VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF MECHANICAL ENGINEERING

M.Tech Mechatronics

Curriculum & Syllabai

(*2022-2023 batch onwards*)

VIT®
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(Deemed to be University under section 3 of UGC Act, 1956)

VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

- Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

- **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 and compassion.

VISION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

- To be a leader in imparting world class education in Mechanical Engineering, leading to nurturing of scientists and technologists of highest caliber who would engage in sustainable development of the globe.

MISSION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

- To create and maintain an environment fostering excellence in instruction & learning, Research and Innovation in Mechanical Engineering and Allied Disciplines.
- To equip students with the required knowledge and skills to engage seamlessly in higher educational and employment sectors ensuring that societal demands are met.

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M. Tech Mechatronics

PROGRAMME OUTCOMES (POs)

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.

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M. Tech Mechatronics

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M. Tech. (Mechatronics) programme, graduates will be able to

- **PSO_1:** Compute, Design, Simulate & analyse various Automotive engineering systems taken into account the social, economic and environmental implications for the current and future mobility.
- **PSO_2:** Practice a multidisciplinary approach to solve real-world automotive problems.
- **PSO_3:** Independently carry out research / investigation to solve practical problems and write / present a substantial technical report/document.

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M. Tech Mechatronics

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

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.

Agenda Item 67/14

To consider and approve the revised programme credit structure, curriculum and course contents of Master of Technology in Mechatronics

ANNEXURE – 18

Master of Technology in Mechatronics

School of Mechanical Engineering

Programme Credit Structure	**Credits**
Discipline Core Courses	24
Skill Enhancement Courses	05
Discipline Elective Courses	12
Open Elective Courses	03
Project/ Internship	26
Total Graded Credit Requirement	70

Discipline Core Courses **24**

		L	**T**	**P**	**C**
MMHA501L	Advanced Sensors and Instrumentation	3	0	0	3
MMHA501P	Advanced Sensors and Instrumentation Lab	0	0	2	1
MMHA502L	Actuators and Drives	3	0	0	3
MMHA503L	Robot dynamics and Programming	3	0	0	3
MMHA503P	Robot dynamics and Programming Lab	0	0	2	1
MMHA504L	System Design and Control	3	0	0	3
MMHA505L	Industrial Controllers	3	0	0	3
MMHA505P	Industrial Controllers Lab	0	0	2	1
MMHA506L	Advanced Control Systems	3	0	0	3
MMHA507L	Industrial Process Automation	2	0	0	2
MMHA507P	Industrial Process Automation Lab	0	0	2	1

Skill Enhancement Courses **05**

MENG501P	Technical Report Writing	0	0	4	2
MSTS501P	Qualitative Skills Practice	0	0	3	1.5
MSTS502P	Quantitative Skills Practice	0	0	3	1.5

Discipline Elective Courses **12**

MMHA601L	Machine Vision Systems	3	0	0	3
MMHA602L	Mobile and Autonomous Robots	3	0	0	3
MMHA603L	MEMS and Microsystems	3	0	0	3
MMHA604L	Data acquisition and Digital Signal Processing	3	0	0	3
MMHA605L	Embedded systems	3	0	0	3
MMHA606L	Autotronics and Vehicle Intelligence	3	0	0	3
MMHA607L	Intelligent Systems	3	0	0	3
MMHA608L	Wireless Sensor Networks	2	1	0	3
MMHA609L	Virtual Reality and Haptics	3	0	0	3
MMHA610L	Condition Monitoring Techniques	3	0	0	3
MMHA611L	Bio-Mechatronics	3	0	0	3
MMHA612L	Internet of Things and Smart Manufacturing	3	0	0	3
MMHA613L	Manufacturing Automation	3	0	0	3
MMHA613P	Manufacturing Automation Lab	0	0	2	1
MMHA614L	Fluid Power System Design	3	0	0	3
MMHA614P	Fluid Power System Design Lab	0	0	2	1

Open Elective Courses **03**

Engineering Disciplines | Social Sciences

Project and Internship **26**

MMHA696J	Study Oriented Project	02
MMHA697J	Design Project	02
MMHA698J	Internship I/ Dissertation I	10
MMHA699J	Internship II/ Dissertation II	12

Course Code	Course Title	L	T	P	C
MMHA501L	Advanced Sensors and Instrumentation	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

The Objectives of the course are to:

1. Familiarize with sensors used in engineering
2. Understand the signal conditioning circuits

Course Outcome :

On completion of this course student should be able to:

1. Understand the input-output configuration, static and dynamic characteristics of typical measurement systems.
2. Apply the transduction principles of typical transducers used in industrial measurement applications related to force, pressure, level, flow, acceleration, torque, temperature, displacement, speed, etc.
3. Demonstrate the principle of operation and applications of opto electronic, magnetic, digital sensors.
4. Demonstrate the recent trends and advances in the measurement systems.
5. Comprehend the role of signal conditioning circuits and data acquisition in measurement systems.
6. Apply the typical sensors suitable for different industrial applications.

Module:1	Introduction to Instrumentation systems	6 hours

Basic elements of instrumentation systems, Input-Output configuration, Error sources – Calibration – standards, static and dynamic characteristics of instruments.

Module:2	General Transduction Principles for measurement applications	6 hours

Transduction principle – Resistive, Capacitive, Inductive, Piezoresistive, Piezoelectric, optical, Photovoltaic, Thermoelectric, Acoustic and Hall effect.

Module:3	Construction and operation of typical instruments	6 hours

General measurement applications - temperature, pressure, vibration, force, acceleration, torque, position, velocity, angular velocity, humidity, tactile, flow and level measurement.

Module:4	Advanced sensors technologies and applications	6 hours

Opto-electronic sensors, Fiber optic sensor, Magnetic sensors, Digital transducers, LASER based instruments, Ultrasonic sensors, Micro sensors, Bio sensors.

Module:5	Smart sensor systems and applications	6 hours

General architecture of a smart sensor – Self calibration – Wireless sensors- energy harvesting techniques – Web based instrumentation-Applications.

Module:6	Signal conditioning and Data Acquisition	6 hours

Operational Amplifiers, Amplifiers, bridges, filters, analog-to digital and digital-to-analog conversion, Elements of data acquisition system, basics of Virtual instrumentation systems, Data logging.

Module:7	Industrial Applications of sensors and instrumentation systems	7 hours

Vibration measurement in machine tools, Position measurement of end effectors in robots -

Speed measurement of road wheels in Automotive system, Environmental monitoring and biomedical applications- case studies		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours	**45 hours**
Text Book(s)		
1.	Bentley JP, Principles of measurement systems, Pearson Publishers., 2012.	
2.	Ernest. O. Doebelin, “Measurement System Application & Design”, (2008), McGraw Hill Book co 5th edition, 2008.	
Reference Books		
1.	D. Patranabis, “Principles of Industrial Instrumentation”, (2010), Tata McGraw-Hill, Third Edition,	
2.	John G. Webster, HalitEren, “Measurement, Instrumentation, and Sensors Handbook”, (2014), Second Edition, CRC Press.	
3.	D. V. S. Murty, “Transducers and Instrumentation”, (2010), PHI Learning Pvt. Ltd.	
4.	H.R. Taylor, “Data Acquisition for Sensor Systems”, (2013), Springer Science & Business Media..	
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT		
Recommended by Board of Studies	27-07-2022	
Approved by Academic Council	No. 67	Date 08-08-2022

Course Code	Course Title	L	T	P	C
MMHA501P	Advanced Sensors and Instrumentation Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The Objectives of the course are to:

1. Familiarize with sensors used in engineering
2. Understand the signal conditioning circuits

Course Outcome

On completion of this course student should be able to:

1. Understand the input-output configuration, static and dynamic characteristics of typical measurement systems.
2. Apply the transduction principles of typical transducers used in industrial measurement applications related to force, pressure, level, flow, acceleration, torque, temperature, displacement, speed, etc.
3. Demonstrate the principle of operation and applications of opto electronic, magnetic, digital sensors.
4. Demonstrate the recent trends and advances in the measurement systems.
5. Comprehend the role of signal conditioning circuits and data acquisition in measurement systems.
6. Apply the typical sensors suitable for different industrial applications.

Indicative Experiments

1.	Measurement of speed and displacement using linear and rotary sensors.
2.	Force and Torque measurement using strain gauge.
3.	Pressure measurement systems using sensors.
4.	Temperature measurement using RTD and thermocouple.
5.	Vibration and acceleration measurements using. Using peizo electric sensor.
6.	Study on humidity measurement.
7.	Design of complete signal condition circuit for temperature and pressure sensors.
8.	Study on data acquisition systems and interfacing sensors with computer.
9.	Analysis of dynamic characteristics of sensor signals using DAQ system.
10.	Development of data logging using virtual instrument software
	Total Laboratory Hours **30 hours**

Text Book(s)

1.	Bentley JP, Principles of measurement systems, Pearson Publishers., 2012.
2.	Bentley JP, Principles of measurement systems, Pearson Publishers., 2012.

Reference Books

1.	D. Patranabis, “Principles of Industrial Instrumentation”, (2010), Tata McGraw-Hill, Third Edition,
2.	John G. Webster, HalitEren, “Measurement, Instrumentation, and Sensors Handbook”, (2014), Second Edition, CRC Press.
3.	John G. Webster, HalitEren, “Measurement, Instrumentation, and Sensors Handbook”, (2014), Second Edition, CRC Press.
4.	H.R. Taylor, “Data Acquisition for Sensor Systems”, (2013), Springer Science & Business Media..

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA502L	Actuators and Drives	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The Objectives of the course are to:

1. Understand the fundamental concepts of electro-mechanical and fluid power (hydraulics and pneumatics) systems
2. Demonstrate the students with the actuators in the area of hydraulics, pneumatics, electro-mechanical systems and associated equipment's used for the same.
3. Apply the knowledge of several drives for the different actuators and energy conversions, etc. and they come up with energy saving solutions in industrial systems
4. Understand and apply fundamental concepts to the modeling, analysis, and control of brushed DC motors, stepper motors, brushless DC motors, solenoids, and hydraulic and pneumatic actuators.

