO 5.3, LO 5.4).*
4. The learner will gain the ability to explore for four quadrant operations of electric drive systems. (*LO6.1, LO 6.2, LO 6.3).*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEMDM503.1	3	3	--	--	--	--	--	--	--	--	--
MEMDM503.2	3	3	--	--	--	2	--	--	--	--	--
MEMDM503.3	3	3	--	3	--	--	--	--	--	--	2
MEMDM503.4	2	--	--	3	--	--	--	--	--	--	--
Average	**3**	**3**	**--**	**3**	**--**	**2**	**--**	**--**	**--**	**--**	**2**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. G. K. Dubey, “Fundamentals of Electrical Drives”, Narosa, 2001
2. R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, PHI-India, 2005.
3. N. K. De and P. K. Sen, “Electric Drives”, Prentice Hall of India Private Limited, 2006.
4. S. K. Pillai, “A First Course on Electrical Drives”, New Age International
5. S. B. Dewan, G. R. Slemon and A. Straughen, “Power Semiconductor Drives”, John Wiley and Sons, New York 1984

Reference Books :

1. G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall international, New Jersey, 1989
2. B. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia, 2003.

Other Resources :

1. https://archive.nptel.ac.in/courses/108/104/108104140/
2. https://archive.nptel.ac.in/noc/courses/noc19/SEM2/noc19-ee65/

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested breakup of distribution

MCQ test strictly as per GATE exam pattern / level).

Test will be conducted in offline mode	:	05 Marks
Class Test	:	05 Marks
Open book Test	:	05 Marks
Regularity and active participation	:	05 Marks

3. Mid Semester Exam (30 Marks)

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

END SEMESTER EXAMINATION (50 MARKS)

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

Course Type	Course Code	Course Name	Credits
MDM	EEMDM604	AUTOMATION AND ARTIFICIAL INTELLIGENCE	04

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. EEMDM402: Measurement and Control

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct Investigations of Complex Problems
5. PO5: Engineering Tool Usage
6. PO6: The Engineer and The World
7. PO8: Individual and Collaborative Team work
8. PO9: Communication
9. PO11: Life-Long Learning

Course Objectives:

1. To familiarize various elements in an automated system
2. To acquaint with industrial fluid power system
3. To acquaint with PLC software
4. To familiarize with Artificial Intelligence technology

Module	Details	Hrs.
	Course Introduction The significance Automation and Artificial Intelligence. Automation and AI systems are pivotal across numerous industries, with smart manufacturing and IoT-enabled processes being essential in industrial settings. Within automated systems, the critical process of collecting data from various sensors and transmitting signals to different entities is imperative. Understanding architecture of automated system, data transmission in many of the automated systems is an important thing. Artificial intelligence is growing and find application in many of the industrial settings. AI has got many of the applications in mechanical engineering.	**01**
01.	**Automation System**	**5-7**

	Learning Objective: *Learner will be able to apply basic and mechanical engineering knowledge to explore industrial automation systems.*	
	Contents: Elements of mechatronic system. Elements of automated system. Automation principles and strategies, Levels of automation, Types of automation, Advanced automation functions. Automation in production system, Principles and strategies of automation. Requirement of automation systems, Architecture of industrial automation system.	
	Self-Learning Topics: --	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply mechanical engineering knowledge to identify different elements in an automated system. (P.I.- 1.4.1)* *LO 1.2: Apply fundamental engineering concepts to understand the features of automation system (P.I. - 1.2.1)* *LO 1.3: Identify objectives for the need for automation systems in the modern era (P.I.- 2.1.1)* *LO1.4: Combine scientific principles and engineering concepts to explore different levels and types of automation systems in the industrial scenario (P.I.- 2.3.1)* *LO 1.5: Demonstrate the ability to recognize evolving trends in engineering knowledge and practices within the field of automation. (P.I- 11.2.1)* *LO 1.6 : Recognize the need to go for development in the domain of automation(P.I.- 11.2.2)*	
02.	**Industrial Pneumatic and Hydraulic System** ***Learning Objective:*** *Learner will be able to apply knowledge in demonstrating the functionalities of different pneumatic / hydraulic components for designing different pneumatic and hydraulic systems.*	**10-12**
	Contents: **Pneumatic Systems** Pneumatic system. Directional control valves, Flow control valves, Pneumatic cylinders, Development of pneumatic / electro-pneumatic circuits. Design of pneumatic sequencing circuits using Cascade method and Shift register method (up to 2 cylinders). Design of Pneumatic circuits for metal working handling, Clamping, Counter and Timer circuits. **Hydraulic Systems** Basic Hydraulic Circuits: Meter in, Meter out and Bleed off circuits. Intensifier circuits, Regenerative circuit, Counter balance valve circuit and sequencing circuits. Industrial applications of hydraulic system. Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. IOT in Hydraulics and pneumatics.	
	Self-Learning Topics: --	
	Learning Outcomes:	

