Semester- II

Automotive Electronics			
Course Code	**MMTR201**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. Ability to understand the fundamentals of vehicle systems and regulations.
2. Ability to identify various components of a vehicle and explain its functions.
3. Ability to gain fundamental knowledge to develop electronic controls for automotive subsystems.

Module-1

Automotive fundamentals overview – four stroke cycle, engine control, ignition system, spark plug, spark pulse generation, ignition timing, drive train, transmission, brakes, steering system, starting system. Actuators – fuel metering actuators, fuel injector, ignition actuator.

Exhaust After – Treatment System –AIR, catalytic converter, exhaust gas recirculation n (EGR), Evaporative emission systems.

Module-2

Air/ fuel system – fuel handling, air intake system, air/ fuel management **Sensors:** Oxygen (02/EGO) sensors, throttle position sensor (TPS), engine crankshaft angular position (CKP)sensor, magnetic reluctance position sensor, engine speed sensor, ignition timing sensor, hall effect position sensor, shield field sensor, optical crankshaft position sensor, manifold absolute pressure(MAP) sensor-strain gauge and capacitor capsule, Engine coolant temperature(ECT) sensor, intake air temperature (AIT) sensor, knock sensor, airflow rate sensor, throttle angle sensor.

Module-3

Electronic Engine Control – engine parameters, variables, engine performance terms, electronic fuel control system, electronic ignition control, idle speed control, EGR control. Vehicle motion control – cruise control, chassis, power brakes, antilock brake system (ABS), electronic steering control, power steering, traction control, electronically controlled suspension.

Module-4

Communication-serial data, communication systems, protection, body and chassis electrical systems, remote keyless entry, GPS

Automotive Instrumentation– sampling, measurement & signal conversion of various parameters. Radar warning system, low tire pressure warning system, radio navigation, advance driver information system

Module-5

Integrated body- climate control systems, electronic HVAC system, Safety systems- SIR, interior safety, lighting, entertainment systems. Automotive diagnostics – Timing light, engine analyzer, on-board diagnostic off- board diagnostics, expert systems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

(1) "Automobile Electrical and Electronic Systems" Tom Denton, Routledge,5 edition,2017. **Reference Books**

(1) understanding automotive electronics, Willian b. Ribbens, SAMS/Elsevier publishing 6th edition,2002

(2) Automotive electrics automotive electronics systems and components, Robert Bosch Gmbh, john wiley & sons ltd., 5th sedition, 2007

Web links and Video Lectures (e-Resources):

- VTU e-Shikshana Program
- VTU EDUSAT Program

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Obtain an overview of automotive components, subsystems, design cycles, communication protocols and safety systems employed in today's automotive industry.	L2
CO2	Differentiate electronic and mechanical components used in automobile systems	L2
CO3	Apply concept of integration of system components	L2
CO4	Analyse and measure signal conversion parameters	L3
CO5	Obtain an overview of automotive diagnostics	L3

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**2**	**2**	**2**	**3**	**3**	**2**	**2**
CO2	**1**	**1**	**2**	**2**	**3**	**2**	**2**
CO3	**2**	**2**	**2**	**3**	**3**	**2**	**2**
CO4	**3**	**3**	**2**	**3**	**3**	**3**	**2**
CO5	**2**	**2**	**2**	**3**	**3**	**3**	**2**

Signal Processing in Mechatronic Systems			
Course Code	MMTR202	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 : 1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Understand the various aspects of signals and systems.
- Compute the response of discrete-time Linear and Time-Invariant Systems
- Represent the discrete-time signals and systems in frequency domain
- Design analog and digital filters for signal processing.

MODULE-1

Introduction: Signals and Systems-Definition and Examples, Basic Elements of a Digital Signal Processing System, Advantages of Digital Signal Processing over Analog Signal Processing, Classification of Signals, The Concept of Frequency in Continuous-Time and Discrete-Time Signals, Analog to Digital Conversion (Block Diagram Discussion)
Discrete-Time Signals: Elementary Discrete-Time Signals, Classification of Discrete-Time signals, Manipulation of Discrete-time Signals

MODULE-2

Discrete-Time Systems: Input-Output Description of Systems, Block Diagram Representation, Classification of Systems (From Text-1)
Analysis of Discrete-Time Systems: Representation of Discrete-Time Signals using Impulses, Response of LTI Systems-Convolution Sum, Properties of Convolution Sum and Interconnection of LTI systems, Stability and Causality

MODULE-3

Z-Transforms: Definition, Properties, Rational Z-Transforms, Inverse Z-Transforms (Partial Fraction Expansion, Long Division methods), Analysis of LTI systems in Z-domain (Stability and Causality), Relationship between Impulse Response, System Function and Difference Equation Representation

MODULE-4

Design of FIR Filters: Characteristics of practical frequency-selective filters, Design of Linear-phase FIR (low pass and High pass) filters using windows – Rectangular and Hamming windows. Structure for FIR Systems: Direct form, Cascade form

MODULE 5

IIR Filter Design: Infinite Impulse response Filter Format, Bilinear Transformation Design Method, Analog Filters using Low pass prototype transformation, Normalized Butterworth Functions, Bilinear Transformation Design Procedure, Digital Butterworth (Lowpass and Highpass) Filter Design using BLT. Realization of IIR Filters in Direct form I and II, Cascade and Parallel forms

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

3. Two Unit Tests each of **25 Marks**
4. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

6. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
7. The question paper will have ten full questions carrying equal marks.
8. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
9. Each full question will have a sub-question covering all the topics under a module.
10. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Textbooks

(1)John G Proakis and Dimitris G Manolakis, "Digital Signal Processing", Pearson, 4th Edition, 2012

Reference Books:

1. Alan V Oppenheim and Ronald W Schafer, "Discrete Time Signal Processing", Pearson, 3rd Edition, 2014.
2. S Salivahanan, "Digital Signal Processing", Mc Graw Hill Education, 3rd Edition, 2017

Web links and Video Lectures (e-Resources):

https://archive.nptel.ac.in/courses/112/107/112107298/
https://archive.nptel.ac.in/courses/112/103/112103174/
https://archive.nptel.ac.in/courses/108/108/108108109/

Skill Development Activities Suggested

To be conducted using MATLAB or any computational tool:

(i) Generate standard signals and plot them

(ii) Obtain Z-transform of step-sequence, exponential sequence and sinusoidal sequence

(iii) Perform Linear convolution of two sequences and verify commutative, distributive and associative laws

(iv) Design and implementation of IIR (Butterworth) low pass filter to meet given specifications.

(v) Design and implementation of IIR (Butterworth) high pass filter to meet given specifications.

(vi) Design and implementation of low pass FIR filter to meet given specifications.

(vii) Design and implementation of high pass FIR filter to meet given specifications.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Classify the signals.	L2
CO2	Perform operations on discrete-time signals, and classify the systems.	L3
CO3	Compute the response and determine the properties of LTI systems using Z-transforms	L4
CO4	Design FIR and IIR Digital Filters.	L2

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**2**	**3**	**3**	**2**	**3**	**2**	**2**
CO2	**2**	**2**	**3**	**2**	**2**	**2**	**3**
CO3	**3**	**2**	**3**	**2**	**3**	**2**	**2**
CO4	**2**	**2**	**3**	**2**	**2**	**2**	**2**

Semester - II

Micro and Smart Systems			
Course Code	**MMTR203**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab slots	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

- The course aims to develop a detailed knowledge and critical understanding of Smart Systems technologies and the physics of MEMS devices.