Course Outcome :

The student should be able to:

1. Identify key concepts, architecture and principles concerning the hydraulics and pneumatic systems
2. Evaluate key concepts and principles concerning modeling, analysis, and control of brushed dc motors, stepper motors, brushless dc motors, and solenoids.
3. Apply the methods of control algorithms, fault detection and diagnosis.
4. Analyze the set of potential mechanisms and control solutions for the process.
5. Create awareness about actuators, drives and control elements for any applications
6. Selection of actuators and its associated drivers for several working conditions
7. Develop knowledge about the architecture and working principles of the most common electrical motor types
8. Choose and use hydraulic, pneumatic, electrical actuators and drives

Module:1	Hydraulic Actuators	7 hours

Introduction, Classification of actuators, Hydraulic pumps and supply sources, Hydraulic actuators - Linear actuator – Types - Single acting, Double acting special cylinders - tandem, Rodless, Telescopic, mounting details, cushioning mechanism, Rotary actuators, power packs –accumulators.

Module:2	Pneumatic Actuators	7 hours

Pneumatic characteristics and applications, Air generation, treatments and distribution, Components, Air filter, regulator, lubricator, Pneumatic cylinders, Pneumatic motors, Stroke Speed Regulation of Pneumatic Actuators.

Module:3	Control and Regulation Elements	7 hours

Control and regulation Elements – Basics of Direction control valves, flow and pressure control valves - Basic structure of pneumatic and hydraulic systems – Electro pneumatic and Electrohydraulic systems and controls.

Module:4	Electrical DC actuators	6 hours

D.C Motor-Working principle, characteristics, classification, Speed control techniques and braking, Applications - Speed, direction and position control using H-bridge under PWM mode.

Module:5	Electrical AC actuators	6 hours

AC Motor- Working principle, Speed torque characteristics, Speed control and braking, Single and three phases DC drives – Speed control of three phase induction motor – chopper drives – Need for V/ F drives – Energy saving AC drives Applications.		
Module:6	**Other Electrical actuators**	**5 hours**
Stepper Motor – Drive circuits for speed and position control - Servo motors – Linear motors – Relays- Power convertors		
Module:7	**Smart Materials Actuators**	**5 hours**
Smart materials and their application for sensing and actuation, Piezoelectric actuator - Linear actuators Hybrid actuators – Applications, shape memory alloys actuator, magnetostrictive actuators, Electrostrictive actuators, Electro - and magnetorheological fluid actuators – Case study.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Antony Esposito, Fluid Power Systems and Control (2013), Prentice-Hall.
Reference Books	
1.	A. K. Gupta, S. K. Arora, Industrial automation and Robotics (2013), University Science Press.
2.	W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering (2011), Pearson Education.
3.	Andre Veltman, Duco W.J. Pulle, R.W. De Doncker, Fundamentals of Electrical Drives (2007), Springer.
4.	D. Patranabis, Principles of Industrial Instrumentation (2010), Tata McGraw-Hill.

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA503L	Robot Dynamics and Programming	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

The Objectives of the course are to:

1. Introduce the modelling, simulation, and control of spatial multi-degree-of-freedom robotic manipulators.
2. Study the kinematics and dynamics of robotic manipulators.
3. Provide the awareness about the trajectory planning and control of robotic arm.

Course Outcome:

After completing the course, the student will be able to:

1. Discuss the specifications of various types of Industrial Robots.
2. Design appropriate end effectors for various applications.
3. Analyze kinematics of various manipulator configurations
4. Compute required trajectory planning for the given task.
5. Develop appropriate control system for robotic arm.
6. Prepare the program for various robotic applications.

Module:1	Introduction to Industrial robot	5 hours

Brief History of Industrial robotics – Components of robotics system – Types of joints – Work space and work-cell – Types of robotics configurations – DOF of serial and parallel manipulator – Basic motion of robot manipulator – Tool centre point – Robot end effector: Grippers and Tools.

Module:2	Robot Kinematics	6 hours

Position analysis and finite rotation and translation - Homogeneous matrices – Direct and Inverse kinematics: Two link planner, PUMA 560, Stanford arm, SCARA and Stewart Platform.

Module:3	Velocity and statics of robot manipulators	6 hours

Linear and angular velocity vector and matrix – Forward and inverse velocity kinematics (Jacobian) – Statics and force analysis of robot manipulator – Identifying singularity in work space.

Module:4	Dynamics of robots	6 hours

- Mass and inertia of links - equation of motion – Forward and inverse dynamics of robot manipulator – Lagrangian formulation of motion – Rigid link Recursive Acceleration.

Module:5	Trajectory planning	6 hours

Path planning – trajectory planning – Joint space trajectory planning – Cartesian space trajectory planning – Blending – Continuous trajectory recording (Trajectory following)

Module:6	Manipulator control	6 hours

Time optimal control method – Disturbance rejection – PD and PID control – Computed torque control – Adaptive control – Feedback linearization for under actuated systems.

Module:7	RAPID Language	8 hours

RAPID language basic commands-Motion Instructions-Pick and place operation using Industrial robot-manual mode, automatic mode, subroutine command based programming. Movemaster command language-Introduction, syntax, simple problems. Industrial Applications of robots - Pick and Place – Machine tending – Painting – welding – fettling –

Assembly – Service Robot application: Underwater robot –surgical robot – autonomous guided vehicle		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Craig, John J., Introduction to Robotics: Mechanics and Control (2005), Prentice Hall Inc.

Reference Books

1.	Mark W.Spong, M. Vidyasagar, Robotics Dynamics and control (2008), Wiley publication.
2.	AshitavaGhosal: Robotics- Fundamental Concepts and Analysis (2014), Oxford University Press.
3.	S.R.Deb, Robotics Technology and Flexible Automation (2010), Tata Mc-Graw Hill.
4.	J.P.Merlet, Parallel Robots (2005), Springer
5.	S K SAHA: Introduction to Robotics 2nd Edition (2016), McGraw Hill Education. ISBN (13 Digits): 978-93-329-0280-0. ISBN: 93-329-0280-1.

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA503P	Robot Dynamics and Programming Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The Objectives of the course are to:

1. Introduce the modelling, simulation, and control of spatial multi-degree-of-freedom robotic manipulators.
2. Study the kinematics and dynamics of robotic manipulators.
3. Provide the awareness about the trajectory planning and control of robotic arm.

Course Outcome

After completing the course, the student will be able to:

1. Discuss the specifications of various types of Industrial Robots.
2. Design appropriate end effectors for various applications.
3. Analyze kinematics of various manipulator configurations
4. Compute required trajectory planning for the given task.
5. Develop appropriate control system for robotic arm.
6. Prepare the program for various robotic applications

Indicative Experiments	
1.	Design & Simulation of Four Bar Crank-Rocker, Crank- Crank, and Rocker-Rocker Mechanism using MTAB Sim-mechanics and ADAMS
2.	Calculate the DH parameters for the Two link planner using Mat-Lab
3.	Solve the inverse kinematic problem for two link planner using Mat-Lab
4.	Compute position, velocities and acceleration for given manipulator configuration.
5.	Simulation of Robot for Arc Welding applications using Work Space LT [Rectangular and Circular Paths]
6.	Measure the Tool centre point for the given tool or gripper
7.	Program the Industrial robot to follow the contour surface
8.	Program the Industrial robot to draw the given profile in a plain
9.	Program the Industrial robot to draw the given profile in an Incline plain
10.	Simulate work cell for CNC tending using Rapid Programming
11.	Simulate work cell for Pelletizing and De-Pelletizing using Rapid Programming
	Total Laboratory Hours **30 hours**

Text Book(s)

1.	Craig, John J., Introduction to Robotics: Mechanics and Control (2005), Prentice Hall Inc.

Reference Books

1.	Mark W.Spong, M. Vidyasagar, Robotics Dynamics and control (2008), Wiley publication.
2.	AshitavaGhosal: Robotics- Fundamental Concepts and Analysis (2014), Oxford University Press.
3.	S.R.Deb, Robotics Technology and Flexible Automation (2010), Tata Mc-Graw Hill.
4.	J.P.Merlet, Parallel Robots (2005), Springer
5.	S K SAHA: Introduction to Robotics 2nd Edition (2016), McGraw Hill Education. ISBN (13 Digits): 978-93-329-0280-0. ISBN: 93-329-0280-1.

Mode of Assessment: Continuous Assessment and Final Assessment Test			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA504L	System Design and Control	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The Objectives of the course are to:

1. Create an awareness about the mechatronics design process
2. Expose the students to system modelling and system identification of mechatronic systems.
3. Create an interest in students for mathematical simulation of the dynamics of systems.
4. Enable students to apply the above in a real time industrial application

Course Outcome :

On completion of this course student should be able to:

1. Design of a mechatronic system.
2. Compile the concepts of system and modelling techniques
3. Apply the software for simulating dynamic systems
4. Outline the principles and analysis of basic control systems.
5. Study of optimization methods in physical systems
6. Examine the above for various industrial measurement and control applications

Module:1	Introduction to Mechatronics systems	6 hours

Introduction to Mechatronics system – Key elements – Mechatronics Design process – Traditional and Mechatronics designs – Model based system design.

Module:2	Concepts of system and modelling	6 hours

Concept of systems - modelling of systems - model representations - block diagram, transfer function, state space representation - system identification techniques – linearization of nonlinear models.

Module:3	Modelling of physical systems	6 hours

Development of mathematical models: mechanical, electrical, electromechanical, Thermal, Hydraulic and Pneumatic systems.

Module:4	Simulation	6 hours

Simulation-basics – types – hardware in loop simulations – time response parameters - time response of 1st and 2ndorder systems - simulation of systems in software environment.

Module:5	Basic control systems	6 hours

Basic Elements of Control System – Open loop and Closed loop systems – Characteristics of on-off, P, PI, PD and PID Controllers –Implementation issues of PID Controller – Modified PID Controller – Tuning of controllers.

Module:6	Analysis of systems	8 hours

Time domain and frequency domain analysis of the systems using Routh Hurwitz criterion – Root locus – Frequency domain analysis –Gain margin – Phase margin - Bode Plot – Polar Plot – Nyquist stability criterion.

Module:7	Design optimization	5 hours

Optimization – problem formulation - constraints – overview of optimization techniques-optimal design of mechatronics systems.