	A learner will be able to *LO 2.1: Apply mechanical engineering knowledge for understanding different characteristics of pneumatic systems and hydraulic systems. (P.I.-1.4.1)* *LO 2.2: Apply engineering fundamentals to select various pneumatic/hydraulic components to develop pneumatic/ hydraulic circuits (P.I.-3.1)* *LO 2.3: Identify design objectives and formal idea generation tools to develop hydraulic / pneumatic system across various applications (P.I.-3.3.1)* *LO: 2.4: Apply formal idea generation tools to develop pneumatic/hydraulic circuits for given application (P.I.-3.2.1)* *LO 2.5: Apply principles of sustainable development while designing pneumatic/hydraulic circuits in the context of environment and sustainability (P.I.- 3.1.5, 6.2.2)* *LO 2.6: Understand relationship between the technical, socio economic and environmental dimensions of sustainability while designing hydraulic / pneumatic system across various applications (P.I.- 3.1.6, 6.1.2)* *LO 2.7: Develop the teamwork skills while collaboratively designing and implementing pneumatic and hydraulic systems for specific tasks. (P.I.-8.2.1)*	
03.	**PLC and Data Communication** ***Learning Objective:*** *Learner will be able to demonstrate the ability to apply PLC software to develop ladder diagrams for industrial applications.*	**10-12**
	Contents: Functions of PLC, Architecture of PLC, PLC Ladder Diagram. Communication in PLCs, Implementation of counters, Timers, Time Delays, Basic hydraulic circuits: Implementation of PLC programming for Pneumatic / Hydraulic system. Data handling, advanced motion controlled multi axis PLC. Industrial applications of PLC. Industrial data communication, Modbus, Supervisory control systems. SCADA, Distributed control system, Safety systems:- Human machine interface, Total integrated automation:- Industry 4.0	
	Self-Learning Topics: --	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply fundamental engineering concepts to demonstrate the various applications of PLCs in real life applications (P.I-1.3.1)* *LO 3.2: Apply mechanical engineering knowledge for understanding architecture of PLCs. (P.I.-1.4.1)* *LO 3.3: exhibit skill in using PLC software and to explore various communication systems in PLC to build electro-pneumatic/electro-hydraulic circuits for given applications (P.I.-5.1.1)* *LO 3.4: acquire proficiency to build PLC ladder logic for given application (P.I.-5.2.2)* *LO 3.5: Develop the team work skills while collaboratively designing and implementing PLC logics for specific tasks. (P.I.- 8.2.1)*	
04.	**Machine Learning Techniques** ***Learning Objectives:*** *Learner will be able to apply engineering and mathematical knowledge to explore different machine learning techniques for different applications.*	**11-13**