MODULE-1

Glimpses of Microsystems: scaling effects, Smart materials and systems: an overview Micro sensor: Micro actuators Microsystems examples, structural health monitoring and vibration control

MODULE-2

Microfabrication processes: Structure of silicon and other materials Silicon wafer processing; Thin-film deposition Lithography, wet etching and dry etching Bulk micromachining and Surface micromachining Wafer-bonding; LIGA and other moulding techniques Soft lithography and polymer processing Thick-film processing; Low temperature co-fired ceramic processing Smart material processing.

MODULE-3

Mechanics of Solids Stresses and deformation: bars and beams Micro device suspensions: lumped modelling Residual stress and stress gradients Poisson effect; Anticlastic curvature; examples of micromechanical structures Vibrations of bars and beams Gyroscopic effect Frequency response; damping; quality factor Basic 10Hrs. micro-flows for damping calculation.

MODULE-4

Types of numerical methods for solving partial differential equations, Weak form; shape functions, Iso parametric formulation and numerical integration, Implementation of the finite element method, FEM for piezoelectric.

MODULE 5

Electronics and packaging: Semiconductor devices: basics, Signal conditioning for microsystems devices, Integration of Microsystems and microelectronics, Packaging of Microsystems: why and how, Flip-chip, ball grid, etc.; reliability, Case studies

PRACTICAL COMPONENT OF IPCC*(May cover all / major modules)*

Sl.NO	Experiments
1	Creating the Piezoresistors
2	Documenting, Cleaning & Oxidation
3	Aluminum Markers
4	Backside Alignment & Si Bulk Etch
5	Aluminum Pads, Debond & Anneal
6	Photolithography & Etching (Vias).
7	Release & Test

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

1. Two Tests each of **25 Marks**
2. Two assignments each of **25 Marks/One Skill Development Activity of 50 marks**
3. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The **15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for **10 marks**. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test at the end /after completion of all the experimentsshall be conducted for **50 marks** and scaled down to **05 marks.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

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SEE for IPCC

Theory SEE will be conducted by the University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

1. The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
2. The question paper will have ten questions. Each question is set for 20 marks.
3. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
4. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course (CIE+SEE)

Suggested Learning Resources:

Books

(1) Microsystem Design, S.D. Senturia, Kluwer Academic Publishers, 2001

(2) MEMS & Microsystems Design and Manufacture, Tai-Ran Hsu, McGraw Hill, 2002.

(3) Smart Material Systems and MEMS: Design and Development Methodologies, V.K.Varadan, K.J. Vinoy, and S. Gopalakrishnan, Wiley, 2006.

Reference Books

(1) Micromachined Transducers Sourcebook, G.T.A. Kovacs, WCB McGraw-Hill, 1998.

(2) Microsensors: principles and applications, J.W. Gardner, John Wiley & Sons, 1994.

(3) Principles of Microfabrication, M. Madou, CRC Press, 1998.

Web links and Video Lectures (e-Resources):

- VTU e-Shikshana Program
- VTU EDUSAT Program

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

Quizzes

Assignments

Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Describe micro systems, micro sensors and type of micro fabrication processes	L2
CO2	Distinguish electronic and mechanical components used in automobile systems	L3
CO3	Apply concept of mechanics of solids.	L3
CO4	Analyse partial differentiation for micro systems	L3
CO5	Describe electronic packaging of micro electronics	L3

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**2**	**2**	**3**	**3**	**3**	**3**	**2**
CO2	**2**	**3**	**3**	**2**	**2**	**2**	**2**
CO3	**2**	**2**	**3**	**3**	**3**	**3**	**2**
CO4	**2**	**3**	**2**	**2**	**2**	**3**	**3**
CO5	**2**	**2**	**3**	**3**	**3**	**3**	**3**

Professional Elective 3

Industry 4.0 and IIOT			
Course Code	MMTR214A	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 : 1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:
This course will enable students to
1. To identify areas on which the content of education should focused on in the future in terms to Industry 4.0.
2. Illustrate diverse methods of deploying smart objects and connect them to network.
3. Compare different Application protocols for IoT.

MODULE-1

Introduction to Industry 4.0: Introduction, core idea of Industry 4.0,origin concept of industry 4.0,Industry 4.0 production system, current state of industry 4.0, Technologies, How is India preparing for Industry 4.0

MODULE-2

A Conceptual Framework for Industry 4.0: Introduction, Main Concepts and Components of Industry 4.0, State of Art, Supportive Technologies, Proposed Framework for Industry 4.0.

MODULE-3

Technology Roadmap for Industry 4.0 : Introduction, Proposed Framework for Technology Roadmap, Strategy Phase, Strategy Phase, New Product and Process Development Phase.

MODULE-4

What is IoT: Genesis of IoT, IoT and Digitization, IoT Impact, Convergence of IT and IoT, IoT Challenges, IoT Network Architecture and Design, Drivers Behind New Network Architectures, Comparing IoT Architectures, A Simplified IoT Architecture, The Core IoT Functional Stack, IoT Data Management and Compute Stack.

MODULE 5

Smart Objects: The "Things" in IoT, Sensors, Actuators, and Smart Objects, Sensor Networks, Connecting Smart Objects, Communications Criteria, IoT Access Technologies.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

5. Two Unit Tests each of **25 Marks**
6. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**
CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

11. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
12. The question paper will have ten full questions carrying equal marks.
13. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
14. Each full question will have a sub-question covering all the topics under a module.
15. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Alp Ustundag and Emre Cevikcan,"Industry 4.0: Managing the Digital Transformation".
2. Bartodziej, Christoph Jan,"The Concept Industry 4.0". Klaus Schwab,"The Fourth Industrial Revolution".
3. Christian Schröder ,"The Challenges of Industry 4.0 for Small and Medium-sized Enterprises".
4. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry,"IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", 1 stEdition, Pearson Education (Cisco Press Indian Reprint). (ISBN: 978- 9386873743)
5. Srinivasa K G, "Internet of Things",CENGAGE Leaning India, 2017

Web links and Video Lectures (e-Resources):

VTU e-Shikshana Program
VTU EDUSAT Program

Skill Development Activities Suggested

Quizzes
Assignments
Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Describe Industry 4.0 and scope for Indian Industry	L2
CO2	Demonstrate conceptual framework and road map of Industry 4.0.	L3
CO3	Describe Robotic technology and Augmented reality for Industry 4.0	L4
CO4	Interpret the impact and challenges posed by IoT networks leading to new architectural models.	L2
CO5	Compare and contrast the deployment of smart objects and the technologies to connect them to network	L2

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**2**	**3**	**3**	**2**	**2**	**2**	**2**
CO2	**2**	**2**	**3**	**2**	**3**	**2**	**3**
CO3	**3**	**2**	**3**	**2**	**2**	**2**	**3**
CO4	**3**	**2**	**3**	**2**	**3**	**2**	**2**
CO5	**2**	**3**	**2**	**3**	**2**	**2**	**3**

Smart Materials and Structures			
Course Code	MMTR214B	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 : 1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. Develop an essential understanding of structure-property relationship of smart materials, as well as their applications in practical applications.
2. Develop student's capability to design functional structures using smart materials; and provide students an opportunity to learn the new knowledge through project approaches.

MODULE-1

Smart Structures: Types of Smart Structures, Potential Feasibility of Smart Structures, Key Elements of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, Depoling and Coersive Field, field strain relation. Hysteresis, Creep and Strain Rate effects, Inch worm Linear Motor.