Case Studies: Case studies on building mechatronics systems for measurement and control

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

Text Book(s)

1.	Devdasshetty and Richard A. Kolk, Mechatronics System Design (2012), 2nd edition, Cengage learning India Pvt. Ltd.

Reference Books

1.	W. Bolton, Mechatronics - Electronic Control systems in Mechanical and Electrical Engineering (2010), Pearson Education.
2.	K.Ogata, Modern Control Engineering (2010), Prentice Hall of India Pvt. Ltd.
3.	FaridGolnaraghi, Benjamin C. Kuo, Automatic Control systems (2014), 9th edition, Wiley India Pvt Ltd
4.	Dean C Karnopp, Donald L. Margolis Ronald C. Rosenberg, System dynamics" (2012), John Wiley & Sons.

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA505L	Industrial Controllers	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The Objectives of the course are to:

1. Outline the functions of various controllers used in industrial automation systems.
2. Learn the architecture, programming of microcontroller and interfacing with field devices.
3. Discuss the architecture and functions of PLC systems and learn PLC programming.

Course Outcome :

The student should be able to

1. Compare the architecture and functions of micro-computing systems for industrial applications.
2. Explain the architecture 8051 Microcontroller.
3. Create microcontroller assembly language programs.
4. Outline the interfacing techniques with 8051 microcontroller
5. Explain the architecture and functions of PLC and program PLC with ladder logic.
6. Outline selection of industrial controllers, communications standards and distributed control systems.

Module:1	Introduction to programmable controllers	6 hours

Overview of controllers for industrial automation – General description of mini computers, digital signal processors, microprocessors, microcontrollers, Programmable Logic Controller (PLC) and soft PLCs.

Module:2	Architecture of Microcontrollers	6 hours

Overview of the architecture of typical microcontroller. Overview of the architecture of high-end processors.

Module:3	Microcontroller programming	6 hours

Description of instruction sets; Addressing modes; Timers and counters; Assembly language programs with algorithms.

Module:4	Interfacing with 8051	6 hours

Serial port and interrupt programming, interfacing with keyboards, LEDs, LCDs, ADCs. DACs, memory, sensors, motor drivers, etc.

Module:5	Programmable Logic Controllers	6 hours

Architecture of PLC; Configuring I/O modules; memory, programming devices, program scan; Soft PLCS; Troubleshooting.

Module:6	PLC Programming	6 hours

Programming methods; Timers and counters, math instructions, data manipulations and PID control functions.

Module:7	Industrial Communication standards and HMI	7 hours

Communication standards; HMI/MMI, overview of supervisory and distributed control systems. Case Studies:Study ofmicrocontroller and PLC control systems for various industrial cases.

Module:8	Contemporary Issues	2 hours

			Total Lecture hours:	**45 hours**
Text Book(s)				
1.	David Calcutt, Frederick Cowan, Hassan Parchizadeh, 8051 Microcontroller: An Applications Based Introduction (2003), Newnes,			
2.	Manish K Patel, The 8051 Microcontroller Based Embedded Systems, (2017), Tata McGraw-Hill Publishing Co Ltd.			
3.	Frank D Petruzella, Programmable Logic Controllers Paperback (2010), 4th edition, McGraw-Hill Higher Education.			
Reference Books				
1.	Yu-Cheng Liu, Glenn A. Gibson, Microcomputer Systems: The 8086 / 8088 Family – Architecture, Programming and Design (2007), Second Edition, Prentice Hall of India.			
2.	Mohamed Ali Mazidi, Janice GillispieMazidi, RolinMcKinlay, The 8051 Microcontroller and Embedded Systems: Using Assembly and C (2011), Second Edition, Pearson Education.			
3.	W. Bolton, Programmable Logic Controller (2015), Elsevier-Newnes publication, 6th edition.			
4.	A. K. Gupta, S. K. Arora, Industrial Automation and Robotics (2013), 3rd edition, Lakshmi Publications, India.			
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT				
Recommended by Board of Studies		27-07-2022		
Approved by Academic Council		No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA505P	Industrial Controllers Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The Objectives of the course are to:

1. Outline the functions of various controllers used in industrial automation systems.
2. Learn the architecture, programming of microcontroller and interfacing with field devices.
3. Discuss the architecture and functions of PLC systems and learn PLC programming.

Course Outcome

The student should be able to

1. Compare the architecture and functions of micro-computing systems for industrial applications.
2. Explain the architecture 8051 Microcontroller.
3. Create microcontroller assembly language programs.
4. Outline the interfacing techniques with 8051 microcontroller
5. Explain the architecture and functions of PLC and program PLC with ladder logic.
6. Outline selection of industrial controllers, communications standards and distributed control systems.

Indicative Experiments	
1.	Basic Programming of microcontroller.
2.	Keypad and display interfacing with microcontroller.
3.	PWM duty cycle and motor speed control using microcontroller.
5.	Serial communications using microcontroller
6.	PLC Programming for simple control applications with logic, timers, counters, data manipulation and math instructions.
7.	Interfacing input and output field devices with PLC systems.
8.	PLC control of electro-pneumatic and electro-hydraulic systems.
9.	Control of Bottle filling system using PLC
10.	Interfacing Analog field devices with PLC.
	Total Laboratory Hours **30 hours**

Text Book(s)	
1.	David Calcutt, Frederick Cowan, Hassan Parchizadeh, 8051 Microcontroller: An Applications Based Introduction (2003), Newnes,
2.	Manish K Patel, The 8051 Microcontroller Based Embedded Systems, (2017), Tata McGraw-Hill Publishing Co Ltd
3.	Frank D Petruzella, Programmable Logic Controllers Paperback (2010), 4th edition, McGraw-Hill Higher Education.

Reference Books	
1.	Yu-Cheng Liu, Glenn A. Gibson, Microcomputer Systems: The 8086 / 8088 Family – Architecture, Programming and Design (2007), Second Edition, Prentice Hall of India.
2.	Mohamed Ali Mazidi, Janice GillispieMazidi, RolinMcKinlay, The 8051 Microcontroller and Embedded Systems: Using Assembly and C (2011), Second Edition, Pearson Education.
3.	W. Bolton, Programmable Logic Controller (2015), Elsevier-Newnes publication, 6th edition.
4.	A. K. Gupta, S. K. Arora, Industrial Automation and Robotics (2013), 3rd edition, Lakshmi Publications, India.

Mode of Assessment: Continuous Assessment and Final Assessment Test			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA506L	Advanced Control Systems	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

1. To review the continuous time control system design with realistic system specifications.
2. To design a digital control system for a continuous system model.
3. To provide knowledge of state variable models and fundamental notions of state feedback design
4. To provide understanding of different control algorithms considering nonlinearities, uncertainities and robustness.

Course Outcome :

On the completion of this course the student will be able to:

1. Design continuous time control system design with realistic system specifications.
2. Analysis of discrete system response using Z-Transform.
3. Infer controllability/ observability of a system.
4. Design a digital Controller with realistic system specifications.
5. Design the state feedback control law for a time domain specification.
6. Understand control system design for for non linear systems.
7. Comprehend the basics of optimal control, robust control, predictive control

Module:1	Classical Control Systems	6 hours

Review of feedback systems and design of PID Controllers - Design of controllers using Root Loci and Bode plots – Lead, Lag, Lag-lead and parallel compensators.

Module:2	Digital Control Systems	6 hours

Sampling and holding – Z-transform - Correlation between time response and root locations in S plane and Z plane – Direct design in Z and W plane.

Module:3	Digital Controller Design	6 hours

State space design – Design via pole placement - digital PID controller design

Module:4	State Space Analysis	6 hours

State space representations – conversion from transfer function model – solving time-invariant state equations – Controllability – Observability.

Module:5	Control System Design in State Space	6 hours

Pole placement controllers in state space - design of servo and regulatory controllers – state observers.

Module:6	Nonlinear and Predictive Control	6 hours

Common physical non-linear system, phase plane method - Liapunov's stability criterion - Popov's stability criterion - Model reference and predictive control systems – state estimators – Kalman algorithm.

Module:7	Supervisory Level Systems	7 hours

Introduction to Adaptive control, optimal control, robust control, multi-variable control systems.
Case studies: Control of motion and other dynamics of mechatronics systems

Module:8	Contemporary Issues	2 hours

			Total Lecture hours:	**45 hours**
Text Book(s)				
1.	K. Ogata, Modern Control Engineering, (2010) Prentice Hall of India Pvt. Ltd., New Delhi.			
Reference Books				
1.	Gene F. Franklin, J. D. Powell, A E Naeini, Feedback Control of Dynamic Systems, (2008) Pearson India.			
2.	K. Ogata, Discrete-Time Control Systems, (2009) Prentice Hall of India Pvt. Ltd., New Delhi.			
3.	Alok Sinha, Linear Systems: Optimal and Robust Control, (2007) Taylor & Francis.			
4.	Brian D. O. Anderson and John B. Moore, Optimal Control: Linear Quadratic Methods, (2007) Dover Publications			
5.	H.K. Khalil, Nonlinear Systems, (2001) Prentice Hall.			
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT				
Recommended by Board of Studies		27-07-2022		
Approved by Academic Council		No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA507L	Industrial Process Automation	2	0	0	2
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The Objectives of the course are to

1. Impart knowledge on PLC, Supervisory control and factory automation

Course Outcome :

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

1. Explain the Industrial process automation and its strategy
2. Demonstrate the Modes of computer control in automations
3. Design a simple automation system using PLC and SCADA for the industry
4. Explain the Industrial networks for developing the communication Infrastructure
5. Design a HMI for industry automation system
6. Apply automation systems in different industrial processes

Module:1	**Industrial Process Automation**	**4 hours**
Need for process automation - generic duties of an automation system**,** Concepts of process automation in automotive, food/beverage, oil/gas and chemical industries.		
Module:2	**Automation strategy**	**4 hours**
Physical architecture of an automation system- Plant wide control systems, Process control systems-continuous and batch process-feedback control system overview.		
Module:3	**Automation system control strategies & DCS**	**4 hours**
Modes of computer control, DCS- Introduction, Architecture and components, Controllers and functional features		
Module:4	**SCADA**	**4 hours**
Introduction, Architecture and components, Controllers and functional features, RTU technology, Interfacing PLC to SCADA/DCS.		
Module:5	**Industrial Communication Infrastructure**	**4 hours**
Serial communication standards - RS232/422/485 - Modbus. Industrial networks - HART - Device Net - Profibus and Fieldbus communication.		
Module:6	**Operator consoles and interfaces**	**4 hours**
HMI Basics, Types, Applications of Human Machine Interface - HMI Processing - Interaction styles and general design interaction - strategies interface metaphors and conceptual models HCI and the World Wide Web HCI - security accessibility of user interfaces, evaluation HCI and social computing.		
Module:7	**Case Studies**	**4 hours**
Case studies on applications of automation systems in different industrial processes.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	B. R. Mehta and Y. J. Reddy, Industrial Process Automation Systems Design and Implementation, Elsevier Inc. 2015.

