School of Electronics Engineering

M. Tech. – Automotive Electronics

Curriculum and Syllabus

2023-24

VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OFTECHNOLOGY

World class Education: Excellence in education, grounded in ethics and critical thinking, for improvement of life.

Cutting edge Research: An innovation ecosystem to extend knowledge and solve critical problems.

Impactful People: Happy, accountable, caring and effective workforce and students.

Rewarding Co-creations: Active collaboration with national & international industries & universities for productivity and economic development.

Service to Society: Service to the region and world through knowledge andcompassion.

VISION STATEMENT OF THE SCHOOL OF ELECTRONICS ENGINEERING

To be a leader by imparting in-depth knowledge in Electronics Engineering, nurturing engineers, technologists and researchers of highest competence, who would engage in sustainable development to cater the global needs of industry and society.

MISSION STATEMENT OF THE SCHOOL OF ELECTRONICS ENGINEERING

- Create and maintain an environment to excel in teaching, learning and applied research in the fields of electronics, communication engineering and allied disciplines which pioneer for sustainable growth.
- Equip our students with necessary knowledge and skills which enable themto be lifelong learners to solve practical problems and to improve the quality of human life

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PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The graduates of the programme will be able to

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems

2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry

3. Graduates will function in their profession with social awareness and responsibility

4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country

5. Graduates will be successful in pursuing higher studies in engineering or management

6. Graduates will pursue career paths in teaching or research

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PROGRAMME OUTCOMES (POs)

On completion of the Programme the students will have the

PO_01: Having an ability to apply mathematics and science in engineering applications.

PO_02: Having an ability to design a component or a product applying all the relevant standards and with realistic constraints, including public health, safety, culture, society and environment

PO_03: Having an ability to design and conduct experiments, as well as to analyse and interpret data, and synthesis of information

PO_04: Having an ability to use techniques, skills, resources and modern engineering and IT tools necessary for engineering practice

PO_05: Having problem solving ability- to assess social issues (societal, health, safety, legal and cultural) and engineering problems

PO_06: Having adaptive thinking and adaptability in relation to environmental context and sustainable development

PO_07: Having a clear understanding of professional and ethical responsibility

PO_08: Having a good cognitive load management skills related to project management and finance

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M. Tech. Automotive Electronics, graduates will be able to:

PSO1. Apply advanced concepts of Automotive Electronics to design and develop components and systems for applications in automotive systems.

PSO2. Use state-of-art hardware and software tools to experiment the automotive electronics systems to solve industry and real-world problems.

PSO3. Independently carry out research on diverse Automotive Electronics strategies to address practical problems and present a substantial technical report.

CREDIT INFO		
S.no	**Catagory**	**Credits**
1	Discipline Core	24
2	Discipline Elective	12
3	Projects and Internship	26
4	Open Elective	3
5	Skill Enhancement	5
Total Credits		70

Discipline Core									
sl.no	**Course Code**	**Course Title**	**Course Type**	**Version**	**L**	**T**	**P**	**J**	**Credits**
1	MAME501L	Sensors and Engine Management Systems	Theory Only	1.0	3	0	0	0	3.0
2	MAME502L	Microcontrollers for Vehicular Systems	Theory Only	1.0	3	0	0	0	3.0
3	MAME502P	Microcontrollers for Vehicular Systems Lab	Lab Only	1.0	0	0	2	0	1.0
4	MAME503L	Vehicle Control Systems	Theory Only	1.0	3	0	0	0	3.0
5	MAME504L	Automotive Networking and Protocols	Theory Only	1.0	3	0	0	0	3.0
6	MAME504P	Automotive Networking and Protocols Lab	Lab Only	1.0	0	0	2	0	1.0
7	MAME505L	Electric and Electronic Power Systems for Vehicles	Theory Only	1.0	3	0	0	0	3.0
8	MAME506L	Automotive Power Electronics and Motor Drives	Theory Only	1.0	3	0	0	0	3.0
9	MAME506P	Automotive Power Electronics and Motor Drives Lab	Lab Only	1.0	0	0	2	0	1.0
10	MAME507L	Alternative Drives, Traction and Controls	Theory Only	1.0	3	0	0	0	3.0

Discipline Elective									
sl.no	**Course Code**	**Course Title**	**Course Type**	**Version**	**L**	**T**	**P**	**J**	**Credits**
1	MAME605L	Vehicular Information and Communication Systems	Theory Only	1.0	3	0	0	0	3.0
2	MAME606L	Parallel Programming using Multi cores and Graphical Programming Units	Theory Only	1.0	3	0	0	0	3.0
3	MAME607L	Digital Signal Processing and its Applications	Theory Only	1.0	3	0	0	0	3.0
4	MAME607P	Digital Signal Processing and its Applications Lab	Lab Only	1.0	0	0	2	0	1.0
5	MAME608L	Open Source Hardware and Software System Design	Theory Only	1.0	3	0	0	0	3.0
6	MAME609L	Machine Vision System for Automotive	Theory Only	1.0	3	0	0	0	3.0
7	MAME609P	Machine Vision System for Automotive Lab	Lab Only	1.0	0	0	2	0	1.0
8	MAME610L	Automotive Fault Diagnostics	Theory Only	1.0	3	1	0	0	4.0
9	MAME611L	Emission Control and Diagnosis	Theory Only	1.0	3	0	0	0	3.0
10	MAME612L	Vehicle Safety Systems	Theory Only	1.0	2	0	0	0	2.0
11	MAME613L	Vehicle Bodies	Theory Only	1.0	2	0	0	0	2.0
12	MAME614L	Engine Peripherals	Theory Only	1.0	2	0	0	0	2.0
13	MAME615L	Vehicle Security and Comfort Systems	Theory Only	1.0	3	0	0	0	3.0
14	MAME616L	Automotive IoT	Theory Only	1.0	3	0	0	0	3.0

Discipline Elective									
15	MAME617L	Augmented and Virtual Reality for Automotive Applications	Theory Only	1.0	3	0	0	0	3.0
16	MAME618L	Soft Computing Techniques	Theory Only	1.0	3	0	0	0	3.0
17	MEDS501L	Embedded System Design	Theory Only	1.0	3	0	0	0	3.0
18	MEDS601L	Electromagnetic Interference and Compatibility in ESD	Theory Only	1.0	3	0	0	0	3.0
19	MEDS616L	Machine Learning and Deep Learning	Theory Only	1.0	3	0	0	0	3.0

Projects and Internship									
sl.no	Course Code	Course Title	Course Type	Version	L	T	P	J	Credits
1	MAME696J	Study Oriented Project	Project	1.0	0	0	0	0	2.0
2	MAME697J	Design Project	Project	1.0	0	0	0	0	2.0
3	MAME698J	Internship I/ Dissertation I	Project	1.0	0	0	0	0	10.0
4	MAME699J	Internship II/ Dissertation II	Project	1.0	0	0	0	0	12.0

Open Elective									
sl.no	Course Code	Course Title	Course Type	Version	L	T	P	J	Credits
1	CFOC508M	Entrepreneurship	Online Course	1.0	0	0	0	0	3.0
2	MFRE501L	Francais Fonctionnel	Theory Only	1.0	3	0	0	0	3.0
3	MGER501L	Deutsch fuer Anfaenger	Theory Only	1.0	3	0	0	0	3.0
4	MSTS601L	Advanced Competitive Coding	Soft Skill	1.0	3	0	0	0	3.0

Skill Enhancement									
sl.no	Course Code	Course Title	Course Type	Version	L	T	P	J	Credits
1	MENG501P	Technical Report Writing	Lab Only	1.0	0	0	4	0	2.0
2	MSTS501P	Qualitative Skills Practice	Soft Skill	1.0	0	0	3	0	1.5
3	MSTS502P	Quantitative Skills Practice	Soft Skill	1.0	0	0	3	0	1.5

Course Code	Course Title	L	T	P	C
MAME501L	Sensors and Engine Management Systems	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at

1. Giving details of the Engine sensor waveforms and methods to analyze the same.
2. Providing an overview of petrol and diesel engines using Engine Control Unit (ECU).
3. Giving insights into the operation of ECU with the suitable mapping of sensors.

Course Outcome

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

1. Comprehend the concepts of ECU design for automotive applications.
2. Analyze response of Transducers and sensors for automotive applications
3. Understand the various after treatment and alternative fuel-based systems.
4. Comprehend the operation of petrol engine management systems.
5. Understand the operation of automotive sensors and fuel injection systems.
6. Comprehend the Electronic control unit pertaining to chassis and body.
7. Illustrate the various Automotive subsystems.

Module:1	Electronic Control Unit(ECU) Design	6 hours

The concepts of ECU design for automotive applications, Need for ECUs, advances in ECUs for automotive, design complexities of ECUs, V-Model for Automotive ECU's Architecture, analog and digital interfaces.

Module:2	Basics of Engine Control systems	6 hours

IC engines operation – Petrol and Diesel; IC engine as a propulsion source for Automobiles; the need for engine controls and management; Control objectives linked to fuel efficiency, emission limits and vehicle performance; advantages of using Electronic engine controls.

Module:3	Petrol Engine Management Systems	7 hours

Evolution of Petrol engine controls, Electronic ignition, multi-point fuel injection, direct injection; Basics of ignition system and fuel injection system; Architecture of a EMS with multi point fuel injection.

Module:4	Diesel Engine Management Systems	6 hours

Basics of Diesel engine Controls ; Evolution of diesel engine controls; in-line fuel pump; rotary fuel pump; EGR control; Electric motor driven fuel pump; electronic fuel injection control and timing.

Module:5	After Treatment and Alternate Fuel	6 hours

Automobile emission – source, control, tests, standards (Indian), Exhaust Gas Recirculation (EGR), Catalytic converter, Alternative fuels – hydrogen – CNG, LPG, Biodiesel.

Module:6	Transducer Principles	6 hours

Transducers classification and basic principles, General Input-output configuration, static characteristics and dynamic characteristics of instruments, Variable resistance transducers, Metal and semiconductor strain gages and their signal conditioning ,Inductive transducers, Electromagnetic sensors, Hall effect sensors, Capacitive transducers, Piezo electric transducers and their signal conditioning, Ultrasonic sensors.

Module:7	Sensors for Transportation	6 hours

Vehicle Body:- Torque sensors/ Force sensors, Sensors Flap air flow sensors, Temperature sensor, Ultrasonic sensors, Ranging radar (ACC) Power Train:- Fuel level sensors, Speed and RPM sensors, Lambda Oxygen sensor, Hotwire air mass meter Chassis:- Steering wheel angle sensor, Vibration and acceleration sensors, Pressure sensors, Speed and RPM sensors.