	Contents: Introduction to Artificial Intelligence Introduction, Historical development, Intelligent systems. Types of intelligent agents, Components of AI, Foundations of AI, Scope of AI. Current trends in AI, Relevance to Mechanical engineering. Problem Solving: Tree and Graph Search, Uninformed v/s informed search, Uninformed methods: Depth first search, Breadth first search. Informed search: heuristic search. Best first search, Branch and bound. Machine Learning: Introduction, types of machine learning: Supervised, Unsupervised, Reinforcement learning. Learning with Decision Trees: Introduction to Decision Trees, Classification and Regression Trees, K means clustering algorithm, K nearest neighbours algorithm, hierarchical clustering. Concept of ensemble methods: Bagging, boosting and Random forests.	
	Self-Learning Topics: --	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply mechanical engineering knowledge to understand scope of machine learning in mechanical engineering (P.I.-1.1.4.1)* *LO 4.2: Apply fundamental engineering concepts to demonstrate the various applications of machine learning in real life applications (P.I.-1.3.1)* *LO 4.3: Combine scientific principles and mathematical knowledge to Identify suitable machine learning methods to collect data for machine learning models. (P.I.-2.1.3)* *LO 4.4: Apply engineering mathematics and computations to select more appropriate machine learning techniques to the given problem (P.I.- 2.4.1)* *LO 4.5: acquire skill in identifying discipline specific techniques to build machine learning models for given tasks. (P. I.- 5.1.1)* *LO 4.6: acquire skill in applying discipline specific tools to develop machine learning model (P.I.- 5.2.2)* *LO 4.7: Demonstrate the ability to recognize evolving trends in engineering knowledge and practices within the field of artificial intelligence. (P.I.-11.2.1)*	
05.	**Artificial Neural Network** ***Learning Objective/s:*** *Learner will demonstrate the ability to apply their knowledge to explore various methods of Artificial Neural Network (ANN) models.*	**10-12**
	Contents: Learning with regression: Linear regression, Logistic regression. Artificial Neural Networks. Concept of ANN, Basic models of artificial Neural networks. Important terminologies of ANNs, McCulloch-Pitts Neuron, NN architecture, Perceptron. Delta learning rule, Backpropagation algorithm, Gradient descent algorithm, Feed forward networks and activation function. Introduction to AI Technologies in the realm of Automation. Concept of Natural Language processing. Machine vision, Deep learning, Expert systems, Genetic algorithms, Industry 4.0.	
	Self-Learning Topics: --	

	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply engineering concepts and mathematical knowledge that applies algorithms for developing neural networks system (P.I.- 2.1.3)* *LO 5.2: Apply scientific principles and engineering concepts to develop ANN model (P.I.- 2.3.1)* *LO 5.3: Analyze the given data for regression techniques in machine learning applications (P.I.- 4.3.2)* *LO 5.4: Use appropriate procedures and tools for developing Artificial Neural Network (P.I.- 4.3.1)* *LO 5.5: Develop skill to deliver impactful oral presentations on various artificial intelligence techniques and their real-life applications. (P.I- 9.2.2)*	
06.	**AI Applications** ***Learning Objective/s:*** *Learner will demonstrate proficiency in delving into AI applications within the manufacturing sector.*	**6-8**
	Contents: **Application of AI in Manufacturing** Applications in quality control, Anomaly detection, and Process optimization. Model selection and evaluation for manufacture. Deep learning techniques, Convolutional neural networks and Recurrent neural networks. Integration of robotics and AI in manufacturing processes. Case studies of AI-driven improvements in manufacturing efficiency and quality. Real World Applications Real-world applications in manufacturing: AI-driven process optimization and quality control. AI's role in supply chain management, Demand forecasting, and Production scheduling. Sustainable and green manufacturing through AI. Future trends and preparing for Industry 5.0: Challenges and opportunities in the evolving landscape of AI in manufacturing. The role of AI in fostering innovation and competitiveness. Preparing for the future of manufacturing with AI skills and knowledge.	
	Self-Learning Topics: --	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply mathematical and engineering knowledge to analyze Artificial Intelligence techniques for manufacturing applications (P.I.- 2.1.3)* *LO 6.2: Apply engineering mathematics and computations to apply artificial intelligence techniques to mechanical engineering applications (P.I.- 2.4.1)* *LO 6.3: Demonstrate effective communication and problem-solving ability to explore AIs role in real world applications. (P.I.- 9.2.2)* *LO 6.4: Demonstrate in ability to explore emerging trends in AIs application in mechanical domain (P.I.- 11.2.1)*	
	Course Conclusion	**01**