MODULE-2

Shape memory Alloy: Experimental Phenomenology, Shape Memory Effect, Phase Transformation, Tanaka's Constitutive Model, testing of SMA Wires, Vibration Control through SMA, Multiplexing. Applications of SMA and Problems.

MODULE-3

Vibration Absorbers: series and Parallel Damped Vibrations (Overview), Active Vibration Absorbers, Fiber Optics, Physical Phenomena, Characteristics, Sensors, Fiber Optics in Crack Detection, applications. Control of Structures: Modelling, Control Strategies and Limitations, Active Structures in Practice.

MODULE-4

MEMS–Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration.

MODULE 5

ER and MR Fluids: Mechanisms and properties, Fluid Composition and behaviour, The Bingham Plastic and Related Models, Pre-Yield Response. Post-Yield flow applications in Clutches, Dampers and Others.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

7. Two Unit Tests each of **25 Marks**
8. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the Cos and Pos

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

16. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
17. The question paper will have ten full questions carrying equal marks.
18. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
19. Each full question will have a sub-question covering all the topics under a module.
20. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

(1) Smart Material sand Structures- M.V. Gandhiand B. So Thompson, Chapmanand Hall, London; NewYork,1992.

(2) Smart Structures and Materials- B. Culshaw, Artech House, Boston,1996.

(3) Smart Structures: Analysis and Design-A.V.Srinivasan, Cambridge University Press, Cambridge, NewYork,2001.

Reference Books

(1) Piezoelectric Sensories : Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin; New York, 2002

(2) Hand book of Giant Magneto strictive Materials-G.Engdahl, Academic Press, San Diego,Calif.;London,2000

Web links and Video Lectures (e-Resources):

VTU e-Shikshana Program
VTU EDUSAT Program

Skill Development Activities Suggested

Quizzes
Assignments
Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand the behaviour and applicability of various smart material	L2
CO2	Design simple models for smart structures &materials.	L3
CO3	Perform simulations of smart structures & materials application Conduct experiments to verify the predictions	L3
CO4	Ability to analyse vibration absorbers and control of structures.	L2
CO5	Exposure to MEMS	L3

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**2**	**3**	**3**	**2**	**2**	**2**	**2**
CO2	**3**	**2**	**3**	**2**	**2**	**2**	**3**
CO3	**2**	**2**	**3**	**2**	**3**	**2**	**2**
CO4	**2**	**2**	**3**	**2**	**2**	**2**	**3**
CO5	**2**	**3**	**3**	**3**	**3**	**2**	**3**

Advanced Computer Concepts for Automation			
Course Code	MMTR214C	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 : 1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:
1. Discuss Database management systems, databases and its applications
2. Familiarize the students with a good formal foundation on the relational model.
3. Outline the various systematic database design approaches

MODULE-1

Introduction to Big Data: Big Data and its Importance – Four V"s of Big Data – Drivers for Big Data –Introduction to Big Data Analytics – Big Data Analytics applications. Hadoop"s Parallel World – Data discovery – Open source technology for Big Data Analytics – cloud and Big Data –Predictive Analytics – Mobile Business Intelligence and Big Data – Crowd Sourcing Analytics – Inter- and Trans-Firewall, Analytics - Information Management.

MODULE-2

Processing Big Data: Integrating disparate data stores - Mapping data to the programming framework Connecting and extracting data from storage - Transforming data for processing - Subdividing data in preparation for Hadoop Map Reduce.

MODULE-3

Hadoop Mapreduce: Employing Hadoop Map Reduce - Creating the components of Hadoop Map Reduce jobs - Distributing data processing across server farms -Executing Hadoop Map Reduce jobs - Monitoring the progress of job flows - The Building Blocks of Hadoop Map Reduce - Distinguishing Hadoop daemons - Investigating the Hadoop Distributed File System Selecting appropriate execution modes: local, pseudo-distributed, fully distributed.

MODULE-4

Database Management System: Comparison of File System, Database Management System, Characteristic Features of Database Management Systems, Relational Databases. Data Base Models: DBMS Languages and Interfaces. Data Base Security and Authorization.

MODULE 5

Big Data Tools and Techniques: Installing and Running Pig – Comparison with Databases – Pig Latin – User Define Functions – Data Processing Operators – Installing and Running Hive – Hive QL – Tables – Querying Data – UserDefined Functions – Oracle Big Data.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

9. Two Unit Tests each of **25 Marks**
10. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

21. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
22. The question paper will have ten full questions carrying equal marks.
23. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
24. Each full question will have a sub-question covering all the topics under a module.
25. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

- Fundamentals of DBMS – RamezElmasri and Navathe, Addison Wesley, 5th edition, 2009
- Michael Minelli, Michehe Chambers, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today"s Business", I Edition, Wiely 2013
- Arvind Sathi, "Big Data Analytics: Disruptive Technologies for Changing the Game", 1st Edition, IBM Corporation, 2012
- Bill Franks, "Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics", 1st Edition, Wiley and SAS Business Series, 2012.
- Tom White, "Hadoop: The Definitive Guide", 3rd Edition, O"reilly, 2012.
- Introduction to DBMS – Date C.J, Addison Wesley, 3rd edition, 1981
- Michael Berthold, David J. Hand, "Intelligent Data Analysis", Springer, 2007.
- Jay Liebowitz, "Big Data and Business Analytics" Auerbach Publications, CRC press (2013)
- Tom Plunkett, Mark Hornick, "Using R to Unlock the Value of Big Data: Big Data Analytics with Oracle R

Web links and Video Lectures (e-Resources):

VTU e-Shikshana Program
VTU EDUSAT Program

Skill Development Activities Suggested

Quizzes
Assignments
Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand of big data and its importance and its applications in different sectors	L2
CO2	Data identification and its extraction from various sources and transforming them for processing.	L3
CO3	apply Hadoop Map-Reduce techniques for data processing	L4
CO4	Describe about database, highlighting its characteristics and discuss key components of the database and providing security and authorization to the databases.	L2
CO5	Apply various tools and techniques of Big Data to solve the problems.	L3

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**2**	**3**	**3**	**2**	**3**	**2**	**2**
CO2	**2**	**2**	**3**	**2**	**2**	**2**	**3**
CO3	**3**	**2**	**3**	**2**	**2**	**2**	**2**
CO4	**2**	**2**	**3**	**2**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**3**	**2**

Drives and Control Systems for Mechatronics			
Course Code	MMTR214D	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 : 1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:
1. The course is designed to give a solid grounding of fundamental concepts of industrial automation systems and their control.
2. The course specifically focuses on architecture, components, and techniques for automation in industries.

MODULE-1

Introduction: Working principle of synchronous, Asynchronous & stepper motors, Difference between Induction and servo motors, Torque v/s speed characteristics, Power v/s. Speed characteristics, Vector duty induction motors, Concepts of linear and frameless motors, Selection of feedback system, Duty cycle.

MODULE-2

Industrials Drives: DC and AC motors operation and selection, method of control and application of brushless DC motor, PMSM, stepper motor, A.C servomotor, selection criteria for servo motor and servo amplifier, universal motor, electric drive, types of industrial drives, the characteristics of drive, advantages of drives over other prime movers, motor rating, heating effects.

MODULE-3

Motion Laws For Rotary And Linear Systems: converting rotary to linear system, concepts and principles of ball screws, rack and pinion, belt and pulley, chain drives, gear drives, Selection of converting systems, Dynamic response gearing, and control approaches of Robots, Control loops using Current amplifier.