Reference Books

1.	K.L.Sharma, Overview of Industrial Process Automation, Elsevier, 2011
2.	Frank Lamb, Industrial Automation: Hands On, McGraw-Hill Professional, 2013

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA507P	Industrial Process Automation Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The Objectives of the course are to:

1. Impart knowledge on PLC, Supervisory control and factory automation

Course Outcome

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

1. Explain the Industrial process automation and its strategy
2. Demonstrate the Modes of computer control in automations
3. Design a simple automation system using PLC and SCADA for the industry
4. Explain the Industrial networks for developing the communication Infrastructure
5. Design a HMI for industry automation system
6. Apply automation systems in different industrial processes

Indicative Experiments	
1.	Automation of bottle filling system using PLC
2.	Development of HMI interface with PLC Programming
3.	PLC Programming for Elevator control applications
4.	Implementation of SCADA for supervisory control of Boiler plant in simulation environment
5.	Implementation of DCS for overall control of cement factory in simulation environment
6.	Interfacing HMI with internet for controlling a remote process
	Total Laboratory Hours **30 hours**

Text Book(s)

1.	B. R. Mehta and Y. J. Reddy, Industrial Process Automation Systems Design and Implementation, Elsevier Inc. 2015.

Reference Books

1.	K.L.Sharma, Overview of Industrial Process Automation, Elsevier, 2011
2.	Frank Lamb, Industrial Automation: Hands On, McGraw-Hill Professional, 2013

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA601L	**Machine Vision Systems**	**3**	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives :

The Objectives of the course are to:

1. Introduce students to the fundamentals of image formation;
2. Review image processing techniques for computer vision
3. Understand the shape and region analysis.
4. Develop an appreciation for various issues in the design of computer vision and object recognition systems; and
5. Provide the student with programming experience from implementing computer vision and object recognition applications.

Course Outcome :

On completion of this course student should be able to:

1. Demonstrate the image processing and image analysis techniques by a machine vision system.
2. Demonstrate the possibilities and limitations of application of image processing and computer vision.
3. Explain various image enhancement and restoration techniques.
4. Describe colour image processing, image compression, image segmentation and representation.
5. Evaluate the techniques for image enhancement and image restoration.
6. Interpret image segmentation and representation techniques.

Module:1	**Introduction**	**5 hours**
Human Vision - Machine Vision and Computer Vision – HMI		
Module:2	**Hardware Components**	**7 hours**
MVS camera -Analog, Digital- CID, CCD, CMOS, Camera Calibration - Frame Grabber, Manual & Auto shutter		
Module:3	**Lighting System**	**5 hours**
Lighting parameters**,** Lighting sources, selection - Lighting Techniques - Type and selection		
Module:4	**Image Acquisition**	**7 hours**
Digital camera Interfaces, Camera Computer Interfaces, Specifications and selection		
Module:5	**Image Processing**	**8 hours**
Fundamentals of Digital Image-Filtering technique -Processing of binary and grey scale images-segmentation- thresholding-connectivity-noise reduction-edge detection-region growing and region splitting - binary and gray morphology operations.		
Module:6	**Image Analysis**	**7 hours**
Feature extraction-Texture Analysis -Pattern recognition, image resolution-depth and volume, color processing, Template Matching -Decision Making, 3D Machine Vision Techniques		
Module:7	**Practical Applications**	**4 hours**
Applications of machine vision in Automotive Industries, Manufacturing, Electronics, Printing, Pharmaceutical, Biomedical, Robotics, Agricultural Applications.		
Module:8	**Contemporary Issues**	**2 hours**

			Total Lecture hours:	**45 hours**
Text Book(s)				
1.	E. R. Davies, ,(Machine Vision: Theory, Algorithms, Practicalities (2014Academic Press.			
Reference Books				
1.	Alexander Hornberg, Handbook on Machine Vision (2006), Wiley.			
2.	Milan Sonka, Vaclav Hlavac, Roger Boyle, Image Processing Analysis and machine Vision (2014), Cengage Learning.			
3.	Rafael C. Gonzalez, Richard Eugene Woods, Digital Image Processing (2009), Pearson.			
4.	Herbert Freeman, Machine Vision: Algorithms, Architectures and Systems (2012), Academic Press.			
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT				
Recommended by Board of Studies		27-07-2022		
Approved by Academic Council		No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA602L	Mobile and Autonomous Robots	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The Objectives of the course are to;

1. Outline the basic concepts of Mobile Robot and its types.
2. Study various types of locomotion and its kinematics behavior.
3. Understand the important of localization and its associated sensor system.
4. Solve various path planning algorithm and task allocation.

Course Outcome:

After completing the course, the student will be able to:

1. Predict the various types of autonomous system and its challenges.
2. Identify the types of locomotion and its kinematic constrain.
3. Predict the suitable sensors for localizations in mobile robotics system.
4. Compute path planning with various algorithm and task allocation problem in multi robotic system
5. Discuss various application of service and industrial autonomous robotic system.

Module:1	Introduction	6 hours

Tele-operated Robot – Master and slave - Autonomous Robot - Components of autonomous robotic system – challenges in autonomous robot – redundant manipulator – types of autonomous robotic system.

Module:2	Locomotion	6 hours

Types of locomotion – Key issues in locomotion –Wheeled mobile robot – types of wheel – wheel stability – wheel configurations - biomimetic locomotion

Module:3	Kinematics	7 hours

Hilare mobile robot – car-link mobile robot – Degree of mobility- Instantaneous Center of Rotation

Module:4	Perception	6 hours

Dead Reckoning- Heading Sensors- Ground-Based RF Beacons and GPS, Sensors for Map-Based Positioning- Odometry- Active Beacon Navigation Systems- Landmark, Sizing and Torque Calculations.

Module:5	Localization	7 hours

Self-localizations and mapping - Challenges in localizations – IR based localizations – vision based localizations – Ultrasonic based localizations -Map representation and Map building- Map based localization scheme – other localization systems

Module:6	Planning, Navigation and Collaborative Robots	7 hours

Introduction – Competences for Navigation: Planning and Reacting: Path planning: Road map, Cell decomposition , Potential field – Obstacle avoidance: Bug algorithm – A*algorithm - Vector field histogram – Dynamic window approach - Navigation Architectures

Module:7	Multi robots and its application	4 hours

Leader based multi robot system – leader less mobile robot system - task allocation – fault tolerance – swarm robotics. Applications - Military mobile robots – Underwater robots – Service robot – Surveillance robots – Nano robots – Case study.

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

Text Book(s)

1.	Roland Siegwart, Illah Reza Nourbakhsh, Davidescaramuzza: Introduction to Autonomous Mobile Robots, (2011). The MIT Press. ISBN: 9780262015356.

Reference Books

1.	FarbodFahimi, Autonomous Robots Modeling, Path Planning and control, (2009), Springer. ISBN: 9780387095370.
2.	Bruno Siciliano, OussamaKhatib, Handbook of Robotics 2ndedition, (2016), Springer. ISBN: 9783319325507.
3.	Shuzhi Sam Ge, Autonomous Mobile Robots: Sensing, Control, Decision making and Applications (2006), CRC Press, Taylor and Francis Group.
4.	Jitendra R. Rao, Ajith K. Gopal, Mobile Intelligent Autonomous Systems, (2012), CRC Press, Taylor and Francis Group. ISBN: 9781439863008.
5.	Krzysztof Kozlowski, Robot Motion and Control, (2012), Springer. ISBN: 9781447123422.

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA603L	MEMS and Microsystems	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The Objectives of the course are to:

1. Understanding the concept of MEMS and Microsystems.
2. Analyzing the diverse technological and functional approaches
3. Provide an insight on micro sensors, actuators and micro fluidics

Course Outcome :

On completion of this course student should be able to:

1. Demonstrate the micro fabrication techniques
2. Assess whether using a MEMS based solution is the relevant and best approach
3. Select the most suitable manufacturing process, actuators, sensors and strategies for micro fabrication
4. Develop the knowledge on general properties of Microfluidics and physics involved in liquid flow
5. Design & analyze the microfabrication techniques in Bio electro mechanical systems and Optical MEMs Fluid structure interaction in Microflow devices

Module:1	**Introduction to MEMS and micro system design**	**6 hours**

MEMS and micro system definition, Material Properties, Structural behavior, Fabrication technologies.

Module:2	**Sensors used in MEMs and microsystems**	**6 hours**

Different types of sensors used for MEMS and microsystems, sensing methods, signal transduction, feedback systems.

Module:3	**Micro actuators**	**6 hours**

Basic principles and working of micro-actuators-Thermal actuators-SMA actuators-Piezo-electric Actuators-Electrostatic actuators-micro grippers-micro motors.

Module:4	**Micro fluidics**	**6 hours**

Fluid flow ,micro scale transport, different components of a micro fluidic system

Module:5	**Design aspects of MEMs and microsystems**	**7 hours**

Design of micro accelerometers-vibration control of a plate –part of a micro system)-Micro mirror design -Micro dispenser design.

Module:6	**Bio electro mechanical systems**	**7 hours**

Bio-MEMS and micro systems, –examples of micro systems in biology-lab-on-a chip-Diagnostics at the micro scale with examples.