Module:8	Contemporary Issues	2 hours

	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Fundamentals of Internal Combustion Engines - H.N. Gupta - Second edition (2015) – PHI publisher
2.	Internal Combustion Engines - 2012 -V Ganesan –Tata McGraw Hill
3.	Automotive Sensors (Sensors Technology) –2009 by John Turner & Joe Watson (Author)
Reference Books	
1.	Automotive Sensors, BOSCH. 2002
2.	Fundamentals of Automotive Electronics Book - Sixth Edition-2015 - Alma Hillier

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME502L	Microcontrollers for Vehicular Systems	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Introducing the students to various automotive grade microcontroller for vehicles.
2. Teaching Embedded C programming with 8051 controller and ARM processor.
3. Explaining the architecture and features of ARM processor.

Course Outcome

At the end of the course, the students will able to

1. Understand the architecture of 8051 Microcontroller.
2. Write programs for solving problems using 8051 Microcontroller.
3. Comprehend ARM architecture & its features
4. Describe the architecture of Cortex-M.
5. Perform ARM processor based experiments using Embedded C programming tool.
6. Have an overview of the types of ARM cores in the market and to make a suitable choice for an application.
7. Comprehend various Microcontroller for powertrain and body electronics.

Module:1	**Introduction to 8 bit microcontrollers**	**5 hours**
RISC / CISC and Harvard / Princeton, 8bit Architecture [8051,PIC18], External memory interface, Ports, Timers/counters, Serial Communication, Interrupts.		
Module:2	**8 bit microcontrollers programming for Body, Safety and Temperature**	**7 hours**
Programming in Embedded C [8051, PIC18], Applications on Body, safety and Temperature.		
Module:3	**ARM Architecture**	**7 hours**
ARM Design Philosophy, Overview of ARM architecture, States[ARM, Thumb, Jazelle], Registers, modes, Conditional Execution, Pipelining, Vector Tables, Exception handling.		
Module:4	**ARM Core**	**6 hours**
Architecture of Cortex-M, Memory Addressing, IO ports, Timers/counter, Watch Dog Timer, PWM, ADC/DAC, UART, Interrupts, Displays, C programming.		
Module:5	**ARM core programming**	**6 hours**
Embedded C programming for IO ports, Timers, PWM, ADC and External interfaces.		
Module:6	**Automotive 32-bit MCU**	**6 hours**
Choosing MCU's for Automotive Applications, Atmel – SMART ARM based MCU, ST- SPC5 32-bit Automotive MCU, NXPAutomotive MCU.		
Module:7	**Automotive MCU by Applications**	**6 hours**
Automotive microcontrollers for Powertrain Control, Hybrid and Electric Auxiliaries, Transmission and Body Electronics.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	The 8051 Microcontroller and Embedded Systems Using Assembly and C -3rd Edition - Muhammad Ali Mazidi -2015

Reference Books

1.	8051 Microcontrollers - David Calcutt, Fred Cowan, Hassan Parchizadeh – Newness –
2.	2011 The Definitive Guide to the ARM Cortex M0 - Joseph Yiu –Newness -2015
3.	Automotive Microcontrollers, Volume 2 by Ronald K. Jurgen – SAE publication-2012

Mode of Assessment: Continuous Assessment and Final Assessment Test			
Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME502P	Microcontrollers for Vehicular Systems Lab	0	0	2	1
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Introducing the students to various automotive grade microcontrollers for vehicles.
2. Teaching Embedded C programming with 8051 controller and ARM processor.
3. Explaining the architecture and features of ARM processor.

Course Outcome

At the end of the course, the students will able to

1. Understand the architecture of 8051 Microcontroller.
2. Write programs for solving problems using 8051 Microcontroller.
3. Comprehend ARM architecture & its features
4. Describe the architecture of Cortex-M.
5. Perform ARM processor based experiments using Embedded C programming tool.
6. Have an overview of the types of ARM cores in the market and to make a suitable choice for an application.
7. Comprehend various Microcontroller for powertrain and body electronics.

Indicative Experiments

1.	[**8051 Micro controller using Embedded C in Keil and implementation in 8051 Microcontroller] (expt. 1 to 5)** Programming with Arithmetic logic instructions – GPIO programming	2 hours
2.	Programming with timer – using timer for calculating delay	4 hours
3.	Programming with Serial Communication – Serial communication data transfer and receiver	4 hours
4.	Programming with Interrupt – providing external interrupt to activate ISR	4 hours
5.	Programming with LCD – interface LCD to display outputs	2 hours
6.	[**ARM Micro controller using Embedded C using simulator and LPC2148 –ARM microcontroller] (expt. 6 to 10)** Programming with Arithmetic logic instructions – Basic programming like addition, subtraction.	2 hours
7.	Programming with Arithmetic logic instructions - multiply, division, AND , OR etc., logic execution	2 hours
8.	GPIO programming ARM microcontroller - GPIO programming	4 hours
9.	Timers programming ARM Microcontroller– using timer for calculating delay	4 hours
10.	PWM Generation ARM Microcontroller- DC motor control	2 hours
	Total Laboratory Hours	**30 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME503L	Vehicle Control Systems	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Getting the know-how required for mathematical modeling, performance and stability analysis of feedback vehicle control system.
2. Providing a comprehensive coverage of controller design, state space design methods and digital control system.
3. Acquiring the skills for carrying out typical projects involving vehicle controls using MATLAB and SIMULINK.

Course Outcome

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

1. Understand the modeling aspects involved in the design of the physical system for vehicle applications
2. Identify the steady state and transient response of the different order of the system, analyse its performance and compute error coefficients.
3. Evaluate the stability of the system in frequency domain
4. Design a controller for automotive application using MATLAB/SIMULINK
5. Comprehend the Classical controller design
6. Identify the state space design methods like SISO, etc.
7. Explain the stability test procedure and get introduced to digital controller design.

Module:1	**System Modeling using Transfer function**	**6 hours**
Fundamentals of modeling -transfer function approach. Introduction to block diagrams & signal flow graphs. Introduction to SIMULINK.		
Module:2	**Performance of Feedback Control System**	**6 hours**
First order, Second order control system response for step, ramp and impulse inputs. Error Analysis - Type number -characteristic equation -Poles and Zeroes concept -Error Analysis and performance indices.		
Module:3	**Stability analysis of feedback control system**	**6 hours**
Frequency response plots -frequency domain specifications -stability analysis- Routh Hurwitz stability criteria –Root Locus – stability in the frequency domain –gain and phase margins – Nyquist stability criterion.		
Module:4	**Controller Design**	**6 hours**
Proportional, Integral, Derivative controllers, P, PI, and PID control actions and mathematical models. Using SIMULINK to build 'P','PI', 'PID'controller modules and carry out experiments. Importance and interpretations of results.		
Module:5	**Classical controller design**	**6 hours**
Classical design in the frequency domain- lead, lag compensator design.		
Module:6	**Modern control theory**	**7 hours**
State space design methods: SISO, MIMO systems, Various forms of representation of the system (Bush form, etc), controllability and observability, state observer.		
Module:7	**Introduction to Digital Control System**	**6 hours**
Discrete Time systems, Sampling and aliasing considerations, System time response, characteristics -Jury's stability test -mapping s to z plane -Digital controller design: from analog to digital design.		
Module:8	**Contemporary Issues**	**2 hours**

	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Katsuhiko Ogata, —Modern Control Engineeringll, Prentice Hall, (4th Edition), 2015
2.	K. Ogata, —Discrete-Time Control Systems, Prentice-Hall, Inc., 1994
Reference Books	
1.	I.J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International (P) Limited, 4th Edition, 2006
2.	Norman S. Nise," Control Systems Engineering ", 6th Edition December 2015
3.	Uwe Kiencke, Lars Nielsen, —Automotive Control Systems: For Engine, Driveline, and Vehiclell, Springer; 1 edition, March 30, 2000
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test	

Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME504L	Automotive Networking and Protocols	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Providing an overview of automotive network systems.
2. Exposing students to the aspects of design, development, application and performance issues associated with automotive network systems.

Course Outcome

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

1. Illustrate the basics of automotive networking and protocols
2. Comprehend the general protocols and their usage in automotive sector
3. Understand the LIN protocol and implement inconvenience feature applications
4. Design and implement CAN protocol for chassis and power train applications
5. Understand the concepts of time triggered protocols and it‘s usage in automotive field
6. Design and implement in media-oriented system transport protocol applications
7. Understand FlexRay protocol and their usage in safety critical applications

Module:1	**Introduction to Automotive Networking**	**6 hours**
Overview of Data communication and networking –need for In-Vehicle networking –layers of OSI reference model –multiplexing and de-multiplexing concepts –vehicle buses.		
Module:2	**General purpose protocols**	**6 hours**
Overview of general purpose networks and protocols –Ethernet, TCP, UDP, IP		
Module:3	**Protocol for low data rate applications**	**6 hours**
LIN standard overview –workflow concept-applications –LIN protocol specification –signals –Frame transfer –Frame types –Schedule tables –Task behaviour model –Network management – status management.		
Module:4	**Protocol for medium data rate applications**	**7 hours**
Overview of CAN –fundamentals –Message transfer –frame types-Error handling –fault confinement-Bit time requirements		
Module:5	**Time triggered protocol**	**6 hours**
Introduction to CAN open –TTCAN –Device net –SAE J1939		
Module:6	**Protocol for infotainment**	**6 hours**
MOST –Overview of data channels –control channel-synchronous channel –asynchronous channel –Logical device model –functions-methods-properties-protocol basics- Network section-data transport –Blocks –frames –Preamble-boundary descriptor		
Module:7	**Protocols for safety critical applications**	**6 hours**
FlexRay-Introduction –network topology –ECUs and bus interfaces –controller host interface and protocol operation controls –media access control and frame and symbol processing –coding/decoding unit		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1. J.Gabrielleen, Automotive in-vehicle networks, John Wiley & Sons, Limited, 2016

Reference Books

1. Robert Bosch, Bosch automotive networking, Bentley publishers,2007

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<tr><td>2.
3.
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5.
6.</td><td colspan="3">Society of automotive engineers, In-vehicle networks ,2015
Ronald K Jurgen, —Automotive Electronics Handbook, McGraw-Hill Inc. 1999.
IndraWidjaja, Alberto Leon-Garcia, —Communication Networks: Fundamental Concepts and Key Architectures, McGraw-Hill College; 1st edition, 2000.
Konrad Etschberger, Controller Area Network, IXXAT Automation, August 22, 2001.
Olaf Pfeiffer, Andrew Ayre, Christian Keydel, —Embedded Networking with CAN and CANopen, Anna books/Rtc Books, 2003</td></tr>
<tr><td colspan="4">Mode of Assessment: Continuous Assessment and Final Assessment Test</td></tr>
<tr><td colspan="2">Recommended by Board of Studies</td><td colspan="2">28-07-2022</td></tr>
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Course Code	Course Title	L	T	P	C
MAME504P	Automotive Networking and Protocols Lab	0	0	2	1
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Providing an overview of automotive network systems.
2. Exposing students to the aspects of design, development, application and performance issues associated with automotive network systems.