MODULE-4

Introduction to Programmable Logic Controllers: Definitions of PLC, basic structure of PLC, working principles, data storage methods, inputs / outputs flag processing"s, types of variables, definition of firmware, software.

MODULE 5

Logic, Instructions & Application of PLC: What is logic, Conventional Ladder v/s PLC ladder, series and parallel function of OR, AND, NOT logic, Ex Or logic, Analysis of rung. Timer and Counter Instructions; on delay and Off delay and retentive timer instructions, PLC counter up and down instructions, combining counters and timers, Comparison and data handling instructions, Sequencer instruction, Visualization Systems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

11. Two Unit Tests each of **25 Marks**
12. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

26. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
27. The question paper will have ten full questions carrying equal marks.
28. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
29. Each full question will have a sub-question covering all the topics under a module.
30. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Process Control Instrumentation Technology, Johnson Curties, Prentice hall of India, 8th edition
2. Andrew Parr, Industrial drives, Butterworth – Heineamann
3. Andrew Parr, Industrial drives, Butterworth – Heineamann
4. G.K. Dubey. Fundamentals of electrical drives
5. Programmable Logic Controllers by W.Bolton

Reference Books

1. Introduction to Programmable Logic Controllers by Garry Dunning, 2nd edition, Thomson, ISBN:981-240 625-5
2. Instrumentation Engineers Hand Book - Process Control, Bela G Liptak, Chilton book company, Pennsylvania
3. A.E. Fitzerald , C. Kingsley and S.D Umans, Electric Machinery - McGraw Hill Int. Student edition
4. S.K. Pillai. A First course on electric drives –Wiley Eastern 1990 5. Programmable Logic Controllers by Hugh Jack

Web links and Video Lectures (e-Resources):

VTU e-Shikshana Program
VTU EDUSAT Program

Skill Development Activities Suggested

Quizzes
Assignments
Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand the basics of Electric drives	L2
CO2	Explain industrial processes and selection of drives	L3
CO3	Differentiate various control systems	L4
CO4	Develop motor control circuits	L2
CO5	Illustrate computer based industrial control	L3

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	3	2	3	2	2
CO2	2	2	3	2	2	2	3
CO3	3	2	3	2	2	2	2
CO4	2	2	3	2	3	2	2
CO5	3	3	3	2	2	3	2

Professional Elective-4			
AI&ML in industrial automation			
Course Code	MMTR215A	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 :0 : 1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives: This can contribute in industrial automation, information technology and other sectors like healthcare, agriculture, wearable, space, and meteorology through analysis of raw data, extract intelligence from that and design, develop, support and testing of AI and ML based systems along with embedded applications.

MODULE-1

Artificial Intelligence: What is AI?, The Foundations of Artificial Intelligence, The History of Artificial Intelligence, Intelligent Agents: Agents and Environments, the Concept of Rationality, the Nature of Environments, the Structure of Agents.

MODULE-2

Problem-solving: Problem-Solving Agents, Example Problems, Searching for Solutions, Uninformed Search Strategies, Breadth-first search, Uniform-cost search, Depth-first search, Depth-limited search, Iterative deepening depth-first search, Bidirectional search. Informed (Heuristic) Search Strategies, Greedy best-first search, A* search, Heuristic Functions, The effect of heuristic accuracy on performance.

MODULE-3

Beyond Classical Search: Local Search Algorithms and Optimization Problems, Hill-climbing search, Simulated annealing, Local beam search, Genetic algorithms, Local Search in Continuous Spaces, Searching with Nondeterministic Actions, Searching with Partial Observations, Online Search Agents and Unknown Environments.

MODULE-4

Knowledge Representation: Ontological Engineering, Categories and Objects, Events, Mental Events and Mental Objects, Reasoning Systems for Categories, Semantic networks, Description logics, Reasoning with Default Information, Truth maintenance systems.

MODULE 5

Uncertain knowledge and reasoning: Quantifying Uncertainty, Acting under Uncertainty, Basic Probability Notation, Inference Using Full Joint Distributions, Bayes' Rule and Its Use, Probabilistic Reasoning, Representing Knowledge in an Uncertain Domain, The Semantics of Bayesian Networks, Exact Inference in Bayesian Networks, Approximate Inference in Bayesian Networks, and Inference by Markov chain simulation.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

13. Two Unit Tests each of **25 Marks**
14. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

31. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
32. The question paper will have ten full questions carrying equal marks.
33. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
34. Each full question will have a sub-question covering all the topics under a module.
35. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Artificial Intelligence: A Modern Approach by StuartRussell and Peter Nowig, PEARSON 3rd Ed.
2. A Guide to Expert Systems - Donald A Waterman, Addison Wesley,2nd edition,1986.

References:

1. Introduction to Artificial Intelligence and Expert Systems – DAN.W.Patterson, PHI, 2nd edition, 2009.
2. Artificial Intelligence- George.F.Luger, Pearson Education, Asia, 3rd Edition,2009.
3. Artificial Intelligence: An Engineering Approach- Robert J. Schalkeff, PHI, Second edition, 1990.

Web links and Video Lectures (e-Resources):

VTU e-Shikshana Program
VTU EDUSAT Program

Skill Development Activities Suggested

Quizzes
Assignments
Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Describe and explain the applications of AI	L4
CO2	Select search strategies based on application requirement.	L4
CO3	Explain knowledge representation methods, discuss architecture of expert systems.	L4
CO4	Application of on-line search agent for purchase application.	L3

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**4**	**3**	**3**	**3**	**3**	**3**	**3**
CO2	**4**	**4**	**3**	**3**	**3**	**3**	**2**
CO3	**3**	**4**	**3**	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**	**3**	**2**

Professional Elective-4			
Python Programming for Automation			
Course Code	MMTR215B	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 :1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:
1. To provide exposure to basic problem-solving techniques with computers
2. To develop the logical thinking abilities and to propose novel solutions for real world problems through programming language constructs.

MODULE-1

Introduction to Python Programming: Demo of Interactive and script mode, Tokens in Python – Variables, Keywords, Comments, Literals, Data types, Indentation, Operators and its precedence, Expressions, Input and Print functions. Sequential approach

MODULE-2

Control Structures: Selective statements – if, if-else, nested if, if –elif ladder statements Iterative statements - while, for, Nested loops, else in loops, break, continue and pass statements.

MODULE-3

Collections: List: Create, Access, Slicing, Negative Indices, List Methods, and comprehensions Tuples: Create, Indexing and Slicing, Operations on tuples. Dictionary: Create, add, and replace values, operations on dictionaries. Sets: Create and operations on set.

MODULE-4

Strings and Regular Expressions: Strings: Formatting, Comparison, Slicing, Splitting, Stripping, Negative indices, String functions. Regular expression: Matching the patterns, Search and replace.

MODULE 5

Functions: Types, parameters, arguments: positional arguments, keyword arguments, parameters with default values, functions with arbitrary arguments, Scope of variables: Local and global scope, Recursion and Lambda functions.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

15. Two Unit Tests each of **25 Marks**
16. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

36. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
37. The question paper will have ten full questions carrying equal marks.
38. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
39. Each full question will have a sub-question covering all the topics under a module.
40. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Eric Matthes, Python Crash Course: A Hands-On, Project-Based Introduction to Programming, 2nd Edition, No starch Press, 2019.