Module:7	**Optical MEMs and micro systems**	**5 hours**

Micro opto-electronic devices, micro optical switches, micro optical arrays in solar panel**s**

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

Text Book(s)

1. Stephen D.Senturia, Microsystem Design (2007), Springer Science.

Reference Books			
1.	James J. Allen, Micro Electro Mechanical System Design (2005), CRC Press, Taylor & Francis Group.		
2.	Jacopo Iannacci, Practical Guide to RF-MEMS (2013), John Wiley & Sons Ltd.		
3.	MinhangBao, Analysis and Design Principles of MEMS devices (2005), Elsevier.		
4.	Marc J. Madou, Fundamentals of Microfabrication and Nanotechnology, (2011), CRC		
5.	Tai-Ran Hsui, MEMS & Microsystems: Design, Manufacture and Nano scale Engineering (2008), John Wiley and Sons Ltd.		
6.	V. Choudhary, K. Iniewski, MEMS: Fundamental Technology and Applications, CRC Press, (2017).		
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA604L	Data Acquisition and Digital Signal Processing	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

1. To understand the mathematical representations of continuous time, discrete time and digital representations.
2. To analyse Discrete time systems using Z - transform.
3. To design and implement IIR filters and FIR filters
4. To obtain knowledge and ability to use the appropriate tools like digital signal processors to build DSP systems for real time problems.

Course Outcome :

On the completion of this course the student will be able to:

1. Understand the continuous time, discrete time and digital representations and its limitations.
2. Understand the Z transform and analyze the System response.
3. Design and implement IIR filtering operations with the real time constraints.
4. Design a FIR filter for specific digital signal applications.
5. Understanding the DAQ Hardware and Software requirements and its implementations.
6. Applications of Signal processing techniques to speech signals.
7. Identify the techniques, skills and modern technical tools necessary for engineering practice to design and simulate a DSP systems.

Module:1	**Discrete Systems and Signals**	**4 hours**

Systems and Signals – classification –continuous and discrete systems – Analog to digital and Digital to analogconvertors

Module:2	**Data Acquisition systems:**	**5 hours**

Basics of DAQ Hardware and Software –Concepts of Data Acquisition and terminology

Module:3	**DAQ system Implementation**	**6 hours**

Installing Hardware, Installing drivers -Configuring the Hardware – addressing the hardware Digital and AnalogI/O function – Buffered I/O – Real time Data Acquisition.

Module:4	**Discretization of signals**	**8 hours**

Introduction to Digitizing Analog Signals, Z-Transformation- Fast Fourier transform; Aliasing; Quantization noise;Thermal noise.

Module:5	**Filter Design**	**9 hours**

Multiple band optimal FIR filters – design of filters withsimultaneous constraints in time and frequency response – Optimizationmethods for designing IIR filters, comparison of optimum FIR filter.

Module:6	**Signal Processing Hardware**	**6 hours**

Multipliers, dividers, different forms of FIRHardware, De-multiplexing and multiplexing, realization of frequencysynthesizer.

Module:7	**Applications of DSP**	**5 hours**

Speech: Model of speech production, speech analysis – synthesis system analyzers and

synthesizers, linear prediction of speech				
Module:8	**Contemporary Issues**			**2 hours**
			Total Lecture hours:	**45 hours**
Text Book(s)				
1.	Patrick H. Garrett, Advanced Instrumentation and Computer I/O Design: Defined Accuracy Decision			
2.	Control and Process Applications (2013), 2nd edition, Wiley. John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing (2007), 3rd edition Prentice Hall.			
Reference Books				
1.	John Park and Steve Mackay, Practical Data Acquisition for Instrumentation and Control Systems(2006), Elsevier			
2.	S. Gupta and J P Gupta, Data Acquisition and Process Control (1994), Instrument Society of America			
3.	Dimitris G. Manolakis, Vinay K. Ingle, Stephen M. Kogon, Statistical and Adaptive Signal Processing(2005) Artech House, Inc.			
4.	S.K.Mitra, Digital Signal Processing (2006), 3rd edition, Tata Mc-graw Hill			
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT				
Recommended by Board of Studies		27-07-2022		
Approved by Academic Council		No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA605L	Embedded Systems	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

1. To give an emphasis on the characteristics and hardware architecture of embedded system and real time operating systems.
2. To provide essential knowledge on various steps involved in executing a higher level language and development of required software.
3. To provide the essential knowledge in the operating systems and design methodologies for embedded system development.

Course Outcome :

On the completion of this course the student will be able to:

1. Understand the characteristics and concepts of embedded system.
2. Understand the architecture of hardware embedded system
3. Interpret the bus protocols involved in interfacing with memory blocks.
4. Understand the steps of embedded system programming.
5. Compare the concepts of RTOS with general purpose OS.
6. Design hardware components/architecture for embedded system applications.
7. Design a component or a product applying all the relevant standards with realistic constraints in practical case studies.

Module:1	Introduction to Embedded Systems	3 hours

Definition, history and applications of Embedded System - Concept of Real time Systems - Embedded System Design - Design Process - Quality Attributes.

Module:2	Embedded System Architecture	7 hours

Instruction Set Architecture - CISC and RISC instruction set architecture - Basic Embedded Processor/Microcontroller Architecture - DSP Processors – Harvard Architecture - Memory System Architecture - I/0 Sub-system – Coprocessors and Hardware Accelerators - Processor Performance Enhancement

Module:3	Designing Embedded Computing Platform	7 hours

Bus Protocols – Bus Organization - Memory Devices and their Characteristics –RAM, ROM, UVROM, EEPROM, Flash Memory, DRAM - I/O Devices – Component Interfacing – Memory and I/O device Interfacing

Module:4	Programming Embedded Systems	7 hours

Program Design - Design Patterns for Embedded Systems - Programming Languages - Desired Language Characteristics - Object Oriented Programming - Use of High Level Languages - Compiling, Assembling, Linking, Debugging - Program Validation and Testing.

Module:5	Operating System	7 hours

Basic Features of an Operating System - Kernel Features - Real-time Kernels - Processes and Threads - Context Switching –Scheduling - Inter-process Communication - Real-time Memory Management.

Module:6	Embedded System Development	7 hours

Design Methodologies – Requirement Analysis and Use case Modeling - Static Modeling - Object and Class Structuring - Dynamic Modeling - Architectural Design - Hardware-Software Partitioning - Hardware-software Integration - Fault-tolerance Techniques - Reliability Evaluation Techniques

Module:7	**Case Studies**	**5 hours**
Design examples of embedded systems such as Inkjet Printer, Set-top Box, Elevator Control System, Automated Teller Machine (ATM) system.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Wayne Wolf, Computers as Components – Principles of Embedded Computing System Design, (2009), Morgan Kaufmann Publishers.
Reference Books	
1.	Ball S.R., Embedded microprocessor Systems – Real World Design, (2002), 3rd Ed, Newness, Elsevier Science
2.	C.M. Krishna, Kang G. Shin, Real Time systems, (2009), McGraw Hill
3.	Frank Vahid, Tony Givagis, Embedded System Design. (2009), Wiley Edition.

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA606L	Autotronics and Vehicle Intelligence	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The Objectives of the course are to:

1. Understand the automotive electronics
2. Introduce the different vehicle systems
3. Study the importance of vehicle intelligence system

Course Outcome :

On completion of this course student should be able to:

1. Comprehensive fundamental and technical knowledge of sensors and transducers used in auto vehicles and vehicle intelligence.
2. Ability to understand, analyze and use various SI and CI Management systems
3. Ability to use numerical coding for system modelling and simulation
4. Selection of automotive sensors and actuators for a specific application
5. Designing a suitable controller for energy management in electric and hybrid vehicles
6. Acquire Knowledge on several intelligent vehicle system and safety systems

Module:1	Automotive Fundamentals	6 hours

Engine Components – Drive train – suspension system, ABS, Steering System

Module:2	Fuel Supply System	6 hours

Fuel Injection system - components, electronic fuel injection –Throttle body versus Port Injection - MPFI- CRDI. Fuel Ignition System – Electronic ignition system – operation – types – Battery, magneto ignition systems – Electronic spark timing control

Module:3	Automotive Sensors	6 hours

Knock sensors, oxygen sensors, crankshaft angular position sensor, temperature sensor, speed sensor, Pressure sensor, Mass air flow sensor, Manifold Absolute Pressure Sensors, crash sensor, Coolant level sensors, Brake fluid level sensors – operation, types, characteristics, advantage and their applications

Module:4	Engine Management system	6 hours

On-board diagnostics, Exhaust emission control, Catalytic Converters, New Developments in engine management, adaptive Cruise control

Module:5	Control of Electric and hybrid vehicles	6 hours

Electric Vehicle - batteries electric motor and controller, regenerative braking – Control of hybrid vehicles – CNG electric hybrid vehicle – Hybrid Vehicle case studies

Module:6	Automotive Safety Sensor applications	6 hours

Automatic Rain sensing/wiper activation system, drowsy-driver sensing system, Active Safety Sensor systems, Passive Sensor Safety system - Side Impact Sensing, front impact sensing system.

Module:7	Intelligent Vehicle System	7 hours

MEMS and Microsystems.Vision based autonomous road vehicles, Object detection, Collision warning and avoidance system – Tyre pressure warning system, security systems, Emergency Electronic braking. Intelligent Vehicle Systems – Unmanned ground vehicles, Vehicle Platooning.

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

Text Book(s)	
1.	William B.Ribben, Understanding Automotive Electronic: An Engineering Perspective (2012), Elsevier Science.
Reference Books	
1.	Tom Denton, Automobile Electrical and Electronic systems (2013), Rouletedge, Taylor & Francis Group.
2.	Tom Denton, Automobile Mechanical and Electrical Systems (2011), Taylor & Francis Group
3.	Gianfranco Pistoia, Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market (2010), Elsevier.
4.	Ronald K.Jurgen, Electric and Hybrid-electric vehicles (2011), SAE International.

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA607L	Intelligent Systems	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The Objectives of the course are to:

1. Acquire knowledge about different searching techniques and definitions
2. Study the concept of representing knowledge of ANN architecture, fuzzy logic and genetic algorithm

Course Outcome :

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

1. Explain the characteristics of AI systems with different searching techniques and algorithms
2. Design a simple AI system
3. Demonstrate the Genetic algorithms programming
4. Apply Hybrid techniques for Industrial Applications of intelligent systems
5. Evaluate the applications of types of AI algorithms for real time industrial applications

Module:1	**Fuzzy set theory and fuzzy logic system**	**6 hours**

Basic concepts in Fuzzy Set theory – Operations of Fuzzy sets – Fuzzy relational equations –Fuzzy inference – Fuzzification – Defuzzification –Decision making logic – Membership functions – Rule base

Module:2	**Adaptive fuzzy systems**	**6 hours**

Performance index – Modification of rule base – Modification of member ship functions – simultaneous modification of rule base and membership functions

Module:3	**Introduction to artificial neural networks**	**7 hours**

Fundamentals of Neural networks – Neural network architectures – Learning methods– multilayer perceptrons -Back propagation algorithm and its variants – Different types of learning

Module:4	**Mapping and recurrent networks**	**7 hours**

Counter propagation – Cognitron and Neocognitron - Hopfield Net- Kohonnen Nets- Grossberg Nets- Adaptive Resonance Theory.