Course Outcome

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

1. Illustrate the basics of automotive networking and protocols
2. Comprehend the general protocols and their usage in automotive sector
3. Understand the LIN protocol and implement inconvenience feature applications
4. Design and implement CAN protocol for chassis and power train applications
5. Understand the concepts of time triggered protocols and it‘s usage in automotive field
6. Design and implement in media-oriented system transport protocol applications
7. Understand FlexRay protocol and their usage in safety critical applications

Indicative Experiments

1.	LIN node to node communication using HCS512 microcontroller • Data will be sent and received from master and slave node using LIN protocol	8 hours
2.	CAN node to node communication using HCS512 microcontroller • Data will be sent and received from master and slave node using CAN protocol	8 hours
3.	FlexRay communication using EVB9S12XF512E board • Multiple Data bytes sent using FlexRay protocol	6 hours
4.	TCP/IP communication using LabView • Sending data to particular port address using TCP/IP protocol	4 hours
5.	TCP/UDP communication using LabView • Sending data to particular port address using TCP/UDP protocol	4 hours
	Total Laboratory Hours	**30 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME505L	Electric and Electronic Power Systems for Vehicles	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course to aimed at

1. Developing the skills to understand the circuit and electrical wiring diagram and interpret the same.
2. Providing students with a good understanding of automotive electrical systems with particular emphasize on batteries, charging, ignition, starters and lighting systems.
3. Imparting students the knowledge about the new developments and advancements of automotive electrical technologies.

Course Outcome

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

1. Interpret the electrical wiring, circuit diagram for automotive applications
2. Understand the role of batteries in vehicles
3. Develop a charging system for vehicles
4. Understand the starter and ignition systems in vehicles
5. Demonstrate knowledge on lighting systems for vehicles.
6. Comprehend the passive restraint systems and electrical accessories in vehicles
7. Design and implement various electrical outlet systems for vehicles

Module:1	**Electrical Systems and Circuits**	**6 hours**

System approach –electrical wiring, terminals and switching –multiplexed wiring systems – CAN – circuit diagrams and symbols, Requirements for two wheeler, three wheeler vehicles, Requirements for heavy vehicles- trucks and trailers.

Module:2	**Batteries**	**6 hours**

Vehicle Batteries –Lead-Acid batteries –maintenance and charging –diagnosing Lead acid battery faults –advanced battery technology.

Module:3	**Charging systems**	**7 hours**

Requirements of charging systems —generation of electrical energy in motor vehicle – physical principles – alternators –characteristic curves –charging circuits –diagnosing charging system faults.

Module:4	**Starting system**	**6 hours**

Requirements –starter motors and circuits –types of starter motors –diagnosing starting system faults.

Module:5	**Ignition system**	**6 hours**

Fundamentals –electronic ignition –programmed ignition –distributor less ignition –direct ignition spark plug ignition –diagnosing faults.

Module:6	**Lighting system**	**6 hours**

Insulated and earth return systems, positive and negative earth systems, Concealed headlights Lighting circuit types, glare and preventive methods.

Module:7	**Gauges, Accessories and Passive restraint systems**	**6 hours**

Electrical fuel pump, speedometer, oil and temperature gauges, Horns, Wipers, washers, Blower motors, Defoggers, Power windows, seats, door locks, Air bag systems, Seat belt pretensioners

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Automotive Electricals / Electronics System and Components, Tom Denton, 3rd

	Edition, 2015
Reference Books	
1.	Judge, A.W., —Modern Electrical Equipment of Automobiles‖, Chapman & Hall London, 1992
2.	Young, A.P., &Griffiths.L., —Automobile Electrical Equipment‖, English Languages Book Society & New Press, 1990
3.	Automotive Electricals Electronics System and Components, Robert Bosch Gmbh, 4th Edition, 2004
4.	Automotive Hand Book, Robert Bosch, Bently Publishers, 1997
5.	Jurgen, R., Automotive Electronics Hand Book, 2015

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME506L	Automotive Power Electronics and Motor Drives	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Imparting an in-depth knowledge about power electronics devices using MATLAB
2. Acquiring the design capability of converters and inverters for the electric and hybrid vehicles 3. Gaining knowledge on the different motors and their application in electric vehicles

Course Outcome

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

1. Understand the operation of power semiconductor devices
2. Understand the operation of AC-DC converters at different loads
3. Understand the operation of three phase inverters
4. Design different converters: buck, boost and buck-boost converters
5. Understand the concepts of ultracapacitor and its usage in automotive field
6. Describe the different speed control methods of induction motors
7. Give details about the operation and characteristics of different motors

Module:1	**Power Electronics**	**6 hours**
Introduction to power electronics- Structure , operation and characteristics of automotive semiconductor devices -SCR,Power Transistor, Power MOSFET and IGBT- turn on and off circuits – series and parallel operation of SCR –protection Circuits –design of snubber circuits		
Module:2	**Converters**	**6 hours**
Half wave controlled converter with R,RL-RLE load, fully controlled converters with R-RL-RLE load-Three phase half wave controlled converter with R-RL load- Three phase fully controlled converter with R-RL load		
Module:3	**Inverters**	**6 hours**
Voltage source inverter with 120 degree and 180 degree conduction mode-current source inverters – PWM techniques		
Module:4	**Choppers**	**6 hours**
Step up and step down choppers –Different types of coppers – use of choppers		
Module:5	**Ultracapacitors**	**6 hours**
Theory of electronic double layer capacitance-model and cell balancing-sizing criteria-converter interface-ultracapacitors in combination with batteries		
Module:6	**Automotive motor Control**	**6 hours**
Methods of controlling speed – Induction and DC Motor controls		
Module:7	**Automotive drive system**	**7 hours**
BLDC - Motor construction, characteristics and operation -Open loop and close loop control through speed and current sensors-Switched Reluctance Motor -Motor construction, operation and its application.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1. P.S. Bimbhra, “Power Electronics:”, Khanna Publishers, 14th edition,2015

Reference Books

1.	Ali Emadi, “Handbook of Automotive power electronics and motor Drives” CRC Press, 2015.		
2.	Bimal K Bose, “Power Electronics and Motor Drive: Advances and Trends”, Elsevier, Inc., 2006.		
Mode of Assessment: Continuous Assessment and Final Assessment Test			
Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME506P	Automotive Power Electronics and Motor Drives Lab	0	0	2	1
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Imparting an in-depth knowledge about power electronics devices using MATLAB
2. Acquiring the design capability of converters and inverters for the electric and hybrid vehicles 3. Gaining knowledge on the different motors and their application in electric vehicles

Course Outcome

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

1. Understand the operation of power semiconductor devices
2. Understand the operation of AC-DC converters at different loads
3. Understand the operation of three phase inverters
4. Design different converters: buck, boost and buck-boost converters
5. Understand the concepts of ultra-capacitor and its usage in automotive field
6. Describe the different speed control methods of induction motors
7. Give details about the operation and characteristics of different motors

Indicative Experiments

1.	Design and study of anode current curve using SCR	2 hours
2.	Design and study of transfer and output characteristics of MOSFET	4 hours
3.	Design and study of transfer and output characteristics of IGBT	4 hours
4.	Single Phase half wave controlled convertor with R load(using SCR), triggering from microcontroller.	4 hours
5.	Three Phase half wave controlled convertor with R, RL, load using MATLAB	4 hours
6.	Three Phase voltage source inverter (VSI) 120 degree mode of conduction using MATLAB	4 hours
7.	Step-up-chopper and step-down chopper using MATLAB	4 hours
8.	Brushless DC (BLDC) motor modeling using MATLAB	4 hours
	Total Laboratory Hours	**30 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME507L	Alternative Drives, Traction and Controls	3	0	0	3
Pre-requisite	MAME505L	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Acquainting students with the basics of propulsion using IC engines and electric motors
2. Knowing about different energy storage and conversion schemes for Hybrid vehicles
3. Giving details about the different architectures for Hybrid electric vehicles

Course Outcome

At the end of the course, the students will able to

1. Understand automotive electrical systems
2. Suggest an alternate vehicle technology
3. Understand the difference in electric motors and IC engines for propulsion in automobiles
4. Describe the charging systems for different storages devices
5. Understand the types of motors used and control mechanism involved for these types of motors in vehicles
6. Explain the various architectures for Hybrid electric vehicles
7. Understand the need of fuel cells and use them for hybrid vehicles

Module:1	Automotive Electrical Systems	6 hours

Electrical Systems and Circuits - Starting systems - Ignition Systems - Lighting & accessories - Electromagnetic Interference and Compatibility

Module:2	Hybrid Vehicle Technology	6 hours

Background on need for alternate vehicle technologies for propulsion - Emissions from IC engine based transportation and regulating standards - Projections on availability of non-renewable energy sources - Alternate technologies for vehicles for reducing urban pollution and for extending availability of resources - Importance of Hybrid Electric Vehicles technology

Module:3	Basics of Vehicle Propulsion	7 hours

Components comprising traction torque - Vehicle performance Parameters – Speed and Acceleration - Fuel economy in IC engine vehicles - Torque – Speed characteristics of IC engines - Comparison of Electric motors and IC engines as vehicle propulsion power sources - Basics of Electric vehicles - Types of Motors and the speed – Torque characteristics

Module:4	Energy Storage / Energy Conversion	6 hours

Different types of Batteries for Electric vehicles - Lead acid batteries, Nickel Metal Hydride Batteries, Lithium ion batteries - Comparison of different types of batteries - Battery Management systems / Energy Management Systems - Wireless Charging Systems - Fast Charging Systems - Super Capacitors - Fuel Cells - Solar Energy Converters.

Module:5	Motors and Controllers	6 hours

DC motors - Principle and control - Induction motor drives - Methods of speed control of Induction motor - Constant V / f control - Vector control method - Inverter for Vector control - Basic principles of BLDC motors - Performance analysis and control of BLDC Motors - Sensor less technique for driving BLDC motors - Regenerative braking with electric drive - Four quadrant operation - Optimizing energy recovery.

Module:6	Architectures for Hybrid Electric Vehicles	6 hours

Series, parallel and series – parallel hybrids - Different architectures for Hybrid Electric vehicles - Series Hybrid Electric vehicle basics - Sizing of major components - Peak power sourcing - Parallel Hybrid electric vehicle basics - Engine on / off control strategy - Peak

power sourcing - Drive train rating - Parallel Mild hybrid Electric drive system - Series-parallel mild hybrid electric vehicle system.		
Module:7	**Industry examples of Hybrid Electric Vehicle**	**6 hours**
Fuel cell: Basic principles of fuel cells		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Modern Electric, Hybrid Electric and Fuel cell vehicles - by MehrdadEhsani, Yimin Gao, Sebatien Gay and Ali Emadi; Published by CRC press,2015
Reference Books	
1.	Iqbal Husain, Electric & Hybrid Vehicles, CRC Press, 2015
2.	Ronald K Jurgen, Automotive Electronics Handbook, McGraw-Hill Inc. 1999

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME605L	Vehicular Information and Communication Systems	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Teaching the students concepts of data processing, instrumentation and ECU recording equipment.
2. Providing students, a good understanding about automotive sound system and navigation for vehicular systems
3. Providing details about the positioning and guidance systems.