2. Martic C Brown, Python: The Complete Reference, 4th Edition, McGraw Hill Publishers, 2018.

3. Charles Dierbach, Introduction to Computer Science using Python: A Computational Problem Solving Focus,2nd Edition, Wiley India Edition, 2017.

Web links and Video Lectures (e-Resources):

VTU e-Shikshana Program
VTU EDUSAT Program

Skill Development Activities Suggested

Quizzes
Assignments
Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Interpret the basic representation of the data structures and sequential programming	L2
CO2	Knowledge of, and ability to use control framework terminologies	L3
CO3	Ability to work out using the core data structures as lists, dictionaries, tuples, and sets.	L2
CO4	Choose appropriate programming paradigms, interrupt and handle data using files to propose solution through reusable modules.	L3
CO4	Propose possible error-handling constructs for unanticipated states/inputs	L2

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**2**	**3**	**3**	**2**	**2**	**2**	**2**
CO2	**3**	**2**	**3**	**2**	**3**	**2**	**3**
CO3	**3**	**2**	**3**	**2**	**3**	**2**	**2**
CO4	**2**	**2**	**3**	**2**	**2**	**2**	**2**

Professional Elective-4			
Robotics Mechanics and Control			
Course Code	MMTR215C	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 :1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives: Learn algorithmic approaches, mathematical models, and computational and motion control methods applicable to robotic manipulator systems; Recognize and analyze the basic mechanical and electrical systems concerning robots

MODULE-1

Introduction: Effector: locomotion, and manipulation. Serial and parallel manipulators. Descriptions, Transformations and homogeneous transformation matrix.

MODULE-2

Manipulator (serial manipulator) kinematics: Kinematic parameters, different notations, Denavit-Hartenberg (DH) representation, arm matrix. Forward and inverse kinematics. Analytical and numerical solutions. Examples

MODULE-3

Differential kinematics: Differential (velocity) kinematics, velocity propagation, forward differential kinematics and inverse differential kinematics.

MODULE-4

Jacobian matrix and Manipulator statics: Mapping between configuration-space to operational-space. Jacobian matrix and Pseudo inverse concepts.Introduction to workspace singularities.Manipulator statics: Conservation of energy or power, the mapping between operation-space to configuration-space inputs examples

MODULE 5

Manipulator dynamics: Motion dynamics: Forward and inverse dynamics. Lagrangian (Lagrange-Euler) and Newton-Euler formulations. Examples

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

17. Two Unit Tests each of **25 Marks**
18. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

41. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
42. The question paper will have ten full questions carrying equal marks.
43. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
44. Each full question will have a sub-question covering all the topics under a module.
45. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. MECHANICS AND CONTROL OF ROBOTIC MANIPULATORS, Prof. Santhakumar Mohan, Mechanical Engineering, IIT Palakkad.

2. Introduction to Robotics: Mechanics and Control, John J. Craig, Pearson

Web links and Video Lectures (e-Resources):

VTU e-Shikshana Program
VTU EDUSAT Program

Skill Development Activities Suggested

Quizzes
Assignments
Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Student will have the competence to design and implement robotic systems.	L4

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**3**	**3**	**3**	**3**	**3**	**3**	**2**

Professional Elective-4			
Control Systems and Engineering			
Course Code	MMTR215D	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 :0 : 1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Students will gain the knowledge on the concept of time response and frequency response of the control system.
- Students will able to explain different control system stability techniques.
- Students will able to apply root locus technique, bodeplot to determine stability of the control system
- Students will able to apply polar plot to techniques to determine stability of the control system.
- Students will know the concept of state variables and state model.

MODULE-1

Time Response of control systems: Standard test signals, Unit step response of First and Second order Systems. Time response specifications, Time response specifications of second order systems, steady state errors and error constants. Introduction to PI, PD and PID Controllers (excluding design).

MODULE-2

Frequency domain Analysis: Introduction to frequency domain analysis, Correlation between time & frequency response.

Concepts of stability: The Concept of stability. Necessary conditions for stability. Hurwitz stability criterion. Routh stability criterion. Relative stability analysis using RH Criterion.

MODULE-3

The Root Locus Technique: Introduction to Root locus concepts. Construction of root loci. Stability analysis using Root locus technique .Numerical problems on all topics

MODULE-4

Frequency Domain Analysis: frequency domain specifications, polar plot, The Nyquist criterion. Construction of Bode plots and Stability analysis using Bode plots.

MODULE 5

State space Analysis: Concept of state, state variables and state model. State diagrams and State models for Linear continuous-time systems (Electrical systems): State space representation using Physical and Phase variables.Derivation of transfer functions from the state model. Numerical problems on all topics.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

19. Two Unit Tests each of **25 Marks**
20. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

46. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
47. The question paper will have ten full questions carrying equal marks.
48. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
49. Each full question will have a sub-question covering all the topics under a module.
50. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

1. "Control Systems Engineering", I.J. Nagarath and M. Gopal ,New Age International (P) Limited, Publishers, Fifth edition – 2012.2.
2. "Modern Control Engineering ", K. Ogata, Pearson Education Asia/ PHI, 4th Edition, 2002

Reference Books

1. "Automatic Control Systems", Benjamin C. Kuo, John Wiley India Pvt. Ltd., 8th Edition, 2008.
2. "Feedback and Control System", Joseph J Distefano III et al., Schaum's Outlines, TMH, 2nd Edition 2007

Web links and Video Lectures (e-Resources):

- Image databases, https://imageprocessingplace.com/root_files_V3/image_databases.htm
- Student support materials,
- https://imageprocessingplace.com/root_files_V3/students/students.htm
- NPTEL Course, Introduction to Digital Image Processing, https://nptel.ac.in/courses/117105079
- Computer Vision and Image Processing, https://nptel.ac.in/courses/108103174
- Image Processing and Computer Vision – Matlab and Simulink,
- https://in.mathworks.com/solutions/image-video-processing.html

Skill Development Activities Suggested

- Usage of simulation software to analyze system dynamics and evaluate control strategies before implementation. Languages like Ladder Logic, Structured Text, or C++ for PLC (Programmable Logic Controller) programming and control system implementation.
- Use of different types of sensors and transducers used in control systems to measure process variables.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Discuss Time and frequency domain analysis of the control systems	L2
CO2	Discuss the concept of state variables and state model	L2
CO3	Apply the RH criterion techniques and root locus techniques to solve the stability of the control systems	L2
CO4	Analyze the stability of the systems using Bode Plots, Polar and Nyquist plot.	L3

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**2**	**2**	**3**	**2**	**2**	**2**	**2**
CO2	**2**	**2**	**3**	**2**	**3**	**2**	**2**
CO3	**3**	**2**	**3**	**2**	**2**	**2**	**3**
CO4	**3**	**2**	**3**	**2**	**2**	**2**	**2**

Industrial Automation			
Course Code	MMTR206	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 :2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Acquire the basic understanding of automation in production system
- Acquire a basic understanding of material handling and identification technologies
- Understanding of Automated Manufacturing systems
- Acquire a basic understanding of computer based industrial automation
- Acquire a basic understanding of Distributed Control Systems

MODULE-1

Introduction: Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations. Production Economics: Methods of Evaluating Investment Alternatives, Costs in Manufacturing, Break- Even Analysis, Unit cost of production, Cost of Manufacturing Lead time and Work-in process.

MODULE-2

Material handling and identification technologies: Overview of material handling systems, Types of material handling equipment, Design of the system, Conveyor system, Automated guided vehicle system, Automated storage systems, Interfacing handling and storage with manufacturing, Overview of Automatic Identification Methods.