	Upon completing the course, the learner will have the capability to demonstrate the architecture of automated systems, develop pneumatic / hydraulic systems using modern tools. The course also gives a comprehensive architecture of different machine learning techniques and its applications in mechanical engineering. The course briefs about different machine learning algorithms.	
	Total	**60**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.2.1	Apply laws of natural science to an engineering problem
1.3.1	Apply fundamental engineering concepts to solve engineering problems
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.1.1	Articulate problem statements and identify objectives
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy
2.3.2	Identify assumptions (mathematical and physical) necessary to allow modeling of a system at the level of accuracy required
3.2.1	Apply formal idea generation tools to develop multiple engineering design solutions
3.2.3	Identify suitable criteria for evaluation of alternate design solutions
3.3.1	Apply formal decision making tools to select optimal engineering design solutions for further development
4.1.4	Establish a relationship between measured data and underlying physical principles.
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data
4.3.2	Analyze data for trends and correlations, stating possible errors and limitations
5.1.1	Identify modern engineering tools such as computer aided drafting, modeling and analysis; techniques and resources for engineering activities
5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems
5.2.1	Identify the strengths and limitations of tools for (i) acquiring information, (ii) modelling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs
5.2.2	Demonstrate proficiency in using discipline specific tools
8.2.1	Demonstrate effective communication, problem solving, conflict resolution and leadership skills
8.2.2	Treat other team members respectfully

8.3.1 Present results as a team, with smooth integration of contributions from all individual efforts

9.2.1 Listen to and comprehend information, instructions, and viewpoints of others

9.2.2 Deliver effective oral presentations to technical and non-technical audiences

11.1.1 Describe the rationale for requirement for continuing professional development

11.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current

11.2.2 Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap

Course Outcomes: A learner will be able to –

1. Learner will be able to apply skill to explore different automation systems and strategies (*LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 1.5, LO 1.6*).
2. Learner will be able to develop the skill for developing different pneumatic/ hydraulic systems for industry applications (*LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5*).
3. Learner will be able to demonstrate skill in developing PLC Ladder logics for given applications(*LO 3.1, LO 3.2, LO 3.3, LO 3.4).*
4. Learner will be able to demonstrate skill in identifying appropriate machine learning techniques and its concepts for real life applications(*LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5).*
5. Learner will be able to demonstrate skill in identifying appropriate AI models for prediction task and explore real life applications of AI in Mechanical engineering domain(*LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 6.1, LO 6.2, LO 6.3.LO 6.4)).*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EEMDM604.1	3	--	--	--	--	--	--	--	--	--	2
EEMDM604.2	3	--	3	--	--	--	--	2	--	--	--
EEMDM604.3	2	--	--	--	3	--	--	2	--	--	--
EEMDM604.4	2	2	--	2	2	--	--	--	--	--	2
EEMDM604.5	--	3	--	2	--	--	--	--	3	--	3
Average	**3**	**3**	**3**	**2**	**3**	**--**	**--**	**2**	**3**	**--**	**2**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books:

1. Mechatronics System Design, Shetty and Kolk, Cengage Learning, India Edition.
2. Mechatronics - Electronic Control Systems in Mechanical Engineering, Bolton Pearson education.
3. Pneumatic Circuits and Low Cost Automation by Fawcett JR.
4. Industrial Hydraulics: Pippenger
5. Instrumentation and Control System, W. Bolton, Elsevier

6. John W Webb and Reis, Ronald A., "Programmable Logic Controllers: Principles & Applications", Prentice Hall.
7. Frank Petruzella," Programmable Logic Controllers", McGraw-Hill Education; 4 editions.
8. Artificial Intelligence: A Modern Approach by Peter and Norvig ISBN-0-13103805-2.
9. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair ISBN-978-0-07008770-5, TMH.
10. Artificial Intelligence by Saroj Kausik ISBN: - 978-81-315-1099-5, Cengage Learning.
11. Artificial Intelligence and Intelligent Systems by Padhy, Oxford University Press.
12. Artificial Intelligence & Machine Learning by Vinod Chandra. S.S. Anand Harindran. S. (PHI).
13. A first course in Artificial Intelligence – By Deepak Khemani. Mc GrawHill