Module:5	**Genetic algorithms**	**6 hours**

Introduction to genetic algorithm –initialization, selection, mutation and termination-classification of genetic programming

Module:6	**Hybrid Techniques**	**7 hours**

Neuro-fuzzy systems – genetic neuro systems – genetic fuzzysystems. **Probabilistic techniques:** Tree search – Monte-carlo techniques – Radial basis function – Gaussian – Probabilistic neural networks

Module:7	**Industrial Applications of intelligent systems**	**4 hours**

Application of fuzzy logic, Neural network and Genetic algorithm in Mechatronics application.

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

Text Book(s)			
1.	Timothy J.Ross, Fuzzy Logic with Engineering Applications (2016), Wiley 4th edition.		
Reference Books			
1.	David E. Goldberg, Genetic Algorithm in Search Optimization and Machine Learning (2013), Pearson Education.		
2.	Rajasekaran, S., VijayalakshmiPai, G.A., Neural networks, Fuzzy logic and Genetic algorithms (2011), Prentice Hall of India.		
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA608L	Wireless Sensor Networks	2	1	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The Objectives of the course are to:

1. Introduce the characteristics, basic concepts and systems issues in Wireless sensor networks
2. Illustrate architecture and protocols in wireless sensor networks
3. Identify the trends and latest development of the technologies in the area
4. Provide a broad coverage of challenges and latest research results related to the design and management of wireless sensor networks

Course Outcome:

After successfully completing the course the student should be able to:

1. Design the sensor networks for various application setups.
2. Demonstrate the design space and conduct trade-off analysis between performance and resources.
3. Identify the suitable medium access protocols and radio hardware.
4. Design and analysis of energy efficiency and power control in WSN
5. Explain the Operating system and Sensor Network Platforms And Tools

Module:1	Introduction to Wireless Sensor Networks	4 hours

Introduction, Applications of Wireless Sensor Networks, WSN Standards, IEEE 802.15.4, Zigbee. Network Architectures and Protocol Stack – Network architectures for WSN, classification of WSN, protocol stack for WSN.

Module:2	Wireless Transmission Technology and Systems	4 hours

Radio Technology, Available Wireless Technologies Wireless Sensor Technology Sensor Node Technology, Hardware and Software, Sensor Taxonomy, WN Operating Environment

Module:3	Medium Access Control Protocols for Wireless Sensor Networks	4 hours

Fundamentals of MAC Protocols, MAC Protocols for WSNs, Contention-Based protocols: Power Aware Multi-Access with Signaling - Data-Gathering MAC, Contention-Free Protocols: Low Energy Adaptive Clustering Hierarchy, B-MAC, S-MAC. Dissemination Protocol for Large Sensor Network.

Module:4	Deployment and Configuration	4 hours

Target tracking, Localization and Positioning, Coverage and Connectivity, Single-hop and Multi-hop Localization, Self-Configuring Localization Systems.
Routing Challenges and Design Issues in Wireless Sensor Networks, Routing Strategies in Wireless Sensor Networks, Routing protocols: data centric, hierarchical, location based energy efficient routing etc. Querying, Data Dissemination and Gathering.

Module:5	Energy Efficiency and Power control	4 hours

Need for energy efficiency and power control in WSN, passive power conservation mechanisms, active power conservation mechanisms

Module:6	Operating Systems For Wireless Sensor Networks	4 hours

Operating System Design Issues, TinyOS, Contiki – Task management, Protothreads, Memory and IO management.

Module:7	**Sensor Network Platforms And Tools**	**4 hours**
Sensor Node Hardware – Tmote, Micaz, Programming Challenges, Node-level Software Platforms, Node-level Simulators, State-centric Programming		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**
	Total Tutorial hours:	**15 hours**

Text Book(s)	
1.	KazemSohraby, Daniel Minoli, TaiebZnati, “Wireless Sensor Networks, Technology, Protocols and Applications”, Wiley, 2007
Reference Books	
1.	Holger Karl, Andreas Willig, “Protocols And Architectures for Wireless Sensor Networks”, John Wiley, 2005
2.	Jun Zheng, Abbas Jamalipour, “Wireless Sensor Networks: A Networking Perspective”, Wiley, 2009.
3.	Ian F. Akyildiz, Mehmet Can Vuran, “Wireless Sensor Networks”, Wiley, 2010
4.	Ibrahiem M. M. El Emary, S. Ramakrishnan, “Wireless Sensor Networks: From Theory to Applications”, CRC Press Taylor & Francis Group, 2013

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA609L	Virtual Reality and Haptics	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The Objectives of the course are to:

1. Provide an overview of the opportunities and the main issues related to designing and developing VR/AR systems architectures, both in local and in distributed (even web-based) contexts, and to the development of VR/AR applications with a multimodal perspective and approach.
2. Demonstrate the principles and multidisciplinary features of virtual reality.
3. Understand the technology for multimodal user interaction and perception in VR, in particular the visual, audial and haptic interface and behavior.
4. Demonstrate the VR system framework and development tools.
5. Study the human touch perception and Tactile Proprioception.
6. Discuss the haptic components and virtual models.
7. Analyse the significance of knowledge on haptic and augmented reality.

Course Outcome :

On completion of this course student should be able to:

1. Identify, examine, and develop software that reflects fundamental techniques for the design and deployment of VR experiences.
2. Describe how VR systems work using modern technology.
3. Choose, develop, explain, and defend the use of particular designs for VR experiences.
4. Evaluate the benefits and drawbacks of specific VR techniques on the human body.
5. Identify and examine state-of-the-art VR design problems and solutions from the industry and academia.
6. Design and control haptic devices and learn the salient properties of human touch perception that are necessary to be recreated in virtual environments.
7. Demonstrate the use of modeling software that used in the haptic device development.

Module:1	Introduction to Virtual reality	6 hours

Virtual reality concepts – virtual world and real world – Interface to virtual world (inputs and outputs) – Types of interaction – Applications.

Module:2	Haptics	6 hours

Definition - Importance of Touch - Tactile Proprioception - Tactual Stereo genesis - Kinesthetic Interfaces - Tactile Interfaces - Human Haptics - Overview of existing applications.

Module:3	Design of Haptic devices	6 hours

Virtual Reality Input and Virtual Reality Output parameters - Computing Architectures for VR - Haptic assembly architecture - Haptic Interface Design – Kinesthetic devices.

Module:4	Kinematics and dynamics	6 hours

Homogeneous Transformation Matrices - Transformation Invariants - Force Computation - Force Smoothing and Mapping

Module:5	Geometric Modeling	7 hours

Virtual Object Shape - Object Visual Appearance – Position - Object Hierarchies - Physical Modeling: Collision Detection, Surface Deformation, Haptic Texturing.

Module:6	**Virtual Reality Programming**	**6 hours**
Human Factors in Virtual Reality, Programming Haptic Virtual Environments, calibration.		
Module:7	**Teleoperation**	**6 hours**
Implementation and Transparency, Traditional Applications and Emerging Applications of VR – Master and slave mechanism		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	John vince, Essential Virtual Reality Fast (2012), Springer.

Reference Books

1.	GrigoreBurdea, Philippe Coiffet, Virtual Reality Technology (2006), 2nd edition. Wiley India.
2.	John vince, Virtual Reality Systems (2007), Pearson Education.
3.	MatjazMihelj, Jonezpodobnik, Haptics for virtual reality and tele operation (2012), Springer.
4.	B. Hannaford, A. M. Okamura, Handbook of Robotics (2008), Springer

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA610L	Condition Monitoring Techniques	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives :

The Objectives of the course are:

1. Understand the basics of various condition monitoring methods
2. Identify the selection of condition monitoring techniques for various applications.
3. Provide a basic understanding with case studies on different fault diagnosis method.

Course Outcome :

On completion of this course student should be able to:

1. Demonstrate the basic knowledge about various condition monitoring methods in accordance with the established procedures.
2. Explain the different types of sensor design and its application
3. Assess the signal processing methods and its working principles in time and frequency domain
4. Understand the basic knowledge of surface, subsurface and deeper surface NDE techniques which enables to carry out various inspection in accordance with the established procedures.
5. Demonstrate the various types of machine learning algorithms application in condition monitoring methods

Module:1	**Condition monitoring techniques**	**6 hours**

Condition Monitoring in manufacturing industries; Noise monitoring, Wear and debris Analysis, Thermography, Cracks monitoring, Ultrasonic techniques - Case studies.

Module:2	**Sensors for condition monitoring**	**6 hours**

Accelerometers, strain gauges, eddy current probes, LVDT for measurement of displacement, velocity and acceleration; Temperature transducers, radiation pyrometers and thermal imaging devices.

Module:3	**Signal processing**	**6 hours**

Study of periodic and random signals, probability distribution, statistical properties, auto and cross correlation and power spectral density functions.

Module:4	**Signal Analysis**	**6 hours**

Time domain and Frequency domain and Time-frequency domain analysis.

Module:5	**Failure Analysis and Maintenance**	**6 hours**

Maintenance Principles, Failure mode analysis - Equipment down time analysis - Breakdown analysis - condition based maintenance.

Module:6	**Machine Condition monitoring**	**6 hours**

Vibration, Acoustic emission and vibro-acoustics signal analysis; intelligent fault detection system, Case studies.

Module:7	**Machine Learning**	**7 hours**

Vibration, Acoustic emission and vibro-acoustics signal analysis; intelligent fault detection system, Case studies.