MODULE-3

Automated Manufacturing Systems: Components, Classification and overview of manufacturing systems, Cellular manufacturing, Flexible manufacturing system (FMS), FMS and its planning and implementation, Automated assembly system – design and types of automated assembly systems, Analysis of multi station and single station assembly machine.

MODULE-4

Introduction to computer based industrial automation- Direct Digital Control (DDC), Distributed Control System (DCS) and supervisory control and data acquisition (SCADA) based architectures. SCADA for process industries includes understanding of RTUs, Pumping stations, Evacuation processes, Mass Flow Meters and other flow meters, Leak-flow studies of pipelines, Transport Automation

MODULE 5

Distributed Control System: Local Control Unit (LCU) architecture, LCU Process Interfacing Issues, Block diagram and Overview of different LCU security design approaches, Networking of DCS. Introduction to communication protocols- Profibus, Field bus, HART protocols. Data gathering, Data analytics, Real-time analysis of data stream from DCS, Historian build, Integration of business inputs with process data, Leveraging RTU (as different from PLCs and DCS)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

21. Two Unit Tests each of **25 Marks**
22. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

51. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
52. The question paper will have ten full questions carrying equal marks.
53. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
54. Each full question will have a sub-question covering all the topics under a module.
55. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

1. M.P.Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 5th Edition, Pearson Education, 2009

2. Curtis D. Johnson, "Process Control Instrumentation Technology", 8th Edition, Pearson New International, 2013.

3. Lukas M.P, "Distributed Control Systems", Van Nostrand Reinhold Co., New York, 1986.

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc21_me67/preview
- http://www.digimat.in/nptel/courses/video/108105062/L20.html

Skill Development Activities Suggested

Programming language
Sensor Technology
Networking
Robotics

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand the need and basics of Industrial Automation,	L2
CO2	Understand knowledge on Automated Manufacturing system	L2
CO3	Analyze different types of automated manufacturing systems	L2
CO4	Design material handling system in Manufacturing system	L3

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	2	3	2	2	2	2
CO2	2	2	3	2	3	2	2
CO3	2	2	3	2	3	2	2
CO4	2	2	3	2	3	2	3

Advanced Control System Lab			
Course Code	MMTRL207	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Credits	2	Exam Hours	03

Course objectives:

- To impart knowledge on
- 1. Application of fluid power symbols
- 2. Designing a suitable hydraulic or pneumatic circuit
- 3. Automating an Industrial application.

Sl.NO	Experiments
1	Mathematical models of physical systems in the design and analysis of control systems
2	To Study the effect of P, PI, PID controllers using MATLAB.
3	To analyses the stability of linear systems using Bode, Root locus, Nyquist plots
4	To calculate an impulse response of a system described by difference equation y[n]+0.7y[n-1]–0.45y[n-2]-0.6y[n-3]=0.8x[n]-0.44x[n-1]+0.36x[n2]+0.02 x[n-3]
5	Question based on response of LTI systems to different inputs. ALTI system is defined by the difference equation y[n]=x[n]+x[n+1]+x[n+2]. (a)determine the impulse response of the system and sketch it. (b)determine the output y[n]of the system when the input is x[n]=u[n]. c)Determine the output of the system when the input is a complex exponential (E.g.[n]=2*exp(j0.26n)).
6	Comparison of DFT and DCT (in terms of energy compactness) Generate the sequence x[n]=(n-64) for=0,127. (a) Let X[k]=DFT{x[n]}. For various values of 1, set to zero "high frequency coefficients "X[64-1]= ....X[64]= ..... X[64+L]=0andtaketheinverseDFT.Plot the results. (b) Let XDCT[k]=DCT(X[n]).For the same values of L, set to zero "high frequency coefficient "XDCT[127-L]= ....XDCT[127].Take the inverse DCT for each case and compare the reconstruction with the previous case. Use Laasonen Model and Crank Nicolson Model draw the characteristic curves for various boundary conditions.

Course outcomes (Course Skill Set):

- At the end of the course the student will be able to:
- Ability to design and implement pneumatic components system for simple applications.
- Capability to control various types of Control Valve, Pneumatic Double Acting Cylinder
- Demonstrate various valves of pneumatic components with logic control
- Design and develop fluid power circuits to various applications.
- Interpret the specifications of the fluid power system components for various applications.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- **Total marks scored by the students are scaled down to 30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 01 tests for 100 marks, test shall be conducted after the 14th week of the semester.
- In test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- **The test marksis scaled down to 20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and marks of test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated

for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Suggested Learning Resources:

Suggested Learning Resources:

Text Book

(1) Anthony Esposito, "Fluid Power with Applications", Prentice Hall international, 7th edition, 2014.

Reference Books

(1) Jagadeesha T., "Fluid Power Control", NPTEL Web course.
(2) FESTO, "Fundamentals of Pneumatics", Vol I, II, III.
(3) Majumdar .S.R., "Oil Hydraulics", Tata McGraw Hill, 2002.
(4) Werner Deppert , "Kurt Stoll, Pneumatic Application", Vogel verlag ,1986

Ability Enhancement course			
Fuzzy logic for Robotics			
Course Code	**MMTR258A**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	0: 2 :0 : 0	SEE Marks	50
Total Hours of Pedagogy	16	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

- Understand Fuzzy Logic Principles: Develop a solid understanding of fuzzy logic theory and its application in robotics.
- Implement Fuzzy Controllers: Learn to design and implement fuzzy logic controllers for robotic systems to handle imprecise or uncertain information.
- Solve Complex Robotic Decision Problems: Acquire the skills to apply fuzzy logic to address complex decision-making problems in robotics, such as path planning and obstacle avoidance.
- Optimize Robotic Systems: Explore techniques to optimize robotic systems' performance and behaviour using fuzzy logic-based control strategies.
- Apply Fuzzy Logic to Real-world Scenarios: Apply fuzzy logic concepts and techniques to practical robotic applications, demonstrating the ability to enhance robot adaptability and autonomy in uncertain environments.

MODULE-1
Fuzzy set theory – Fuzzy sets – Operation on fuzzy sets – Scalar cardinality, fuzzy cardinality, union and intersection, complement (Yager and Sugeno),
MODULE-2
Fuzzy Arithmetic, Fuzzy Relations & Possibility Theory, Fuzzy Logic, Uncertainty based Information,
MODULE-3
Modelling of non-linear systems using fuzzy models – TSK model – Fuzzy logic controller – Fuzzification – Knowledge base – Decision making logic – Defuzzification – Adaptive fuzzy systems
MODULE-4
Introduction to Neural Networks Differences between Biological and Artificial Neural Networks – Typical Architecture, Common Activation Functions,
MODULE 5
Neural Networks: Case Studies: Inverted Pendulum, CMAC, Robotics, Image compression, and Control systems

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

Three Tests (preferably in MCQ pattern with 20 questions) each of 20 Marks (duration 01 hour)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of 10 Marks

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Quiz/Group discussion/Seminar, any two of three suitably planned to attain the COs and POs for 20 Marks (duration 01 hours)

The sum of total marks of three tests, two assignments, and quiz /seminar/ group discussion will be out of 100 marks and shall be scaled down to 50 marks

Semester End Examinations (SEE)

SEE paper shall be set for 50 questions, each of 01 mark. The pattern of the question **paper is** MCQ (multiple choice questions). The time allotted for SEE is 01 hour. The student has to secure minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Books

1. Fuzzy Sets and Fuzzy Logic – Theory and Applications, George J. Klir& Bo Yuan, Prentice Hall of India Private Limited.
2. Fuzzy Sets, Uncertainty and Information, George J. Klir& Tina A. Folger, Prentice Hall of India Private Limited.
3. Jacek M. Zurada, 'Introduction to Artificial Neural Systems', Jaico Publishing home, 2002.
4. Timothy J. Ross, 'Fuzzy Logic with Engineering Applications', Tata McGraw Hill, 2009.