Reference Books:

1. Artificial Intelligence & Machine Learning by Vinod Chandra. S.S. Anand Harindran. S. (PHI).
2. A first course in Artificial Intelligence – By Deepak Khemani. Mc GrawHill

Other Resources :

1. NPTEL Course: Mechatronics and Manufacturing Automation, by Prof. Shrikrishna N. Joshi, Department of Mechanical Engineering, Indian Institute of Technology Guwahati Web link- https://nptel.ac.in/courses/112103174.
2. NPTEL Course :Fundamentals of Artificial Intelligence, by Prof. Shyamanta M. Hazarika, Indian Institute of Technology Guwahati – Web link - https://nptel.ac.in/courses/112103280.
3. NPTEL Course: Introduction to Machine Learning, by Prof. Balaraman Ravindran, IIT Madras Web link - https://nptel.ac.in/courses/106106139

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment – Theory (20 Marks)

Suggested breakup of distribution

MCQ test strictly as per GATE exam pattern / level).

Test will be conducted in offline mode	:	05 Marks
Class Test	:	05 Marks
Open book Test	:	05 Marks
Regularity and active participation	:	05 Marks

1. Mid Semester Exam (30 Marks)

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

END SEMESTER EXAMINATION (50 MARKS)

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

Course Type	Course Code	Course Name	Credits
MDL	EEMDMLC601	AUTOMATION AND ARTIFICIAL INTELLIGENCE LABORATORY	01

Examination Scheme		
Continuous Assessment	**Practical /Oral**	**Total**
25	25	50

Pre-requisite:

1. ESL102: Basic Electrical Engineering Laboratory
2. ESL206: Basic Electronics Engineering Laboratory

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct Investigations of Complex Problems
5. PO5 : Engineering Tool Usage
6. PO6: The Engineer and the World
7. PO8: Individual and Collaborative Team work
8. PO11: Life-Long Learning

Course Objectives:

1. To familiarize with pneumatic / hydraulic system
2. To acquaint with application of PLC in pneumatic/ hydraulic system
3. To acquaint with ML technologies
4. To acquaint with different machine learning algorithms

Module	Details	Hrs.
	Course Introduction The course introduces the usage of various functionalities of pneumatic / hydraulic systems and how PLC software can be integrated with pneumatic/ hydraulic systems for developing circuits for various real life applications. The course also introduces how machine learning techniques can be effectively applied for mechanical applications..	**01**
01.	***Learning Objective:*** *Learner will be able to demonstrate the skill to effectively use various functionalities of pneumatic systems and components.* **Experiment** Introduction to Pneumatic system, construction and working of different pneumatic components used in various pneumatic systems.	**02**
	Self-Learning Topics: --	

	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply fundamental engineering concepts demonstrate the use of various components of pneumatic systems. (P.I.- 1.3.1)* *LO 1.2: Apply mechanical engineering knowledge to demonstrate the use of various components of pneumatic systems. (P.I.-1.4.1)* *LO 1.3: Identify engineering systems and variables to select more appropriate pneumatic components for specific tasks(P.I.-2.1.2)* *LO 1.4: Identify the mathematical, engineering and other relevant knowledge to select various pneumatic components to build pneumatic systems(P.I.- 2.1.3)*	
02.	***Learning Objective:*** *Learner will be able to demonstrate the skill to integrate different pneumatic components to build and test pneumatic circuits for the given problem.*	**04**
	Experiment Design and development of pneumatic circuits for given applications. Perform the experiment using pneumatic trainer kit.	
	Self-Learning Topics: --	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Combine scientific principles and engineering concepts in selecting appropriate pneumatic components to build a pneumatic circuit for given application (P.I.- 2.3.1)* *LO 2.2: Apply knowledge of engineering mathematics to build a pneumatic circuit for given application (P.I.- 2.4.1)* *LO 2.3: Apply formal idea generation tools to develop pneumatic circuit for given application (P.I.- 3.2.1)* *LO 2.4: Demonstrate the skill to identify suitable criteria to design and develop pneumatic circuits for real life applications. (P.I.-3.2.3)* *LO2.5: Demonstrate the relationship between the technical, socio economic and environmental dimensions of sustainability while designing pneumatic system for specific task (P.I.- 3.1.1,6.1.2)* *LO 2.6: Apply sustainable development principles to design and optimize pneumatic systems for industrial applications. (P.I.- 3.1.1, 6.2.2)*	
03.	***Learning Objective:*** *Learner will be able to apply knowledge for interfacing pneumatic system with PLC software / for building pneumatic systems.*	**04**
	Experiment Design and development of electro-pneumatic circuits using PLC, for given applications. Perform the experiment using pneumatic trainer kit.	
	Self-Learning Topics: --	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Develop experimental approach, specify appropriate equipment and procedures to develop PLC ladder for specific asks (P.I.- 4.2.1)* *LO 3.2: Apply skills in using appropriate tolls and procedure for selection of electro-pneumatic components to develop electro –pneumatic circuits. (P.I.- 4.3.1)*	