Module:8	**Contemporary Issues**	**2 hours**

Total Lecture hours:			**45 hours**
Text Book(s)			
1.	EthemAlpaydin, Introduction to Machine Learning (2010), The MIT Press, Cambridge, London.		
Reference Books			
1.	K. P. Soman, Data mining theory and practice (2006), Prentice-Hall of India.		
2.	Amiya RanjanMohanty , Machinery Condition Monitoring: Principles and Practices (2015), CRC Press		
3.	Mishra, R.C., Pathak, K., Maintenance Engineering and Management (2012), Prentice Hall of India.		
4.	Clarence W. De Silva, Sensors and Actuators: Control System Instrumentation (2007), CRC Press – Taylor and Francis Group.		
5.	BoualemBoashash, Time Frequency Signal Analysis and Processing: A Comprehensive Reference (2015), Elsevier.		
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA611L	Bio-Mechatronics	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The Objectives of the course are to:

1. Learn basic knowledge about Bio mechanics, Bio sensors and actuators, and bio-mechatronics devices.
2. Impart the bio assist devices.
3. Know the different types, bio imaging and processing.
4. Understand about bio mechatronics devices and their functions.

Course Outcome :

On completion of this course student should be able to:

1. Demonstrate the basic knowledge about the Bio mechanics, Bio sensors and actuators, and bio- mechatronics devices.
2. Acquire the different bio imaging and processing.
3. Analyze the Signal processing with bio sensors and actuators.
4. Analyze modern medical measurement devices.
5. Understand the properties of bio assist devices.
6. Understand modern bio-mechatronics devices and its requirements.

Module:1	**Bio Mechanics**	**6 hours**

Cardiovascular biomechanics, Musculoskeletal and orthopedic biomechanics, human ergonomic, Rehabilitation.

Module:2	**Bio Sensors and Actuators**	**6 hours**

Introduction to Bio mechatronics,Electrodes - Types, - Measurement of blood pressure - Blood Gas analyzers: pH of blood,Smart actuators for biological applications

Module:3	**Medical Measurements**	**6 hours**

Heart rate - Heart sound -Pulmonary function measurements -spirometer -finger-tip oximeter - ESR, GSR measurements

Module:4	**Signal Processing**	**7 hours**

Bio-medical signals, Signal acquisition and signal processing-Isolation barriers, Bio-Image processing

Module:5	**Sensory Assist Devices**	**6 hours**

Hearing aids – Implants, Optical Prosthetics, VisualNeuroprostheses – Sonar based systems, Respiratory aids, Tactile devices for visually challenged.

Module:6	**Active and Passive Prosthetic Limbs**	**7 hours**

Introduction to prosthetics,Passive Prosthetics – walking dynamics, Knee and foot prosthesis. Active prosthesis - Control of Prosthetic Arms and Hands, Leg Mechanisms, Ankle–Foot Mechanisms, Prosthesis Suspension

Module:7	**Wearable mechatronics devices**	**5 hours**

Wearable Artificial Kidney, Wireless capsule endoscope, Wearable Exoskeletal rehabilitation system, Wearable hand rehabilitation,

Module:8	**Contemporary Issues**	**2 hours**

		Total Lecture hours:	**45 hours**
Text Book(s)			
1.	Graham M. Brooker, "Introduction to Bio-Mechatronics", Sci Tech Publishing, 2012.		
Reference Books			
1.	Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, "Bio-Medical Instrumentation and Measurements", II edition, Pearson Education, 2009.		
2.	Raymond Tong Kaiyu . "Bio-mechatronics in Medicine and Healthcare" Pan Stanford Publishing, CRC Press, 2011.		
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA612L	Internet of Things and Smart Manufacturing	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The Objectives of the course are to:

1. Understand our MES environment in the context of the ISA95 standards.
2. Introduces the concepts of Industrial Internet of Things, and Cloud Computing. The students are exposed to the architectures, and various frameworks in IIoT and Cloud Computing
3. Provide an insight into the application of cloud computing in manufacturing, enabling high level integration of product development phases. It gives an idea about different tools and methodologies used for cloud based product management
4. Designed to offer learners an introduction to Industry 4.0 (or the Industrial Internet), its applications in the business world. Learners will gain deep insights into how smartness is being harnessed from data and appreciate what needs to be done in order to overcome some of the challenges.
5. Implement Virtualization.

Course Outcome :

On completion of this course student should be able to:

1. Analyze manufacturing operations and determine the lines of responsibility and technical integration between operations and logistics systems.
2. Apply the cloud concepts in a sustainable and global product development.
3. Understand the concept of cloud based distributed environment for collaborative manufacturing.
4. Understand the opportunities, challenges brought about by Industry 4.0 and how organizations and individuals should prepare to reap the benefits.
5. Able to outline the various systems used in a manufacturing plant and their role in an Industry 4.0 world.
6. Implement a prototype of the IoT/cloud system design.
7. Appreciate the smartness in Smart Factories, Smart cities, smart products and smart services.industrial controllers

Module:1	**Introduction**	**6 hours**

Concept of Internet of Things (IoT), common definitions, IoT applications, and functional view.

Module:2	**Internet of Things and Internet Technology**	**6 hours**

Cloud Computing, Semantic Technologies, Networking and Communication Technologies.

Module:3	**Contemporary Manufacturing Paradigms**	**6 hours**

Concept of Agile, Networked, Reconfigurable and Cloud manufacturing.

Module:4	**IoT Enabled Manufacturing System**	**6 hours**

Architecture of IoT-MS, Integration framework of Real-time manufacturing information, Work logic of IoT-MS.

Module:5	**Cloud based Manufacturing Resource configuration**	**6 hours**

Concept of cloud manufacturing,Real-time production information perception and capturing, Cloud service selection, Cloud Machine model.

Module:6	**Smart Factory and Smart Manufacturing**	**7 hours**

Concepts of Industry 4.0 standard, Real-time information based scheduling, capacity planning, material planning, Real-time production monitoring techniques with smart sensors, Configuration of smart shop floor, traceability and call back of defective products		
Module:7	**Case Studies**	**6 hours**
Case studies on applications of IoT in different industrial progressions like virtual visibility maturity model etc.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Yingfeng Zhang, Fei Tao, Optimization of Manufacturing Systems using the Internet of Things, Academic Press- Technology & Engineering, 2016.

Reference Books

1.	Jiafu Wan, IztokHumar, Daqiang Zhang, Industrial IoT Technologies and Applications, Springer, 17-Aug-2016.
2.	K. Wang, Y. Wang, J.O. Strandhagen, T. Yu, Advanced Manufacturing and Automation V, WIT Press, 2016
3.	OvidiuVermesan and Peter Friess, Internet of Things – From Research and Innovation to Market Deployment, River Publishers, 2014.

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA613L	Manufacturing Automation	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The Objectives of the course are to:

1. Impart the fundamentals of automation strategy in manufacturing.
2. Prepare computer aided process planning and CNC part programming for engineering components.
3. Critique on manufacturing support systems and outline intelligent and digital manufacturing.

Course Outcome :

Upon completion of this course, the student will be able to:

1. Outline the concept of automation and assess the degree of automation
2. Prepare process planning for industrial components for production
3. Outline CNC technology for computer aided manufacturing and prepare the Mobile and Autonomous RoboticsCNC codes for part programming.
4. Select the material handling / storage systems and automated inspection systems.
5. Use manufacturing support systems for productivity improvement.
6. Critique on intelligent manufacturing system and digital enterprises.

Module:1	Automation	5 hours

Introduction, automation principles and strategies, basic elements of advanced functions, levels modeling of manufacturing systems

Module:2	Computer Aided Process Planning	6 hours

Computer Aided process planning, Generative, variant, hybrid CAPP, Material requirement planning (MRP), Manufacturing resource planning (MRP II), production planning and control system, master production schedule, Capacity planning, Shop floor control.

Module:3	Computer Aided Manufacturing	6 hours

Group Technology, Part family, Sensor technologies, Automated inspection and testing, Coordinate measuring machines, Machine vision, Rapid prototyping.

Module:4	Automated handling and storage system	7 hours

Automated material handling systems – AGV, Transfer mechanism - Buffer storage – Analysis of transfer lines, Robots in material handling, Automated storage and Retrieval Systems (AS/RS) – carousel storage – Automatic data capture – bar code technology, Automated assembly systems.

Module:5	Modeling and Simulation for Manufacturing Plant Automation	7 hours

Introduction/ need for system Modeling, Building Mathematical Model of a manufacturing plant, Modern Tools- Use of Fuzzy decision making and Artificial Neural Networks in manufacturing automation, AI in manufacturing systems

Module:6	Manufacturing support Systems	6 hours

Flexible manufacturing, Building blocks of FMS, FMS layout, FMS planning and implementation issues, Just-in-Time Manufacturing, lean manufacturing, agile manufacturing, Cellular manufacturing,

Module:7	Intelligent Manufacturing Systems	6 hours

Artificial Intelligence based systems, Knowledge - Based Systems, Expert Systems Technology, Agent Based Technology, Virtual Business, e-Commerce Technologies, Global Manufacturing Networks, Digital enterprise technologies. Introduction to PLM.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**
Text Book(s)		
1.	Mikell P. Grover, Automation, Production Systems and Computer Integrated Manufacturing (2016), Fourth Edition, Pearson Education.	
Reference Books		
1.	P. Radhakrishnan, S. Subramanyan, V. Raju, CAD/CAM/CIM (2011), New age International.	
2.	Mikell P. Grover, Enory W. Jr Zimmers, CAD/CAM (2006), Pearson Education.	
3.	P. N. Rao, CAD/CAM: Principles and Applications (2010), Tata Mc Graw Hill.	
4.	Tien-Chein Chang, Richard A. Wysk, Hsu-Pin (Ben) Wang, Computer Aided Manufacturing (2009), Pearson Education.	
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT		
Recommended by Board of Studies	27-07-2022	
Approved by Academic Council	No.67	Date 08-08-2022

Course Code	Course Title	L	T	P	C
MMHA613P	Manufacturing Automation Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The Objectives of the course are to:

1. Impart the fundamentals of automation strategy in manufacturing.
2. Prepare computer aided process planning and CNC part programming for engineering components.
3. Critique on manufacturing support systems and outline intelligent and digital manufacturing.

Course Outcome

Upon completion of this course, the student will be able to:

1. Outline the concept of automation and assess the degree of automation
2. Prepare process planning for industrial components for production
3. Outline CNC technology for computer aided manufacturing and prepare the Mobile and Autonomous RoboticsCNC codes for part programming.
4. Select the material handling / storage systems and automated inspection systems.
5. Use manufacturing support systems for productivity improvement.
6. Critique on intelligent manufacturing system and digital enterprises.