Reference Books:

5. LaureneFausett, Englewood cliffs, N.J., 'Fundamentals of Neural Networks', Pearson Education, 2008.
6. Simon Haykin, 'Neural Networks', Pearson Education, 2003.
7. George.J.Klir, 'Fuzzy Sets and Fuzzy Logic – Theory and Applications', Pearson, 2015..

Web links and Video Lectures (e-Resources):

https://onlinecourses.nptel.ac.in/noc22_ge04/preview
https://onlinecourses.nptel.ac.in/noc23_ee21/preview

Skill Development Activities Suggested

Robot Navigation, Obstacle Avoidance, Path Following, Grasping and Manipulation

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Mastery of Fuzzy Logic Concepts: Achieve a high level of proficiency in understanding and applying fuzzy logic principles in the context of robotics.	L1
CO2	Fuzzy Controller Design Skills: Develop the ability to design, implement, and fine-tune fuzzy logic controllers for robotic systems to handle uncertain and complex environments.	L2
CO3	Effective Problem Solving: Demonstrate the capacity to use fuzzy logic to solve intricate robotic decision making problems, including navigation, localization, and sensor fusion	L2
CO4	Improved Robotic Performance: Apply fuzzy logic-based control strategies to enhance robotic systems' performance, adaptability, and robustness in real-world scenarios.	L3

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	1	2	2	2	2	2
CO2	2	2	2	2	3	2	2
CO3	2	2	3	2	2	2	2
CO4	3	2	3	2	3	2	1

Ability Enhancement course			
Introduction to Smart Factory and Industry 4.0			
Course Code	**MMTR258B**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	0: 2 :0 : 0	SEE Marks	50
Total Hours of Pedagogy	16	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

- Gain knowledge on Automated Manufacturing system and smart manufacturing.
- Understand the importance of Manufacturing support system.
- Understand the concept of smart design and manufacturing
- Understanding Internet of things in Industries
- Concepts of online monitoring and logistics in the manufacturing systems

MODULE-1

Automation in Production System, Principles and Strategies of Automation, Dimensions -Demand-Driven and Integrated Supply Chains.

MODULE-2

Classification and overview of manufacturing systems, Cellular manufacturing, Flexible manufacturing system (FMS), Process Planning, Computer Aided Process Planning, Concurrent Engineering.

MODULE-3

Digital Tools, Product Representation and Exchange Technologies and Standards, Smart Perception – Sensor Networks and Devices.

MODULE-4

Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Service, Cloud Computing and Industry 4.0

MODULE 5

Online Predictive Modeming, Monitoring, and Intelligent Control of Machining/Manufacturing and Logistics/Supply Chain Processes.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

Three Tests (preferably in MCQ pattern with 20 questions) each of 20 Marks (duration 01 hour)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of 10 Marks

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Quiz/Group discussion/Seminar, any two of three suitably planned to attain the COs and POs for 20 Marks (duration 01 hours)

The sum of total marks of three tests, two assignments, and quiz /seminar/ group discussion will be out of 100 marks and shall be scaled down to 50 marks

Semester End Examinations (SEE)

SEE paper shall be set for 50 questions, each of 01 mark. The pattern of the question **paper is** MCQ (multiple choice questions). The time allotted for SEE is 01 hour. The student has to secure minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Books

1. Michael Deng, Colin Koh, Smart Factory: Transforming Manufacturing for Industry 4.0 (Industry 4.0 in ASEAN Region Series)- ISBN-13: 979-8583886425.

2. Banken, and Alasdair Gilchrist; Industry 4.0, Apress Berkeley, CA, ISBN978-1-4842-2047-4

3. Carlos Toro, Wei Wang, and Humza Akhtar, Implementing Industry 4.0, Springer Cham, ISBN978-3-03067269-0.

4. Erwin Rauch and Manuel Woschank, Industry

4.0 for SMEs - Smart Manufacturing and Logistics for SMEs, ISBN 978-3-03936-567-8.

Web links and Video Lectures (e-Resources):

NPTEL Lectures

Skill Development Activities Suggested

Industrial visit to gain knowledge on smart factory and Industry 4.0

Projects involving Internet of things in industrial models

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	To understand the concepts Automated manufacturing, smart Manufacturing and IOT	L1
CO2	To know the importance of FMS, Smart design in Manufacturing	L2
CO3	To apply the concepts of Internet of Things technology in Industry	L2
CO4	To analyze the production and logistics process in Smart factory system.	L3

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**1**	**1**	**2**	**2**	**2**	**2**	**2**
CO2	**2**	**2**	**2**	**2**	**3**	**2**	**2**
CO3	**2**	**2**	**3**	**2**	**2**	**2**	**2**
CO4	**3**	**2**	**3**	**2**	**3**	**2**	**1**

Ability Enhancement course			
PLC AND SCADA TECHNOLOGY			
Course Code	**MMTR258C**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	0: 2 :0 : 0	SEE Marks	50
Total Hours of Pedagogy	16	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

- Understand the basics and different types of PLC.
- Solve various logical operations using relay logic and construct equivalent ladder diagram.
- Analyse the working of counters, timers and comparators.
- Diagnosis the problem related types of I/O module, Data Acquisition System and Communication Networks (Bus Systems) using Standard Protocol.
- Understand basic concepts of SCADA and analyse its architectures

MODULE-1

What is a plc, technical definition of plc, what are its advantages, characteristics functions of a plc, chronological evolution of plc, types of plc, unitary plc, modular plc, small plc, medium plc, large plc.

MODULE-2

Bit Logic Instructions: introduction: Input and Output contact program symbols, Numbering system of inputs and outputs, Program format.

MODULE-3

PLC Timers and Counters: On Delay and OFF delay timers, Timer-on Delay, Timer off delay, Retentive and nonretentive timers. Format of a timer instruction. PLC Counter: Operation of PLC Counter, Counter Parameters, Counters Instructions Overview Count up (CTU) Countdown (CTD).

MODULE-4

PLC input output (I/O) modules and power supply: Introduction: Classification of I/O, I/O system overview, practical I/O system and its mapping addressing local and expansion I/O, input-output systems, direct I/O, parallel I/O systems serial I/O systems.

MODULE 5

Introduction, definition and history of Supervisory Control and Data Acquisition typical SCADA System Architecture, Communication Requirements, Desirable properties of SCADA system.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

Three Tests (preferably in MCQ pattern with 20 questions) each of 20 Marks (duration 01 hour)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of 10 Marks

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Quiz/Group discussion/Seminar, any two of three suitably planned to attain the COs and POs for 20 Marks (duration 01 hours)

The sum of total marks of three tests, two assignments, and quiz /seminar/ group discussion will be out of 100 marks and shall be scaled down to 50 marks

Semester End Examinations (SEE)

SEE paper shall be set for 50 questions, each of 01 mark. The pattern of the question **paper is** MCQ (multiple choice questions). The time allotted for SEE is 01 hour. The student has to secure minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Books

1. "PLC and Industrial application", Madhuchhandan Gupts and SamarjitSen Gupta, pernram international pub. (Indian) Pvt. Ltd., 2011.