Course Outcome

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

1. Understand the data processing in motor vehicles.
2. Comprehend the networking in automotive.
3. Gain knowledge about the information & communication
4. Understand the ECU recording equipment and Parking systems
5. Explore the sound system for automotive
6. Understand the Positioning and Map Matching for vehicles
7. Understand the Route Planning and Route Guidance techniques for automotive

Module:1	**Data processing in motor vehicles**	**5 hours**
Requirements, Electronic control unit (ECU), Architecture, CARTRONIC.		
Module:2	**Automotive networking**	**6 hours**
Cross-system functions, Requirements for bus systems, Classification of bus systems, Applications in the vehicle, Coupling of networks, Example.		
Module:3	**Instrumentation**	**6 hours**
Information and communication areas, Driver information systems, Instrument clusters, Display types		
Module:4	**ECU recording equipment and Parking systems**	**6 hours**
Legal requirements, Design variations, parking aid with ultrasonic sensors, Further development		
Module:5	**Automotive sound systems**	**7 hours**
Radio tuners, Conventional tuners, Digital receivers, Reception quality, Reception improvement, Auxiliary equipment, Vehicle antennas.		
Module:6	**Positioning and Map Matching**	**7 hours**
Dead Reckoning, Global Positioning System , Sensor fusion. Conventional map matching, Fuzzy logic Based Map matching, Map aided Sensor calibration.		
Module:7	**Route Planning and Route Guidance**	**6 hours**
Shortest Path , Heuristic Search, Bidirectional Search , Hierarchical search **,**Guidance while En Route , Guidance while off Route , Guidance with dynamic information		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Bosch, “Automotive Handbook”, 8th Edition, SAE publication, 2015

Reference Books

1.	Intelligent Vehicle Technologies Theory and Appications– L Vlacic, M Parent,FHarashima - Butterworth Heinemann, 2015
2.	Vehicle location and Navigation Systems – Yilin Zhao – Artech House Inc., 2016 Sussman, Joseph. Perspectives on Intelligent Transportation Systems (ITS). NewYork,

3.	14. NY: Springer, 2010
4.	Mashrur A. Chowdhury, and Adel Sadek, Fundamentals of Intelligent Transportation Systems Planning, Artech House, Inc., 2003

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME606L	Parallel Programming using Multi cores and Graphical Programming Units	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Imparting the knowledge about implementation of multi-threading on single core versus multi-core platforms
2. Providing the basic concept of threads error diffusion and parallel error diffusion.
3. Elaborating the details of Deadlock and Semaphores and implementation of dependent threading features.

Course Outcome

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

1. Understand the basic concepts of multi-core architecture
2. Demonstrate knowledge of the core architectural aspects of Parallel Computing
3. Develop efficient parallel algorithms and apply a suite of techniques that can be applied across a wide range of applications
4. Apply the concept of threading for large scale systems
5. Apply methods to support and manage virtualization
6. Develop and implement the various Parallel Programming Concepts in Linux Platform
7. Analyze the gblockIdx and threadIdx

Module:1	**Multi-core Architecture**	**6 hours**

Overview of Single core processor Architecture and its limitations, Architectural Innovations, Need for Multi-core Processor and its Limitations, Classification Multicores, Multicore system software stack.

Module:2	**Overview of Threading**	**6 hours**

Defining threads – threads inside the OS – threads inside the hardware – Application programming models and threading – virtual environment – Run time virtualization – System virtualization

Module:3	**Fundamental concepts of parallel programming**	**6 hours**

Thread Level Parallelism(TLP), Instruction Level Parallelism(ILP), Comparisons, Cache Hierarchy and Memory-level Parallelism, Cache Coherence, Parallel programming models, Shared Memory and Message Passing, Vectorization

Module:4	**Parallel programming constructs**	**6 hours**

Synchronization – Critical sections – Deadlock – Semaphores – Locks – Condition variables – Messages – Fence – Barrier – Implementation dependent threading features

Module:5	**OpenMP : Portable solution for threading**	**7 hours**

Loop carried dependence – Data-race conditions – Managing shared and private Data – Loop Scheduling and Partitioning – Effective use of reductions – work-sharing sections – Using barrier and Nowait – Interleaving single thread and multi-thread execution – Data copy-in and copy-out – Protecting updates of shared variables – OpenMP Library functions – OpenMP environmental variables – multithreading debugging techniques

Module:6	**CUDA Programming**	**6 hours**

GPUs as Parallel computers – architecture of a modern GPU – Data Parallelism – CUDA program structure – Matrix – Matrix multiplication example – Device memories and data transfer – Kernel functions and threading – predefined variables – Runtime API

Module:7	**CUDA threads and Memories**	**6 hours**

CUDA thread organization – Using block and thread – synchronization and Transparent Scalability – Thread Assignment – Thread scheduling – CUDA device memory types – strategy for reducing global memory traffic

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Multi-Core Programming, Increasing Performance through Software Multi-threading, Shameem Akhter and Jason Roberts, Intel Press, BPB Publications, New Delhi, 2015
Reference Books	
1.	Programming Massively Parallel Processors, A hands-on approach, David B. Kirk and Wen-mei W. Hwu, Elesevier, New Delhi, 2015

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME607L	Digital Signal Processing and its Applications	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Introducing the concepts of sampling, digital filter, adaptive digital system
2. Providing the concepts of information theory and source coding different applications
3. Teaching methods and algorithms which would enable communication to happen as close to the maximum information transfer rate as possible

Course Outcome

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

1. Gain insight into digital models and algorithms to process the signals, after due conversion of signals from analog to digital
2. Determine the techniques to perform analog to digital and digital to analog conversion process
3. Design adaptive filters based on the signal processing and communication concepts
4. Analyse the signal spectrum from the received signal and modulation scheme suitable for information transmission
5. Determine the statistical properties of the signal
6. Find different ways of minimizing the number of bits, needed to represent a given amount of information
7. Find methods to minimize the probability of communication errors, without affecting the rate of communication process

Module:1	Basics	5 hours

The history of digital signal processing : Measurements and analysis , Telecommunications, Audio and television, Household appliances and toys, Automotive, Digital signal processing basics: Continuous and discrete signals, Sampling and reconstruction, Quantization, Processing models for discrete-time series, Common filters may be added digital filters: Filter architectures, Filter synthesis, Digital control systems :Proportional-integral-derivate controllers , Advanced controllers

Module:2	Analog Digital interface	7 hours

System considerations : Encoding and modulation, Number representation and companding systems, Digital-to-analog conversion: Multiplying digital-to-analog converters , Integrating digital-to-analog converters, Bitstream digital-to-analog converters , Sample-and-hold and reconstruction filters , Analog-to-digital conversion : Anti-aliasing filters and sample-and-hold , Flash analog-to-digital converters , Successive approximation analog-to-digital converters , Counting analog-to-digital converters , Integrating analog-to-digital converters , Dither , Sigma–delta analog-to-digital converters

Module:3	Adaptive digital systems	6 hours

Introduction: System structure The processor and the performance function: The adaptive linear combiner, The performance function , Adaptation algorithms : The method of steepest descent , Newton's method, The least mean square algorithm , Applications: Adaptive interference channel, Equalizers, Adaptive beam forming

Module:4	Spectral analysis and modulation	7 hours

Discrete Fourier transform and fast Fourier transform: Spectral analysis , Discrete Fourier transform and fast Fourier, transform approaches , "Z" transforms Using the auto-correlation function, Periodogram averaging, Parametric spectrum analysis, Modulation : Amplitude shift keying (ASK), Frequency shift keying (FSK), Phase shift keying (PSK), Complex modulation , The Hilbert transformer

Module:5	Kalman filters	4 hours

An intuitive approach : Recursive least square estimation , The pseudo-inverse , The Kalman filter : The signal model , The filter, Kalman filter properties , Applications.		
Module:6	**Data compression**	**7 hours**
An information theory primer: Information and entropy ,Source coding : Huffman algorithm, Delta modulation, adaptive delta modulation and continuously variable slope delta modulation, DPCM adaptive DPCM techniques, Speech coding, adaptive predictive coding and sub-band coding, Vocoders and linear predictive coding , JPEG, MPEG, MP3, The Lempel–Ziv algorithm, Recognition techniques: Speech recognition, Image recognition		
Module:7	**Error-correcting codes**	**7 hours**
Channel coding: The channel model , The channel capacity , Error-correcting codes : Hamming distance and error correction , Linear block codes , Cyclic codes, Convolution codes, Viterbi decoding , Interleaving , Concatenated codes and turbo codes		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Digital signal processing and applications, Dag Stranneby and William Walker, Second Edition, Elsevier, New York, 2015
Reference Books	
1.	Advanced digital signal processing noise reduction, SaeedV.Vasaghi, Fourth edition, Wiley, New Delhi, 2015
2.	Digital Signal Processing: Fundamentals and Applications, by Li Tan, First edition 2007

Mode of Evaluation: Continuous Assessment, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME607P	Digital Signal Processing and its Applications Lab	0	0	2	1
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Introducing the concepts of sampling, digital filter, adaptive digital system
2. Providing the concepts of information theory and source coding different applications
3. Teaching methods and algorithms which would enable communication to happen as close to the maximum information transfer rate as possible

Course Outcome

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

1. Gain insight into digital models and algorithms to process the signals, after due conversion of signals from analog to digital
2. Determine the techniques to perform analog to digital and digital to analog conversion process
3. Design adaptive filters based on the signal processing and communication concepts
4. Analyse the signal spectrum from the received signal and modulation scheme suitable for information transmission
5. Determine the statistical properties of the signal
6. Find different ways of minimizing the number of bits, needed to represent a given amount of information
7. Find methods to minimize the probability of communication errors, without affecting the rate of communication process

Indicative Experiments

1.	Auto correlation • To implement auto-correlation using Matlab	2 hours
2.	LMS algorithm • To implement the algorithm using Matlab	4 hours
3.	RLS algorithm • To implement the algorithm using Matlab	4 hours
4.	ASK, FSK, PSK • To implement digital modulation techniques using Matlab	4 hours
5.	Complex modulation • To implement complex modulation techniques using Matlab	4 hours
6.	Reed-Solomon encoding and decoding • To perform reed-Solomon encoding and decoding	4 hours
7.	CRC encoding and decoding • To perform cyclic redundancy check	4 hours
8.	Polynomial division and linear feedback shift registers • To perform division using LFSR	4 hours
	Total Laboratory Hours	**30 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME608L	Open Source Hardware and Software System Design	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Introducing to the students the foundation of open source programming.
2. Understand client-server architectural model for web applications.
3. Teaching the students the basis of Automation using Raspberry Pi.