Indicative Experiments	
1.	CNC part Programming – Step Turning, taper turning, thread cutting, grooving, linear and circular interpolation through canned cycle programming.
2.	CNC part Programming – Mirroring and pocket milling
3.	CNC part program generation using 3D model.
4.	Develop an automated production system simulation for a casting industry using simulation package.
5.	Design an assembly sequence for a bearing assembly unit using assembly simulation package.
6.	Simulate and analyze any one material handling system using material flow simulation
	Total Laboratory Hours **30 hours**

Text Book(s)

1.	Mikell P. Grover, Automation, Production Systems and Computer Integrated Manufacturing (2016), Fourth Edition, Pearson Education.

Reference Books

1.	P. Radhakrishnan, S. Subramanyan, V. Raju, CAD/CAM/CIM (2011), New age International.
2.	Mikell P. Grover, Enory W. Jr Zimmers, CAD/CAM (2006), Pearson Education.
3.	P. N. Rao, CAD/CAM: Principles and Applications (2010), Tata Mc Graw Hill.
4.	Tien-Chein Chang, Richard A. Wysk, Hsu-Pin (Ben) Wang, Computer Aided Manufacturing (2009), Pearson Education.

Mode of Assessment: Continuous Assessment and Final Assessment Test			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA614L	Fluid Power System Design	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The Objectives of the course are to:

1. Provide comprehensive introduction to fluid power system design including both hydraulics and pneumatics.
2. Acquire the knowledge on the fundamental elements of fluid power and properties of fluid,
3. Understand fluid power and differentiate hydraulic and pneumatic systems for their application in industry

Course Outcome :

On completion of this course the students will be able to

1. Understand the fundamental principles and analytical modeling of fluid power components and its symbols, circuits, and systems.
2. Acquire knowledge of the applications of fluid power in various engineering fields.
3. Study the benefits and limitations of fluid power compared with other power transmission technologies and Interface PLC with hydraulic and pneumatic systems.
4. Demonstrate the production of compressed air and its distribution.
5. Understand about hydraulics filters and sealers, types of filter elements,- construction and working of filter in hydraulic unit
6. Understand components of hydraulic systems and its advantages
7. Design and analyze the pneumatic system and its advantages in industrial applications.

Module:1	Introduction to Fluid Power	5 hours

Definition- Hydraulics vs Pneumatics – ISO symbols - Application –Pascal's Law- Transmission and multiplication of force - Basic properties of hydraulic fluids - static head pressure-pressure loss – Power - absolute pressure and Temperature - gas laws- vacuum

Module:2	Hydraulic and Pneumatic Power Supply Source	6 hours

Hydraulic Pump - graphic symbol- pump types -pump flow and pressure- pump drive torque and Power- pump efficiency –air compressor- graphic symbol-compressor types - compressor sizing- vacuum pumps

Module:3	Control Elements	8 hours

Directional control valves - Pressure control valves - Flow control Valves -electronic control components - Valve configurations, General valve analysis, valve lap, flow forces and lateral forces on spool valves. Series and parallel pressure compensation flow control valves. Flapper valve Analysis and Design, Time delay valve, Proportional and Servo valves.

Module:4	Circuits	6 hours

DCV controlling single acting, double acting cylinder - Regenerative circuits, high low circuits, Synchronization circuits, and accumulator sizing. Intensifier circuits, Meter-in, Meter-out and Bleed-off circuits; Fail Safe and Counter balancing circuits- pressure intensifier circuit-accumulator circuits - AND and OR valve circuit

Module:5	Design of Circuits	6 hours

Design and analysis of typical hydraulic and pneumatic circuits - Design method consideration for sequential circuits-intuitive circuit design method-cascade method-sequential logic circuit design using KV method- compound circuit design-step counter design

Module:6	**Electro-Hydraulic and Electro-Pneumatic systems**	**7 hours**
Electrical control of pneumatic and hydraulic circuits-use of relays, timers, counters, Programmable logic control of hydraulic and pneumatic circuits, PLC ladder diagram for various circuits, motion controllers, Servo systems – fundamentals. Applications in Assembly, Feeding, Metalworking, materials handling and plastic working.		
Module:7	**Fluid Power System Maintenance**	**5 hours**
Introduction, Sealing Devices - Reservoir System - Filters and Strainers - Beta Ratio of Filters - Wear of Moving Parts - Gases in Hydraulic Fluids - Temperature Control – Troubleshooting		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	James L.Johnson, Introduction to Fluid power(2003), Delmar Thomson Learning Inc.
Reference Books	
1.	James R. Daines, Fluid Power: Hydraulics and Pneumatics (2012), Goodheart-willcox Publishers.
2.	Ahmed Abu Hanieh, Fluid Power Control (2012), Cambridge International Science Publishing Ltd.
3.	Anthony Esposito, Fluid Power with Applications (2010), Pearson Higher Ed.
4.	M GalalRabie, Fluid power engineering (2009), Mc-Graw Hill.

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA614P	Fluid Power System Design Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The Objectives of the course are to:

1. Provide comprehensive introduction to fluid power system design including both hydraulics and pneumatics.
2. Acquire the knowledge on the fundamental elements of fluid power and properties of fluid,
3. Understand fluid power and differentiate hydraulic and pneumatic systems for their application in industry

Course Outcome

On completion of this course the students will be able to

1. Understand the fundamental principles and analytical modeling of fluid power components and its symbols, circuits, and systems.
2. Acquire knowledge of the applications of fluid power in various engineering fields.
3. Study the benefits and limitations of fluid power compared with other power transmission technologies and Interface PLC with hydraulic and pneumatic systems.
4. Demonstrate the production of compressed air and its distribution.
5. Understand about hydraulics filters and sealers, types of filter elements,- construction and working of filter in hydraulic unit
6. Understand components of hydraulic systems and its advantages
7. Design and analyze the pneumatic system and its advantages in industrial applications.

Indicative Experiments	
1.	Single acting and double acting cylinder using DCV
2.	Automatic reciprocation of double acting cylinder
3.	Controlling the hydraulic rotary actuator using electrical push button switch using meter out circuit
4.	Controlling the double acting hydraulic cylinder using electrical push button switch manually
5.	Or gate & AND gate operation using single acting cylinder.
6.	Simulation of basic pneumatic and hydraulic circuits.
7.	Simulation of sequencing circuits.
8.	Simulation of Electro-Hydraulic systems.
9.	Simulation of Electro-pneumatic systems.
10	Simulation of PLC based electro pneumatic sequencing circuits
	Total Laboratory Hours **30 hours**

Text Book(s)

1.	James L.Johnson, Introduction to Fluid power(2003), Delmar Thomson Learning Inc.

Reference Books

1.	James R. Daines, Fluid Power: Hydraulics and Pneumatics (2012), Goodheart-willcox Publishers.
2.	Ahmed Abu Hanieh, Fluid Power Control (2012), Cambridge International Science Publishing Ltd.
3.	Anthony Esposito, Fluid Power with Applications (2010), Pearson Higher Ed.

4.	M GalalRabie, Fluid power engineering (2009), Mc-Graw Hill.		
Mode of Assessment: Continuous Assessment and Final Assessment Test			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA696J	Study Oriented Project				02
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

1. The student will be able to analyse and interpret published literature for information pertaining to niche areas.
2. Scrutinize technical literature and arrive at conclusions.
3. Use insight and creativity for a better understanding of the domain of interest.

Course Outcome:

1. Retrieve, analyse, and interpret published literature/books providing information related to niche areas/focused domains.
2. Examine technical literature, resolve ambiguity, and develop conclusions.
3. Synthesize knowledge and use insight and creativity to better understand the domain of interest.
4. Publish the findings in the peer reviewed journals / National / International Conferences.

Module Content	(Project duration: One semester)

This is oriented towards reading published literature or books related to niche areas or focussed domains under the guidance of a faculty.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Report to be submitted, presentation and project reviews – Presentation in the National / International Conference on Science, Engineering Technology.

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA697J	**Design Project**				**02**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. Students will be able to design a prototype or process or experiments.
2. Describe and demonstrate the techniques and skills necessary for the project.
3. Acquire knowledge and better understanding of design systems.

Course Outcome:

1. Develop new skills and demonstrate the ability to upgrade a prototype to a design prototype or working model or process or experiments.
2. Utilize the techniques, skills, and modern tools necessary for the project.
3. Synthesize knowledge and use insight and creativity to better understand and improve design systems.
4. Publish the findings in the peer reviewed journals / National / International Conferences.

Module Content **(Project duration: One semester)**

Students are expected to develop new skills and demonstrate the ability to develop prototypes to design prototype or working models related to an engineering product or a process.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Report to be submitted, presentation and project reviews – Presentation in the National / International Conference on Science, Engineering Technology.

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA698J	**Internship I/ Dissertation I**				**10**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field and also to give research orientation.

Course Outcome:

1. Considerably more in-depth knowledge of the major subject/field of study, including deeper insight into current research and development work.
2. The capability to use a holistic view to critically, independently and creatively identify, formulate and deal with complex issues.
3. A consciousness of the ethical aspects of research and development work.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

Module Content **(Project duration: one semester)**

1. Dissertation may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Dissertation should be individual work.
3. Carried out inside or outside the university, in any relevant industry or research institution.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

Mode of Evaluation: Assessment on the project - Dissertation report to be submitted, presentation, project reviews and Final Oral Viva Examination.

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMHA699J	**Internship II/ Dissertation II**				**12**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field.

Course Outcome:

Upon successful completion of this course students will be able to

1. Formulate specific problem statements for ill-defined real life problems with reasonable assumptions and constraints.
2. Perform literature search and / or patent search in the area of interest.
3. Conduct experiments / Design and Analysis / solution iterations and document the results.
4. Perform error analysis / benchmarking / costing.
5. Synthesize the results and arrive at scientific conclusions / products / solution.
6. Document the results in the form of technical report / presentation.

Module Content **(Project duration: one semester)**

1. Dissertation may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Dissertation should be individual work.
3. Carried out inside or outside the university, in any relevant industry or research institution.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

Mode of Evaluation: Assessment on the project - Dissertation report to be submitted, presentation, project reviews and Final Oral Viva Examination.

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