	LO 3.3: Demonstrate the skill in using PLC software to build electro-pneumatic circuits for given applications (P.I.- 5.1.1, 5.2.2) *LO 3.4: Demonstrate effective communication, problem solving skills to develop electro-pneumatic system for industrial needs (P.I.- 8.2.1,8.2.2)*	
04.	***Learning Objective/s:*** *Learner will be able to demonstrate the skill to effectively use various functionalities of hydraulic systems and components..* **Experiment** Introduction to Hydraulic system, construction and working of different hydraulic components used in various hydraulic systems. ***Self-Learning Topics: --*** ***Learning Outcomes:*** *A learner will be able to* *LO 4.1: Apply fundamental engineering concepts demonstrate the use of various components of hydraulic systems (P.I.- 1.3.1)* *LO 4.2: Apply mechanical engineering knowledge to demonstrate the use of various components of hydraulic systems. (P.I.- 1.4.1)* *LO 4.3: Identify engineering systems and variables to select more appropriate hydraulic components for specific tasks (P.I.- 2.1.2)* *LO4.4: Identify the mathematical, engineering and other relevant knowledge to select various hydraulic components to build pneumatic systems (P.I.- 2.1.3)*	**02**
05.	***Learning Objective/s:*** *Learner will be able to demonstrate the skill to integrate different hydraulic components to build and test hydraulic circuits for the given problem* **Experiment:** Design and development of hydraulic circuits for given applications. Perform the experiment using hydraulic trainer kit. ***Self-Learning Topics: --*** ***Learning Outcomes :*** *A learner will be able to* *LO 5.1: Combine scientific principles and engineering concepts in selecting appropriate hydraulic components to build a pneumatic circuit for given application (P.I.- 2.3.1)* *LO 5.2: Apply knowledge of engineering mathematics to build hydraulic circuit for given application (P.I.- 2.4.1)* *LO 5.3: Apply formal idea generation tools to develop hydraulic circuit for given application (P.I.- 3.2.1)* *LO 5.4: Demonstrate the skill to identify suitable criteria to design and develop hydraulic circuits for real life applications. (P.I.-3.2.3)* *LO 5.5: Demonstrate the relationship between the technical, socio economic and environmental dimensions of sustainability while designing hydraulic system for specific task (P.I.- 3.1.1, 6.1.2)* *LO 5.6: Apply sustainable development principles to design and optimize hydraulic systems for industrial applications (P.I.- 3.1.1, 6.2.2)*	**04**