Course Outcome

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

1. Understand the importance of Open Source programming
2. Identify and apply appropriate server side programming for web based applications
3. Understand various database operations
4. Comprehend the operation of different type of Socket programming
5. Understand the details of Raspberry Pi fundamentals and exploring GPIO Interface
6. Develop and implement the various Raspberry Pi project
7. Explore GPIO Interface

Module:1	**Basics**	**5 hours**
Variable types – basic operators – decision making – loops – strings- Lists – Tuples – Dictionary – Date and Time – Functions – Modules – Files – Exceptions – Classes and Objects		
Module:2	**GUI and Web programming**	**7 hours**
Tkinter Programming – Tkinter Widgets - CGI – Web server support – Environmental variables – GET and POST methods – Passing information using POST method		
Module:3	**Data base access**	**6 hours**
MySQLdb – database connection – Creating database table – INSERT – READ – UPDATE – DELETE – COMMIT – ROLEBACK		
Module:4	**Network Programming**	**7 hours**
Sockets – Server socket – Client Socket – General Socket methods – Sending an HTTP e-mail – Sending an attachment as an email		
Module:5	**Raspberry Pi fundamentals**	**6 hours**
Architecture – setting up the Raspberry Pi – Interacting with Raspberry command line – Setting up I2C, serial port – Connect Pi to network		
Module:6	**Raspberry Basic Projects**	**7 hours**
Controlling the brightness of LED – Buzzing sound – Switch high power DC source using transistor and relays – controlling high voltage AC device – Using PWM pulses for control – Pi to run different types of motors – servo motor – DC motor – Stepper motor - Displaying HD images – Playing music		
Module:7	**Advanced Raspberry projects**	**5 hours**
Exploring GPIO Interface – Controlling GPIO output – Detecting GPIO input – Work with switches – keypads – Interfacing various sensors – measuring light – detecting methane – measuring acceleration – measuring temperature – measuring distance – logging into a USB flash drive		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Python programming for Raspberry Pi in 24 hours, Richard Blum and Christine Bresnahan, Sams Teach Yourself, Indiana, 2015

Reference Books

1.	Raspberry Pi Cookbook, Simon Monk, O'Reilly, California, 2015		
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME609L	Machine Vision System for Automotive	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Providing the basic concepts of digital image processing and related algorithms
2. Introducing the concepts of motion estimation, multi camera view processing and depth estimation
3. Elaborating on automation considerations and automotive components testing

Course Outcomes

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

1. Understand the elements of computer vision based systems
2. Acquaint with image formation and processing methods
3. Understand advanced algorithms for depth estimation and multi-camera views
4. Understand various feature extraction techniques
5. Acquaint with motion estimation and SLAM algorithms
6. Understand various operational behaviours of Components in Automation
7. Comprehend the operation of different type of Cylinder blocks, detecting missing balls and behaviours
8. To apply machine vision algorithms to solve challenging problems

Module:1	Elements of Computer Vision System	5 hours

Industrial machine vision, System architecture, Sensors, Camera interfaces and video standards, adjacency conventions, Image acquisition hardware, speed considerations, Steps involved in Computer vision System: Data ingestion, Data pre-processing, Modelling process, Inference and logging.

Module:2	Digital Image Formation and Processing	6 hours

Photometric image formation, Geometric primitives and transformations, Point operators, Linear filtering, Non-linear filtering, Histogram processing, Geometric transformations, Fourier transforms, Pyramids and wavelets, Restoration

Module:3	Depth estimation and Multi-camera views	7 hours

Stereo vision: Perspective, Binocular Stereopsis, Camera and Epipolar Geometry; Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration.

Module:4	Feature Extraction in Vision based Systems	7 hours

Edge detectors: Canny, LOG, DOG; Line detectors Hough Transform, Corners - Harris and Hessian Affine, SIFT, SURF, HOG, GLOH

Module:5	Motion estimation and SLAM	6 hours

Geometric intrinsic calibration, Two-frame structure from motion, Multi-frame structure from motion, Simultaneous Localization and Mapping (SLAM), Translational alignment, Parametric motion, Optical flow, Layered motion.

Module:6	Automation considerations	6 hours

Design of conveyor belts – Choice of various light sources – Design of separators – Grippers – Control of motors – vision / manipulator interface

Module:7	**Automotive component testing applications**	**6 hours**
Differentiating types of cylinder blocks – detecting holes in a camshaft – detecting missing balls in bearings – checking faulty components in a car stereo – differentiating gear types – detecting a lack of sealing compound – detecting improper assembly of a fuse box – Checking an LCD panel.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1.	Computer Vision: Algorithms and Applications, Richard Szeliski, 2nd ed., Springer, 2022, ISBN: 9783030343712.
2.	Computer and machine vision : Theory, Algorithm and Practicalities, E.R. Davies, Fourth Edition (Kindle Edition), 2012, ISBN- 9780123869081
Reference Books	
1.	Mathematics for Machine Learning. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong. Cambridge University Press. 2020. ISBN: 9781108679930.
2.	Artificial Intelligence, Machine Learning, and Deep Learning. Oswald Campesato. Mercury Learning & Information.2020. ISBN: 9781683924661
3.	Intelligent Vision systems for Industry, Bruce G. Batchelor and Paul F. Whelan, Springer, London, 2012, ISBN: 9781447104315

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	07-06-2023		
Approved by Academic Council	No. 70	Date	24-06-2023

Course Code	Course Title	L	T	P	C
MAME609P	Machine Vision System for Automotive Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Providing the basic concepts of digital image processing and related algorithms
2. Introducing the concepts of motion estimation, multi camera view processing and depth estimation
3. Elaborating on automation considerations and automotive components testing

Course Outcomes

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

1. Understand the elements of computer vision based systems
2. Acquaint with image formation and processing methods
3. Understand advanced algorithms for depth estimation and multi-camera views
4. Understand various feature extraction techniques
5. Acquaint with motion estimation and SLAM algorithms
6. Understand various operational behaviours of Components in Automation
7. Comprehend the operation of different type of Cylinder blocks, detecting missing balls and behaviours
8. To apply machine vision algorithms to solve challenging problems

Indicative Experiments		
1	To perform digital image filtering using various masks	4 Hours
2	To Explore Wavelets and Pyramids for frequency domain image processing	4 Hours
3	To implement binocular stereopsis process	4 Hours
4	To extract features using edge detectors, line detectors, corner detectors	4 Hours
5	Implement object tracking using optical flow technique	4 Hours
6	Perform welding inspection of motor parts using image processing	4 Hours
7	Implement program for missing-roller inspection for bearings	6 Hours
	Total	**30 Hours**

Text Books

1. Computer Vision: Algorithms and Applications, Richard Szeliski, 2nd ed., Springer, 2022, ISBN:9783030343712,
2. Computer and machine vision : Theory, Algorithm and Practicalities, E.R. Davies, Fourth Edition (Kindle Edition), 2012, ISBN- 9780123869081

Reference Books

1. Mathematics for Machine Learning. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong. Cambridge University Press. 2020. ISBN: 9781108679930.

2.	Artificial Intelligence, Machine Learning, and Deep Learning. Oswald Campesato. Mercury Learning & Information.2020. ISBN: 9781683924661
3.	Intelligent Vision systems for Industry, Bruce G. Batchelor and Paul F. Whelan, Springer, London, 2012, ISBN: 9781447104315

Mode of Evaluation: Continuous Assessment Test and Final Assessment Test			
Recommended by Board of Studies	07-06-2023		
Approved by Academic Council	No. 70	Date	24-06-2023

Course Code	Course Title	L	T	P	C
MAME610L	Automotive Fault Diagnostics	3	1	0	4
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Familiarising students with the basic concepts of automotive fault diagnostics
2. Teaching students about the fault sensors output waveforms
3. Elaborating the operation of Automotive Oscilloscopes, OBD II and Fault code readers

Course Outcome

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

1. Understand the basic concepts of fault diagnosis in automotive field.
2. Comprehend MIL for various automotive faults.
3. Have a brief idea of various sensors and assess ECU failures with the help of oscilloscope
4. Comprehend the operation of fault-finding systems (OBD)
5. Identify and rectify the faults of automotive sensors and fuel injection systems.
6. Analyze the various failure modes in Electronic control unit of chassis and body units
7. Understand the concepts of Electrical systems fault diagnostics

Module:1	**Diagnostic**	**6 hours**
Diagnostic Techniques - diagnostic process - diagnostics on paper - mechanical diagnostic techniques - electrical diagnostic techniques - fault codes - on and off-board diagnostics - Data sources		
Module:2	**Tools and Equipment**	**6 hours**
Basic equipment - Oscilloscopes - Scanners - Fault code readers - Engine Analysers		
Module:3	**Oscilloscope diagnostics**	**4 hours**
Sensors - Actuators - Ignition System - Other components		
Module:4	**On-board diagnostics**	**6 hours**
A first perspective - Petrol / Gasoline on-board diagnostics monitors - a second perspective		
Module:5	**Engine Systems**	**7 hours**
Diagnostics of Engine operation - Fuel system - Ignition - Emission - Fuel Injection - Diesel injection - Engine management - Fault finding information - air supply and exhaust systems - cooling - lubrication - batteries - starting system - charging system		
Module:6	**Chassis System**	**7 hours**
Diagnostics of brakes - anti-lock brakes diagnostics - traction control diagnostics - steering and types diagnostics - suspension diagnostics		
Module:7	**Electrical System**	**7 hours**
Electronic components and circuits diagnosis - multiplexing - lighting - diagnosing auxiliary system faults - in car entertainment security and communication - body electrical system faults - diagnosing instruments system faults - HVAC diagnostics - Cruise control diagnostics - Air bags and belt tensions diagnostics		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Automotive Technician Training, Tom Denton, Taylor and Francis, New York, 2015

Reference Books

1. Automobile Electrical and Electronic Systems : Automotive Technology - Vehicle Maintenance and Repair, Tom Denton, Fourth Edition, Elsevier, New York, 2015
2. Advanced Automotive Fault Diagnosis: Automotive Technology - Vehicle Maintenance and Repair, Tom Denton, Third Edition, Elsevier, New York, 2012.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME611L	Emission Control and Diagnosis	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Preparing the students to analyze automotive pollution control techniques
2. Introducing the concepts of formation and control techniques of pollutants like sulphur, CO, NOx and particulate matter
3. Preparing the students to analyze smoke for both SI and CI engines

Course Outcome

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

1. Get details of the emission from automobiles
2. Analyze emission from Spark Ignition Engine
3. Analyze emission from Compression Ignition Engine
4. Explain about the exhaust emissions
5. Comprehend the Emission Control Legislation - I
6. Comprehend the Emission Control Legislation – II
7. Understand about the Exhaust gas measuring techniques

Module:1	Emission From Automobiles	6 hours

8 Sources of Air Pollution. Various emissions from Automobiles — Formation — Effects of pollutants on environment and human beings. Emission control techniques – Modification of fuel, after treatment 11 devices. Emission standards. Automotive waste management, old vehicle disposal, recycling, tyre recycling

Module:2	Emission From Spark Ignition Engine And Its Control	7 hours

Emission formation in SI Engines- Carbon monoxide & Carbon di oxide - Unburned hydrocarbon, NOx, Smoke —Effects of design and operating variables on emission formation – controlling of pollutants - Catalytic converters, Charcoal Canister, CCS, Positive Crank case ventilation system, Secondary air injection, thermal reactor, Laser Assisted Combustion

Module:3	Emission From Compression Ignition Engine And Its Control	6 hours

Formation of White, Blue, and Black Smokes, NOx, soot, sulphur particulate and Intermediate Compounds – Physical and Chemical delay — Significance Effect of Operating variables on Emission formation — Fumigation, Split injection, Catalytic Coating, EGR, HCCI, Particulate Traps, SCR, Fuel additives — Cetane number Effect.