2. Ronald L Krutz, "Securing SCADA System", Wiley Publication

REFERENCE BOOKS

1. GaryDunning,"Introduction to Programmable Logic Controllers", Thomson,2 nd Edition.

2. John W Webb, Ronald A Reis,"Programmable Logic Controllers: Principles and Application", PHI Learning, Newdelhi, 5 th Edition

3. Stuart A Boyer, "SCADA Supervisory Control and Data Acqusition", ISA, 4 th Revised edition

Web links and Video Lectures (e-Resources):

NPTEL Lectures

Skill Development Activities Suggested

Seminars

Quizzes

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Demonstrate the concepts of basic programming skills of PLC using logical instructions	L1
CO2	Apply the architecture process involved in programmable logic controller and basic programming skills of PLC using logical instructions	L2
CO3	Examine the various operation involved in the PLC input/output module and SCADA system	L2
CO4	Construct the ladder diagram for PLC using logical instructions, timer and counters, Data Handling instructions and build the SCADA System for Real time industrial process.	L3

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	1	2	2	2	2	2
CO2	2	2	2	2	3	3	2
CO3	2	3	3	3	2	2	2
CO4	3	2	3	2	3	2	2

Ability Enhancement course			
BUSINESS ANALYTICS			
Course Code	**MMTR258D**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	0: 2 :0 : 0	SEE Marks	50
Total Hours of Pedagogy	16	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

- Understand the Fundamentals of Business Analytics
- Equip students with the ability to interpret data, identify trends, and make informed decisions using analytical tools and techniques that drive business success.
- Students will learn how to utilize popular analytical tools (e.g., Excel, R, Python, Tableau) to perform descriptive, predictive, and prescriptive analytics.
- Develop problem-solving and critical thinking skills by applying business analytics techniques to real-world business problems and case studies from industries like automation and manufacturing.
- Foster awareness of the ethical, legal, and social implications of data usage in business analytics, including issues related to privacy, data security, and bias.

MODULE-1

INTRODUCTION TO BUSINESS ANALYTICS Overview of Business Analytics: Definition, Importance, and Applications, Descriptive Analytics, Summarizing business data using measures of central tendency and variability, Introduction to Data Types, Structured vs. Unstructured Data, Role of Business Analytics in Decision-Making Tools and Software for Business Analytics: Overview of popular tools like Excel, R, Python, and Tableau.

MODULE-2

DATA COLLECTION, CLEANING, AND PREPROCESSING Data Collection Techniques: Surveys, Web Scraping, IoT Data from Robotics, Sensors. Data Cleaning: Handling missing data, outliers, and inconsistencies. Data Preprocessing: Normalization, Standardization, and Encoding techniques. Data Integration: Combining data from multiple sources such as ERP systems, IoT devices in robotics, implementing data cleaning and preprocessing techniques using Python.

MODULE-3

PREDICTIVE ANALYTICS Introduction to Predictive Analytics: Overview and importance in business decision-making, Statistical Modeling: Regression analysis, time series forecasting. Machine Learning Techniques: Supervised learning methods Tools: Introduction to machine learning libraries like Scikit-learn, Building a predictive model using a simple dataset for sales forecasting, Predictive analytics in supply chain management, demand forecasting in manufacturing.

MODULE-4

PRESCRIPTIVE ANALYTICS Introduction to Prescriptive Analytics: Techniques and optimization methods, Decision Analysis, Decision trees, sensitivity analysis, scenario analysis, Optimization Techniques, Linear programming, integer programming. Application in Robotics and Automation: Optimizing production schedules, resource allocation in roboticsbased systems, Solving optimization problems using Python (PuLP library) or Excel Solver.

MODULE 5

ADVANCED TOPICS AND APPLICATIONS Big Data Analytics: Overview of Big Data and its role in business analytics. Cloud Computing for Business Analytics: Tools like AWS, Azure, and Google Cloud. AI in Business Analytics: Role of AI and deep learning in predictive and prescriptive analytics. Real-World Applications: Robotics in e-commerce, warehouse automation, predictive maintenance. Ethical and Legal Considerations: Data privacy, ethical use of analytics in business. Future Trends in Business Analytics: IoT analytics, block chain in analytics.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

Three Tests (preferably in MCQ pattern with 20 questions) each of 20 Marks (duration 01 hour)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of 10 Marks

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Quiz/Group discussion/Seminar, any two of three suitably planned to attain the COs and POs for 20 Marks (duration 01 hours)

The sum of total marks of three tests, two assignments, and quiz /seminar/ group discussion will be out of 100 marks and shall be scaled down to 50 marks

Semester End Examinations (SEE)

SEE paper shall be set for 50 questions, each of 01 mark. The pattern of the question **paper is** MCQ (multiple choice questions). The time allotted for SEE is 01 hour. The student has to secure minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Text Books

1. Business Analytics: The Science of Data-Driven Decision Making" by U. Dinesh Kumar
2. "Fundamentals of Business Analytics" by R.N. Prasad and Seema Acharya
3. "Business Intelligence and Analytics: Systems for Decision Support" by Ramesh Sharda, Dursun Delen, and Efraim Turban

Reference Books

1. "Introduction to Statistical Learning" by Gareth James, Daniela Witten, Trevor Hastie, and Robert Tibshirani
2. "Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking" by Foster Provost and Tom Fawcett

Web links and Video Lectures (e-Resources):

NPTEL Business Intelligence & Analytics Course: NPTEL
Udemy Business Analytics Courses: Udemy
Simplilearn's Free Business Analytics Course: Simplilearn.com

Skill Development Activities Suggested

- Basic data manipulation and visualization using Excel or Tableau.
- Implementing data cleaning and preprocessing techniques using Python (Pandas, NumPy).
- Building a predictive model using a simple dataset (e.g., sales forecasting).
- Solving optimization problems using Python (PuLP library) or Excel Solver
- Implementing a small AI-based analytics project, like predicting equipment failure using sensor data.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Define key concepts and tools in business analytics, including descriptive analytics, predictive analytics, and prescriptive analytics.	L1
CO2	Explain the role and importance of business analytics in decision-making across various domains, particularly in robotics and automation industries.	L2
CO3	Apply data collection, cleaning, and preprocessing techniques using Python and other tools like Excel, R, and Tableau to solve real-world business problems.	L2
CO4	Analyze business data using predictive models such as regression and machine learning, identifying trends and making data-driven forecasts to improve business processes.	L3
CO5	Develop and implement optimization models for resource allocation and production scheduling using prescriptive analytics techniques, integrating data from multiple sources.	L3

Program Outcome of this course

Sl. No.	Description	POs
1	Apply Knowledge of Math, Science, and Mechatronic Engineering disciplines to Solve Real Life Industrial Problems.	PO1
2	Build Prototype, Test Analyze and Interpret the Results.	PO2
3	Design Mechatronic Systems, Processes or Products.	PO3
4	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**1**	**1**	**2**	**2**	**2**	**2**	**2**
CO2	**2**	**2**	**2**	**2**	**3**	**3**	**2**
CO3	**2**	**3**	**3**	**3**	**2**	**2**	**2**
CO4	**3**	**2**	**3**	**2**	**3**	**2**	**2**
CO5	**2**	**2**	**3**	**2**	**3**	**3**	**2**