06.	***Learning Objective/s:*** *Learner will be able to apply knowledge for interfacing hydraulic system with PLC software\ for building hydraulic systems.* **Experiment:** Design and development of electro-hydraulic circuits using PLC, for given applications. Perform the experiment using hydraulic trainer kit. ***Self-Learning Topics: --*** ***Learning Outcomes:*** *A learner will be able to* *LO 6.1: Develop experimental approach, specify appropriate equipment and procedures to develop PLC ladder for specific asks (P.I.- 4.2.1)* *LO 6.2: Apply skills in using appropriate tolls and procedure for selection of electro-hydraulic components to develop electro –hydraulic circuits. (P.I.- 4.3.1)* *LO 6.3: Demonstrate the skill using PLC software to build electro –hydraulic circuits for given applications (P.I.- 5.1.1, 5.2.2)* *LO 6.4: Demonstrate effective communication, problem solving skills to develop electro –hydraulic system for industrial needs (P.I- 8.2.1,8.2.2)*	**04**
07.	***Learning Objective/s:*** *Learner will be able to demonstrate the ability to apply modern tools to acquire signals/ data for machine learning models.* **Experiment:** Data acquiring for machine learning model for fault detection. ***Self-Learning Topics: --*** ***Learning Outcomes*** *A learner will be able to* *LO 7.1: Apply basic engineering and mechanical engineering knowledge to demonstrate the skill to acquire data for machine learning model. (P.I.- 1.3.1, 1.4.1)* *LO 7.2: Combine scientific principles and engineering concepts in selecting appropriate methods skill to acquire data for machine learning model (P.I.- 2.3.1, 2.3.2)* *LO 7.3: Apply skills in using appropriate tolls and experimental approach for data acquirement for machine learning model (P.I.- 4.2.1, 4.3.1)* *LO 7.4: Identify appropriate modern tools and its functionalities for acquiring signals for data set for developing machine learning model (P.I.- 5.1.1, 5.3.2)* *LO 7.5: Demonstrate effective communication, problem solving skills to acquire data for machine learning model (P.I- 8.2.1, 8.2.2)*	**04**
08.	***Learning Objective/s:*** *Learner will be able to demonstrate the ability to apply modern tools to identify appropriate ML models for fault detection application.* **Experiment:** Training of data set for building machine learning model for fault detection in rotating system. ***Self-Learning Topics: --*** ***Learning Outcomes:*** *Learner will be able to*	**04**

	LO 8.1: Apply basic engineering and mechanical engineering knowledge to demonstrate the skill to acquire data for machine learning model. (P.I.- 1.3.1, 1.4.1) *LO 8.2: Combine scientific principles and engineering concepts in selecting appropriate methods skill to acquire data for machine learning model (P.I.- 2.3.1, 2.3.2)* *LO 8.3: Demonstrate the skill to identify appropriate tools and methods for developing machine learning algorithm for fault detection in the context of sustainable development (P.I.- 6.2.1, 5.1.1, 5.3.2)* *LO 8.4: Demonstrate effective communication, problem solving skills to develop machine learning model for fault detection (P.I.- 8.2.1 ,8.2.2)* *LO 8.5: Demonstrate the ability to recognize evolving trends in engineering knowledge and practices within the field of artificial intelligence (P.I.- 11.2.1, 11.2.2)*	
	Course Conclusion Learner is able to apply skill in developing electro-pneumatic / hydraulic circuits for various real life applications. Also learner is able to develop machine learning model for fault detection.	**01**
	Total	**30**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply fundamental engineering concepts to solve engineering problems
1.4.1	Apply Mechanical engineering concepts to solve engineering problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.2.1	Reframe complex problems into interconnected sub problems
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy
2.3.2	Identify assumptions (mathematical and physical) necessary to allow modeling of a system at the level of accuracy required
2.4.1	Apply engineering mathematics and computations to solve mathematical models
3.1.1	Recognize that need analysis is key to good problem definition
3.2.1	Apply formal idea generation tools to develop multiple engineering design solutions
3.2.3	Identify suitable criteria for evaluation of alternate design solutions
4.2.1	Design and develop experimental approach, specify appropriate equipment and procedures
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data
5.1.1	Identify modern engineering tools such as computer aided drafting, modeling and analysis; techniques and resources for engineering activities
5.2.2	Demonstrate proficiency in using discipline specific tools
5.3.2	Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use

6.1.2	Understand the relationship between the technical, socio economic and environmental dimensions of sustainability
6.2.1	Describe management techniques for sustainable development
6.2.2	Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline
8.2.1	Demonstrate effective communication, problem solving, conflict resolution and leadership skills
8.2.2	Treat other team members respectfully
11.2.1	Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current
11.2.2	Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field