Module:4	Exhaust Emissions	6 hours

Combustion products, Properties of exhaust gas components

Module:5	Emission control legislation - I	6 hours

Overview, CARB legislation, EPA legislation, EU legislation, Japanese legislation

Module:6	Emission control legislation - II	6 hours

US test cycles for passenger cars and light duty trucks, European test cycles for passenger cars and light duty trucks, Japanese test cycles for passenger cars and light duty trucks, test cycles for heavy commercial vehicles

Module:7	Exhaust gas measuring techniques – I	6 hours

Exhaust gas test on chassis dynamometers, Exhaust gas measuring devices, Diesel smoke emission test, Evaporative emission test

Module:8	Contemporary Issues	2 hours

	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	G.P.Springer ad D.J.Patterson, Engine Emissions, Pollutant formation, Plenum Press, New York, 1986.
2.	D.J.Patterson and N.A.Henin, 'Emission from Combustion Engine and their control', Anna Arbor Science Publication, 1985.
3.	Autmotive Handbook – 9th Edition – 2015, BOSCH
Reference Books	
1.	V.Ganesan, 'Internal combustion Engines', Tata McGraw Hill Book Co, Eighth Reprint, 2005.
2.	Crouse and Anglin, 'Automotive Emission Control', McGraw Hill company.,Newyork
3.	1993. Charles K. Alexander, Matthew N. O. Sadiku, "Fundamentals of Electric Circuits," 2015, 5th Edition, Tata McGraw Hill Education Private Limited, New Delhi, India.
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test	
Recommended by Board of Studies	28-07-2022
Approved by Academic Council	No. 67 Date 08-08-2022

Course Code	Course Title	L	T	P	C
MAME612L	Vehicle Safety Systems	2	0	0	2
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Have a better understanding of good design practices which will enable product improvement that manifests significantly less risk to humans, machines and the environment
2. Gain the ability to design and demonstrate the vehicle safety critical systems to reduce the system errors and faults
3. Introducing the students to do design safety systems using MATLAB simulation

Course Outcome

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

1. Understand the basic concept of vehicle safety
2. Understand the operation of braking system design and its operation
3. Understand the braking system for passenger vehicles
4. Know the working principle of ABS and traction control systems
5. Understand the concepts of braking systems for commercial vehicles
6. Understand the vehicle stabilization for commercial vehicles
7. Understand about the airbag system for passenger safety

Module:1	**Basic concepts of vehicle safety**	**4 hours**
Underlying principles-cause and effect –safety factors-design for uncertainty-identifying component safety factor-Digital models and man testing -compliance		
Module:2	**Braking systems**	**4 hours**
Definitions-principles-design and components of braking system-brake-circuit configurations-braking system design		
Module:3	**Braking system for passenger cars and light utility vehicles**	**4 hours**
Brake booster-brake master cylinder-braking force limiters-disk brakes-drum brakes		
Module:4	**Vehicle stabilization systems for passenger cars**	**4 hours**
Anti-Lock braking system(ABS)-traction control system(TCS)-Electronic stability program(ESP)-Electrohydraulic brakes		
Module:5	**Braking system for commercial vehicles**	**4 hours**
System and configuration-air supply and processing-Transmission device-wheel brakes-parking brake system-retarder braking system		
Module:6	**Vehicle stabilization system for commercial vehicles**	**4 hours**
Electronic stability program(ESP) for commercial vehicles-Electronically controlled braking(ELB)-function-system design-components-electro pneumatic braking		
Module:7	**Occupant injury prevention and distracted driver**	**4 hours**
Introduction-proper use of head restraints-Airbags-distractors and risk reduction-information processing		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1. George A. Peters, Barbara J. Peters, ”Automotive vehicle safety”, Taylor and Francis,3rd

	edition, 2015		
Reference Books			
1.	Robert Bosch, ”Automotive handbook”,9th edition,2015		
2.	Bimal K Bose, “Power Electronics and Motor Drive: Advances and Trends”, Elsevier, Inc., 2006		
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME613L	Vehicle Bodies	2	0	0	2
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Giving insight into the vehicle construction
2. Design and construction of vehicular bodies for passenger car and commercial vehicles
3. Providing an overview of lighting in vehicles

Course Outcome

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

1. Understand Road-vehicle systematics
2. Understand Vehicle bodies for passenger cars
3. Comprehend and analyze commercial vehicles bodies
4. Classify External lighting technologies
5. Classify Internal lighting technologies
6. Brief about Automotive windshield and window glass
7. Comprehend the windshield and rear-window cleaning systems

Module:1	**Road-vehicle systematics**	**2 hours**
Classification according to ECE, Classification according to USA		
Module:2	**Vehicle bodies- passenger cars**	**4 hours**
Main dimensions, Body design, Aerodynamics, Aeroacoustics, body structure, Body materials, Body surface, Body finishing components, Safety		
Module:3	**Vehicle bodies-commercial vehicles**	**4 hours**
Commercial vehicles, Light utility vans, Medium and heavy-duty trucks and tractor vehicles, Buses, Passive safety in commercial vehicles		
Module:4	**Lighting technology-I**	**5 hours**
Functions, Regulations and equipment, Definitions and terms, Main headlamps, European system, Main headlamps, European regulations, Head lamps, USA, Headlamps, US regulations, Headlamp leveling, Europe, Headlamp cleaning systems, Fog lamps, Auxiliary driving lamps		
Module:5	**Lighting technology-II**	**5 hours**
Lights and lamps, Hazard-warning and turn-signal flashers, Side-marker, clearance, and tail lamps, Parking lamps, License-plate lamps, Stop lamps, Rear fog warning lamps, Reversing lamps, Daytime running lamps, Reversing lamps, Daytime running lamps, other lighting devices, Motor-vehicle bulbs.		
Module:6	**Automotive windshield and window glass**	**4 hours**
The material properties of glass, Automotive glazing, Functional design glazing		
Module:7	**Windshield and rear-window cleaning systems**	**4 hours**
Windshield wiper systems, Rear-window wiper systems, Headlamp cleaning systems, Wiper motors, Washing systems		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1. Powloski.. J., “Vehicle Body Engineering”, Business books limited, London,1970

Reference Books

1. Robert Bosch, ”Automotive handbook”, 9th edition, SAE publication 2015

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME614L	Engine Peripherals	2	0	0	2
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Preparing the students to understand engine peripherals connections and operation theory
2. Introducing the basics of engine cooling and lubrication
3. Preparing to study and analyze emission reduction techniques

Course Outcome

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

1. Get an overview of Engine
2. Comprehend the techniques for Engine Cooling
3. Understand about Engine lubrication
4. Demonstrate knowledge on Air filtration
5. Comprehend the concepts of engine peripherals
6. Understand turbochargers and superchargers for IC engines
7. Understand emission reduction systems and exhaust gas systems

Module:1	**Overview of Engine**	**3 hours**
Engine operation, Engine components, Engine types		
Module:2	**Engine Cooling**	**4 hours**
Water cooling, Air cooling, Intercooling, Oil and fuel cooling, cooling module technology, Intelligent thermal management, Exhaust gas cooling		
Module:3	**Engine lubrication**	**3 hours**
Overview, Force feed lubrication system, lubrication components		
Module:4	**Air filtration**	**2 hours**
Air pollution, Air filters		
Module:5	**Other engine peripherals**	**5 hours**
HVAC, alternator, vacuum pump, steering pump, air intake system, exhaust system		
Module:6	**Turbochargers and superchargers for IC engines**	**5 hours**
Superchargers (mechanical driven), Pressure wave, Exhaust gas and multistage superchargers, Acceleration aids		
Module:7	**Emission reduction systems and exhaust gas systems**	**6 hours**
Exhaust gas recirculation systems, secondary air injection, Evaporative emission control system, crankcase ventilation, Manifold, Catalytic converters, particulate converters, muffers connecting elements		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1. Automotive Handbook – BOSCH – 9th Edition -2015

Reference Books

1. T. Kenneth Garrett, Kenneth Newton and William Steeds, “The Motor Vehicle” 13th Edition, Butterworth-Heinemann Limited, London, 2015
2. Heinz Heisler, “Advanced Vehicle Technology”, second edition, Butterworth – Heinemann, New York, 2002

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME615L	Vehicle Security and Comfort Systems	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Teaching the students about locking systems and theft-deterrent systems
2. Providing the technical knowhow of acoustic signalling devices and occupant-protection systems
3. Discussing about the Power-window drives, comfort and safety functions in the passenger compartment and driver assistance systems

Course Outcome

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

1. Understand about locking systems
2. Understand the concept of theft-deterrent systems
3. Understand about the acoustic signalling devices
4. Demonstrate the knowledge about occupant-protection systems
5. Brief about power-window drives
6. Identify the technique for comfort and safety functions in the passenger compartment
7. Understand about driver-assistance systems
8. Design and implement vehicle security and comfort systems

Module:1	**Locking systems**	**6 hours**
Function, structure, operating principle, Open by wire, Electrical locking system, Central locking system, Electronic vehicle immobilizer, functional description Comfort Entry/Go system		
Module:2	**Theft-deterrent systems**	**6 hours**
Regulations, Permissible alarm signals. System design, alarm detectors, Alarm system control unit, Alarm siren, Tilt sensor, Interior monitoring		
Module:3	**Acoustic signaling devices**	**6 hours**
Acoustic signaling devices applications, Horn, Fanfare horns		
Module:4	**Occupant-protection systems**	**6 hours**
Seat belts and seat-belt pretensioners, Front airbag, Side airbag, Components, Rollover protection systems		
Module:5	**Power-window drives**	**6 hours**
Power-window motors, Power-window control, Power sunroof drives		
Module:6	**Comfort and safety functions in the passenger compartment**	**6 hours**
Electrical seat adjustment, Electrical steering-column adjustment, Multi purpose actuator		
Module:7	**Driver-assistance systems**	**7 hours**
Critical driving situations, Causes of accidents and possible action, Applications, Convenience and safety functions, Sensors for all round electronic visibility, Sensor-data fusion.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Automotive Handbook – BOSCH – 9th Edition -2015

Reference Books

1.	Bosch, "Safety, Comfort & Convenience Systems" 7th Edition - 2016		
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAME616L	Automotive IoT	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The course is aimed at making the students to

1. Acquire the required Automotive fundamentals for IoT System Design
2. Get an exposure about the IoT applications in automotive systems.
3. Develop design skills in automotive IoT Systems.