Course Outcomes: A learner will be able to -

1. Demonstrate skill in development of electro-pneumatic circuit for given application (*LO 1.1*, *LO 1.2, LO 1.3, LO 1.4, LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6, LO 3.1, LO 3.2 LO 3.3, LO 3.4).*
2. Demonstrate skill in development of electro- hydraulic circuit for given application *(LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5, LO 5.6, LO 6.1, LO 6.2, LO 6.3, LO 6.4).*
3. Develop skill in acquiring signals/data from systems for machine learning models (*LO 7.1, LO 7.2, LO 7.3, LO 7.4, LO 7.5).*
4. Develop machine learning model for fault detection *LO 8.1, LO 8.2, LO 8.3, LO 8.4, LO 8.5*).

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EEMDMLC601.1	3	3	3	3	3	3	--	3	--	--	--
EEMDMLC601.2	3	3	3	3	3	3	--	3	--	--	--
EEMDMLC601.3	3	3	--	3	3	--	--	3	--	--	--
EEMDMLC601.4	3	3	--	--	3	--	--	3	--	--	3
Average	**3**	**3**	**3**	**3**	**3**	**3**	**--**	**3**	**--**	**--**	**3**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books:

1. Mechatronics System Design, Shetty and Kolk, Cengage Learning, India Edition.
2. Mechatronics - Electronic Control Systems in Mechanical Engineering, Bolton Pearson education.
3. Pneumatic Circuits and Low Cost Automation by Fawcett JR.
4. Industrial Hydraulics: Pippenger
5. Instrumentation and Control System, W. Bolton, Elsevier
6. John W Webb and Reis, Ronald A., "Programmable Logic Controllers: Principles & Applications", Prentice Hall.

7. Frank Petruzella," Programmable Logic Controllers", McGraw-Hill Education; 4 editions.
8. Artificial Intelligence: A Modern Approach by Peter and Norvig ISBN-0-13103805-2.
9. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair ISBN-978-0-07008770-5, TMH.
10. Artificial Intelligence by Saroj KausikISBN: - 978-81-315-1099-5, Cengage Learning.
11. Artificial Intelligence and Intelligent Systems by Padhy, Oxforfd University Press.
12. Artificial Intelligence & Machine Learning by Vinod Chandra.S.S. Anand Harindran. S. (PHI).
13. A first course in Artificial Intelligence – By Deepak Khemani. Mc GrawHill

Reference Books:

1. Artificial Intelligence & Machine Learning by Vinod Chandra.S.S. Anand Harindran. S. (PHI).
2. A first course in Artificial Intelligence – By Deepak Khemani. Mc GrawHill

Other Resources :

1. NPTEL Course: Mechatronics and Manufacturing Automation, by Prof. Shrikrishna N. Joshi, Department of Mechanical Engineering, Indian Institute of Technology Guwahati
   Web link- https://nptel.ac.in/courses/112103174.

2. NPTEL Course: Fundamentals of Artificial Intelligence, by Prof. Shyamanta M. Hazarika, Indian Institute of Technology Guwahati
   Web link - https://nptel.ac.in/courses/112103280.

3. NPTEL Course: Introduction to Machine Learning, by Prof. Balaraman Ravindran, IIT Madras
   Web link - https://nptel.ac.in/courses/106106139

CONTINUOUS ASSESSMENT (25 Marks)

Suggested breakup of distribution

Practical performance based on all the experiments mentioned in the syllabus with proper understanding	:	15 Marks
Oral conducted during the practical performance	:	05 Marks
Regularity and active participation	:	05 Marks

END SEMESTER ASSESSMENT (Practical/Oral Examination) (25 Marks)

Students will be assessed based on the following parameters:

Any one of the experiments based on the syllabus will be given to the students.

- Students are required to write a brief procedure for conducting the experiment including the circuit diagram and observation table, if any.
- The procedure is checked by both internal and external examiners for correctness. Evaluated out of 10 marks.
- Students are required to perform the given experiments, write the inference of the result and conclusion. The result is checked by both internal and external examiners for correctness. Evaluated out of 10 marks.
- Oral will be conducted by pair of Internal and External examiners. Evaluated out of 05 marks.