Course Outcomes

At the end of the course, the students will be able to

1. Understand the required fundamentals for Automotive IoT and Comprehend the applications of Networked Vehicles using IoT
2. Realize the IoT Safety Management in Automotive
3. Realize the Efficiency management using IoT.
4. Associate the Automotive Cyber Security with IoT Systems.
5. Identify the need and importance of Smart Vehicles and Connected Cars
6. Design IoT based solutions for real time automotive applications.

Module:1	Elements of Automotive IoT (AIoT)	7 hours

Fundamentals of Automotive Onboard Diagnostics, Automotive IoT applications: Infotainment, Navigation and control, Electronic toll collection, Automated parking reservation and payment systems, Smart Transportation, Smart Grid

Module:2	Networked Vehicles using IoT	5 hours

Vehicle collision avoidance, Lane change algorithm, Optimal traffic control using Smart applications in IoT, Green traffic management using IoT. Intra vehicle connectivity, Vehicle to internet connectivity

Module:3	IoT Safety Management in Automotive	6 hours

Tire pressure Monitoring using IoT, Immobilizers and Vehicle alarm systems, Remote Diagnostics using IoT, Vehicle tracking, Integrated infotainment systems, emergency calling systems using IoT.

Module:4	Efficiency management using IoT	5 hours

Start, stop and micro hybrids, mild hybrids, Self-driving and ADAS - Advanced driver assistance services, Automated fuel injection mechanisms, Advanced locomotives using IoT.

Module:5	IoT based Navigation	8 hours

Traffic Information - Sharing, Forwarding, optimal paths, Online routing and planning. 5G: Evolving LTE to 5G, Research Challenges and 5G New Radio -, 5G technologies (core network): Network slicing, C-RAN, NFV, SDN. 5G Automotive Use Cases: Cellular Vehicle-2-Everything (C-V2X).

Module:6	Automotive Cyber Security	8 hours

Security in Automotive systems, CMAP - CAN bus mapper, Security risks at High tech vehicles, Mandated legislation and Non mandated communication based threats, Stolen vehicle tracking and recovery, Attack vectors - remote vehicle theft, exfiltration, Virtual non-existence.

Module:7	Smart Vehicles and Connected Cars Training	4 hours

Smart vehicles, V2V Communication, single vehicle applications, Connected cars - Opportunities, risks and turmoil. Policies and Standards

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**
Text Book(s)		
1.	O. Vermesan, Digitizing the Industry: Internet of things connecting Physical, Digital and Virtual Worlds, Jan 2016, River Publishers, The Netherlands	
2.	Tim Schule, Beate Müller, Gereon Meyer, Advanced Microsystems for Automotive Applications: Smart Systems for Green and Automated Driving, 2016, Springer Publishers, USA.	
Reference Books		
1.	O. Vermesan Internet of Things - Converging Technologies for Smart Environments and Integrated Ecosystems, 2015, River Publishers, The Netherlands.	
2.	Daniel Minouli, Building the Internet of Things with IPv4 and IPv6, Oct 2015, John Wiley, USA	
3.	Erik Dahlman, Johan Skold, and Stefan Parkvall, 5G NR: The Next Generation Wireless Access Technology, 2018, Academic Press, Elsevier. Marko Wolf, Secure In-Vehicle Communications, 2012, Springer, USA. The Internet of Things and Connected Cars, Business White paper, 2015, HPE.	
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test		
Recommended by Board of Studies	07-06-2023	
Approved by Academic Council	No. 70	Date 24-06-2023

Course Code	Course Title	L	T	P	C
MAME617L	Augmented and Virtual Reality for Automotive Applications	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The course is aimed at making the students to

1. Understand the concepts of Computer Graphics, VR systems and Virtual Environment.
2. Understand the concepts of Augmented Reality.
3. Apply Augmented and Virtual Reality for automotive applications.

Course Outcomes

At the end of the course, the students will be able to

1. Comprehend the basics of computer graphics.
2. Comprehend the geometric modelling and Geometric Transformations
3. Comprehend VR systems, VR Hardware, Virtual Environment and Augmented Reality
4. Design and Develop a Prototype
5. Develop a Product for automotive applications.
6. To apply augmented and virtual reality to solve challenging problems in automotive industry.

Module:1	Geometric Modelling and Geometric Transformations	6 hours

Geometric Modelling: Introduction, from 2D to 3D, 3D space curves, 3D boundary representation Geometrical Transformations: Introduction, Frames of reference, Modelling transformations, Instances, Picking, Flying, Scaling the VE, Collision detection.

Module:2	Virtual Reality and Computer Graphics	7 hours

Virtual Reality and Virtual Environment: Introduction, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark. 3D Computer Graphics: Introduction, The Virtual world space, positioning the virtual observer, the perspective projection, human vision, stereo perspective projection, 3D clipping, Colour theory, Simple 3D modelling, Illumination models, Reflection models, Shading algorithms, Radiosity, Hidden Surface Removal, Realism -Stereographic image.

Module:3	VR systems and Hardware	4 hours

Generic VR system: Introduction, Virtual environment, Computer environment, VR technology, Model of interaction, VR Systems. VR Hardware: Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems.

Module:4	Virtual Environment	7 hours

Animating the Virtual Environment: Introduction, The dynamics of numbers, Linear and Non-linear interpolation, the animation of objects, linear and non-linear translation, shape & object inbetweening, free from deformation, particle system. Physical Simulation: Introduction, Objects falling in a gravitational field, Rotating wheels, Elastic collisions, projectiles, simple pendulum, springs, Flight dynamics of an aircraft.

Module:5	**Augmented Reality**	**6 hours**
Taxonomy, technology and features of augmented reality, difference between AR and VR, Challenges with AR, AR systems and functionality, Augmented reality methods, visualization techniques for augmented reality, enhancing interactivity in AR environments, evaluating AR systems.		
Module:6	**Design and Development of Prototype**	**6 hours**
Automotive Design Process: Development of concept in 3D - Design the process - VR-based collaborative environment creation, Virtual Prototyping for vehicle design: Modelling the process - Modifying concepts and overcoming the inherent limitations and demands on resources associated with physical modelling - VR-based visualization of idea and Validation of a new vehicle's entire electronic system.		
Module:7	**Product Development, Manufacturing and Training**	**7 hours**
AR and Product Development: Repairing existing models and designing new ones - AR-based remote assistance in real-time - AR-based visualization of new components fit into existing vehicle designs, AR and VR in Vehicle Manufacturing: Virtual assembly line: reconfiguration and optimization of the manufacture assembly lines - AR-based retrofitting - Creation of immersive environment for designers, researchers and engineers, VR and Digital Training: Efficient and cost-effective training delivery methods - Simulation-based training - Learning outcomes while reducing risk and training costs.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Ella Hassanien, Deepak Gupta, Ashish Khanna, Adam Slowik, "Virtual and Augmented Reality for Automobile Industry: Innovation Vision and Applications", Springer International Publishing, 2022
2.	John Vince, "Virtual Reality Systems ", Pearson Education Asia, 2007.
Reference Books	
1.	Alan B. Craig, "Understanding Augmented Reality, Concepts and Applications", Morgan Kaufmann, 2013.
2.	Adams, "Visualizations of Virtual Reality", Tata McGraw Hill, 2000.
3.	Grigore C. Burdea, Philippe Coiffet, "Virtual Reality Technology", Wiley Inter Science, 2nd Edition, 2016.
4.	William R. Sherman, Alan B. Craig, "Understanding Virtual Reality: Interface, Application and Design", Morgan Kaufmann, 2008.
5.	Aukstakalnis S. Practical augmented reality: "A guide to the technologies, applications, and human factors for AR and VR". Addison-Wesley Professional; 2016.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	07-06-2023		
Approved by Academic Council	No. 70	Date	24-06-2023

Course Code	Course Title	L	T	P	C
MAME618L	Soft Computing Techniques	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The course is aimed at making the students to

1. Understanding about the fundamentals of machine learning, neural networks, optimization and Deep Learning
2. Enabling the students to acquire knowledge about data selection and classification
3. Apply soft computing techniques to solve practical problems.

Course Outcomes

At the end of the course, the students will be able to

1. Comprehend the categorization of machine learning algorithms and concepts of python programming.
2. Acquaint with artificial neural network terminologies.
3. Understand advanced algorithms for artificial neural networks.
4. Acquaint with the working mechanisms of evolutionary algorithms
5. Apply genetic algorithms to solve soft computing problems
6. Understand advanced algorithms for object detection and image segmentation and comprehend advanced neural networks for natural language processing.

Module:1	Learning Problems and Python programming concepts	5 hours

Different approaches to learning problems (such as Supervised, Semi-supervised, and Unsupervised), Python: Data structures (Lists, Tuples, Dictionary, Sets), String manipulation, Conditional statements, Functions, Objects and classes.

Module:2	Artificial Neural Network - I	4 hours

Biological inspiration and historical context, Activation functions and their properties, Forward propagation and the role of weights and biases, McCulloch-Pitts Neuron, Perceptron, Training a single-layer neural network, Limitations of single-layer networks, Applications of single-layer neural networks.

Module:3	Artificial Neural Network – II	4 hours

Introduction to Multilayer Perceptron (MLP), Backpropagation algorithm for training MLPs, Stochastic Gradient Descent algorithm and weight optimization techniques, Hyperparameter tuning in MLPs, Applications of MLP.

Module:4	Optimization in Soft Computing-I	9 hours

Overview of optimization in soft computing, Basic Evolutionary Processes, Evolutionary Systems as Problem Solvers, Canonical Evolutionary Algorithms - Evolutionary Programming, Evolution Strategies, A Unified View of Simple EAs, Population Size. Applications of Optimization in Soft Computing: Feature selection and dimensionality reduction, Data clustering and classification

Module:5	Optimization in Soft Computing-II	7 hours

Introduction to Genetic algorithms, Biological Background, Traditional Optimization and Search Techniques, Genetic Algorithm and Search Space, Operators in Genetic Algorithm, Stopping Conditions for Genetic Algorithm Flow, Problem Solving Using Genetic Algorithm: Maximizing a Function

Module:6	**Deep Learning: Object Detection and Segmentation**	**7 hours**
Background of Object Detection, R-CNN, Fast R-CNN, Faster R-CNN, YOLO, SSD, RetinaNet; Segmentation: FCN, SegNet, U-Net, Mask-RCNN, and Application: Object detection for Self driving cars using Python/ Simulink.		
Module:7	**Deep Learning: Natural Language Processing**	**7 hours**
N-gram Language Models, Part Of Speech Tagging and Sequence Labeling, LSTM and Recurrent Neural Networks, Semantic Analysis, Information Extraction, Machine Translation, Application: Speech Recognizer.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1.	Machine Learning Algorithms and Applications, Mohssen Mohammed, Muhammad Badruddin Khan, Eihab Bashier Mohammed Bashier, CRC Press, 2017.
2.	Deep Learning, Ian Goodfellow, YoshuaBengio and Aaron Courville, MIT Press, ISBN: 9780262035613, 2016.
3.	Hands-On Machine Learning With Scikit-Learn, Keras, And TensorFlow: Concepts, Tools, And Techniques To Build Intelligent Systems, Aurélien Géron, O'Reilly Media, Inc., ISBN: 9781492032649, 2019
4.	Principles of Soft Computing, S.N. Sivanandam, S.N. Deepa, Wiley (3rd edition), ISBN: 9788126577132, 2018
Reference Books	
1.	Mathematics for Machine Learning. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong. Cambridge University Press. ISBN: 9781108679930. 2020.
2.	Artificial Intelligence, Machine Learning, and Deep Learning. Oswald Campesato. Mercury Learning & Information.2020. ISBN: 9781683924661
3.	Natural Language Processing with PyTorch, Delip Rao, Brian McMahan, O'Reilly Media, Inc. ISBN: 9781491978238, 2019

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	07-06-2023		
Approved by Academic Council	No. 70	Date	24-06-2023

Course Code	Course Title	L	T	P	C
MEDS501L	Embedded System Design	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The course aimed at

1. Ability to understand comprehensively the technologies and techniques underlying in building an embedded solution to a wearable, mobile and portable system.
2. Analyze UML diagrams and advanced Modelling schemes for different use cases.
3. Understand the building process of embedded systems

Course Outcome

The students will be able to

1. Define an embedded system and compare with general purpose system.
2. Appreciate the methods adapted for the development of a typical embedded system.
3. Get introduced to RTOS and related mechanisms.
4. Classify types of processors and memory architecture
5. Differentiate the features of components and networks in embedded systems
6. Develop real-time working prototypes of different small-scale and medium-scale embedded Systems.
7. Apprehend the various concepts in Multi-Tasking

Module:1	**Introduction to Embedded System**	**5 hours**
Embedded system processor, hardware unit, software embedded into a system, Example of an embedded system, Embedded Design life cycle, Layers of Embedded Systems.		
Module:2	**Embedded System Design Methodologies**	**5 hours**
Embedded System modelling [FSM, SysML, MARTE], UML as Design tool, UML notation, Requirement Analysis and Use case Modelling, Design Examples		
Module:3	**Building Process For Embedded Systems**	**4 hours**
Preprocessing, Compiling, Cross Compiling, Linking, Locating, Compiler Driver, Linker Map Files, Linker Scripts and scatter loading, Loading on the target, Embedded File System.		
Module:4	**System design using general purpose processor**	**7 hours**
Microcontroller architectures (RISC, CISC), Embedded Memory, Strategic selection of processor and memory, Memory Devices and their Characteristics, Cache Memory and Various mapping techniques, DMA.		
Module:5	**Component Interfacing & Networks**	**9 hours**
Memory Interfacing, I/O Device Interfacing, Interrupt Controllers, Networks for Embedded systems- USB, PCI,PCI Express, UART, SPI, I2C, CAN, Wireless Applications - Bluetooth, Zigbee,Wi-Fi.,6LoWPAN , Evolution of Internet of things (IoT).		
Module:6	**Operating Systems**	**7 hours**
Introduction to Operating Systems, Basic Features & Functions of an Operating System, Kernel & its Features [polled loop system, interrupt driven system, multi rate system], Processes/Task and its states, Process/Task Control Block, Threads, Scheduler, Dispatcher.		
Module:7	**Multi Tasking**	**6 hours**
Context Switching , Scheduling and various Scheduling algorithms, Inter-process Communication (Shared Memory, Mail Box, Message Queue), Inter Task Synchronization (Semaphore, Mutex), Dead Lock, Priority Inversion (bounded and unbounded), Priority Ceiling Protocol & Priority Inheritance Protocol		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)			
1.	Raj Kamal, “Embedded systems Architecture, Programming and Design”, Tata McGraw- Hill, 2016.		
2.	Wayne Wolf “Computers as components: Principles of Embedded Computing System Design”, The Morgan Kaufmann Series in Computer Architecture and Design, 2013.		
Reference Books			
1.	Lyla B. Das," Embedded Systems an Integrated Approach", Pearson Education, 2013.		
2.	Shibu K V," Introduction to Embedded Systems", McGraw Hill Education(India) Private Limited, 2014		
3.	Sriram V Iyer, Pankaj Gupta " Embedded Real Time Systems Programming", Tata McGraw- Hill, 2012		
4.	Steve Heath, “Embedded Systems Design”, EDN Series, 2013.		
Mode of Evaluation: Continuous Assessment, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MEDS601L	Electromagnetic Interference and Compatibility	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The course is aimed at:

1. Imparting knowledge about EMI environment
2. Teaching EMI coupling principles, EMI control techniques and design of PCBs for EMC
3. Giving exposure to EMI Standards, Regulations and Measurements

Course Outcomes

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

1. Understand terminologies of EMI and EMC
2. Analyze and understand various EMI coupling mechanisms
3. List various EMI Test and Measurement methods
4. Analyze various techniques needed to suppress EMI
5. Perceive different EMC regulations followed worldwide
6. Ability to design an Electromagnetic Compatible systems.
7. Analyze and comprehend different techniques needed for Signal Integrity and ability to understand various models for EMI/EMC

Module:1	EMI Environment	4 hours

EMI-EMC Definitions and units of Parameters, Sources of EMI, conducted and radiated EMI, Transient EMI

Module:2	EMI Coupling Mechanisms	6 hours

Conducted, Radiated and Transient Coupling, Common Impedance Ground Coupling, Radiated Common Mode and Ground Loop Coupling, Radiated Differential Mode Coupling, Near Field Cable to Cable Coupling, Power Mains and Power Supply Coupling.

Module:3	EMI Test and Measurements	8 hours

EMI Specification / Standards / Limits: Units of specifications, Civilian standards Military standards. EMI Test Instruments / Systems, EMI Test, EMI Shielded Chamber, Open Area Test Site, TEM Cell Antennas, Conductors Sensors/Injectors/Couplers. EMI Measurement Methods: Military Test Method and Procedures, Calibration Procedures, Modeling interferences

Module:4	EMI Control Techniques	7 hours

Shielding, Filtering, Grounding, Bonding, Isolation Transformer, Transient Suppressors, Cable Routing, Signal Control, Component Selection and Mounting, Electrostatic discharge protection schemes

Module:5	EMC Standards and Regulations	5 hours

National and Intentional standardizing organizations- FCC, CISPR, ANSI, DOD, IEC, CENEEC, FCC CE and RE standards, CISPR, CE and RE Standards, IEC/EN, CS standards, SAE Automotive EMC standard, Frequency assignment - spectrum conversation.

Module:6	System Design for EMC	8 hours

PCB Traces Cross Talk, Impedance Control, Power Distribution Decoupling, Zoning, Motherboard Designs and Propagation Delay Performance Models,

System Enclosures, Power line filter placement, Interconnection and Number of Printed Circuit Boards, PCB and subsystem decoupling		
Module:7	**Signal Integrity and EMI/EMC Models**	**5 hours**
Effect of terminations on line wave forms, Matching schemes for Signal Integrity, Effects of line discontinuities, Statistical EMI/EMC models.		
Module:8	**Contemporary Issues**	**2 hours**
Guest Lectures from Industry and, Research and Development Organizations		
	Total Lecture hours:	**30 hours**
Text Book(s)		
1.	Clayton R. Paul,IntroductiontoElectromagneticcompatibility,2010, 2nd edition., Wiley & Sons, New Jersey	
Reference Books		
1.	HenryW.ott, Electromagnetic Compatibility Engineering, 2011, 1sted. John Wiley and Sons, NewJersey.	
2.	Patrick G. André and Kenneth Wyatt, EMI Troubleshooting Cookbook for Product Designers 2014, 1st ed., SciTech Publishing, New Jersey	
Mode of Evaluation: Continuous Assessment, Digital Assignment, Quiz and Final Assessment Test		
Recommended by Board of Studies	07-06-2023	
Approved by Academic Council	No. 70	Date 24-06-2023

Course Code	Course Title	L	T	P	C
MEDS616L	Machine Leaning and Deep Learning	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The course is aimed at

1. Understanding about the fundamentals of machine learning and neural networks
2. Enabling the students to acquire knowledge about pattern recognition.
3. Motivating the students to apply deep learning algorithms for solving real life problems.

Course Outcomes

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

1. Comprehend the categorization of machine learning algorithms.
2. Understand the types of neural network architectures, activation functions
3. Acquaint with the pattern association using neural networks
4. Explore various terminologies related with pattern recognition
5. Adopt different feature selection and classification techniques
6. Understand the architectures of convolutional neural networks and Comprehend advanced neural network architectures such as RNN, Autoencoders, and GANs.

Module:1	Learning Problems and Algorithms	4 hours

Various paradigms of learning problems, Supervised, Semi-supervised and Unsupervised algorithms

Module:2	Neural Network – I	8 hours

Differences between Biological and Artificial Neural Networks - Typical Architecture, Common Activation Functions, Multi-layer neural network, Linear Separability, Hebb Net, Perceptron, Adaline, Standard Back propagation

Module:3	Neural Network – II	8 hours

Training Algorithms for Pattern Association - Hebb rule and Delta rule, Hetero associative, Auto associative, Kohonen Self Organising Maps, Examples of Feature Maps, Learning Vector Quantization, Gradient descent, Boltzmann Machine Learning

Module:4	Machine Learning: Terminologies	7 hours

Classifying Samples: The confusion matrix, Accuracy, Precision, Recall, F1- Score, the curse of dimensionality, training, testing, validation, cross validation, overfitting, under-fitting the data, early stopping, regularization, bias and variance

Module:5	Machine Learning: Feature Selection and Classification	7 hours

Feature Selection, normalization, dimensionality reduction, Classifiers: KNN, SVM, Decision trees, Naïve Bayes, Binary classification, multi class classification, clustering.

Module:6	Convolutional Neural Networks	5 hours

Feed forward networks, Activation functions, backpropagation in CNN, optimizers, batch normalization, convolution layers, pooling layers, fully connected layers, dropout, Examples of CNNs.

Module:7	**RNNs, Auto encoders and GANs**	**4 hours**
State, Structure of RNN Cell, LSTM and GRU, Time distributed layers, Generating Text, Auto encoders: Convolutional Auto encoders, De-noising auto encoders, Variational auto encoders, GANs: The discriminator, generator, DCGANs		
Module:8	**Contemporary Issues**	**2 hours**
Guest Lectures from Industry and, Research and Development Organizations		
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	J. S. R. Jang, C. T. Sun, E. Mizutani, Neuro Fuzzy and Soft Computing - A Computational Approach to Learning and Machine Intelligence, 2012, PHI learning
2.	Deep Learning, Ian Good fellow, Yoshua Bengio and Aaron Courville, MIT Press, ISBN: 9780262035613, 2016.
Reference Books	
1.	The Elements of Statistical Learning. Trevor Hastie, Robert Tibshirani and Jerome Friedman. Second Edition. 2009.
2.	Understanding Machine Learning. ShaiShalev-Shwartz and Shai Ben-David. Cambridge University Press. 2017.

Mode of Evaluation: Continuous Assessment, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	07-06-2023		
Approved by Academic Council	No. 70	Date	24-06-2023