VIVEKANAND EDUCATION SOCIETY'S
Institute of Technology

(An Autonomous Institute Affiliated to University of Mumbai, Approved by A.I.C.T.E & Recognized by Govt. of Maharashtra)

Department of Automation and Robotics

Department of Automation and Robotics Syllabus (NEP Scheme)

Sem -V
w.e.f. A.Y. 2025-26

VIVEKANAND EDUCATION SOCIETY'S
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Department of Automation and Robotics

Semester V
Syllabus

VIVEKANAND EDUCATION SOCIETY'S
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Department of Automation and Robotics

Semester V Scheme									
Course Type	**Course Code**	**Course Name**	**Teaching scheme (Contact Hours)**			**Credits Assigned**			
			Th	**Pr**	**Tut**	**Th**	**Pr**	**Tut**	**Total**
Programme Core Course (PCC)	NARPC51	Automatic Control System	3	2	-	3	1	-	4
	NARPC52	Robot Kinematics	3	2	-	3	1	-	4
	NARPC53	Process Instrumentation & Drives	3	2	-	3	1	-	4
Program Elective Course (PEC)	NARPE151	PEC-1	3	-	-	3	-	-	3
Multidisciplinary Minor (MDM)	NARMM51	Course -3	3	-	-	3	-	-	3
Open Elective (OE)	NOE5XX	OE-2	3	-	1	3	-	1	4
Total Credits			**18**	**6**	**1**	**18**	**3**	**1**	**22**

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Department of Automation and Robotics

Semester V Marks Scheme								
Course Type	**Course Code**	**Course Name**	**TH**	**MT**	**CA**	**TW**	**PR/ OR**	**Total**
Programme Core Course (PCC)	NARPC51	Automatic Control System	60	20	20	25	25	150
	NARPC52	Robot Kinematics	60	20	20	25	25	150
	NARPC53	Process Instrumentation & Drives	60	20	20	25	25	150
Program Elective Course (PEC)	NARPE151	PEC-1	60	20	20	-	-	100
Multidisciplinary Minor (MDM)	NARMM51	Course -3	60	20	20	-	-	100
Open Elective (OE)	NOE5XX	OE-2	60	20	20	-	-	100
Total Credits			360	120	120	75	75	750

* Code for subject Lab

Sem V Program Electives (PEC-1)
Advanced Sensors
Analytical Instrumentation
Digital Signal Processing

Sem V Open Electives (OE-2)
Cyber Laws & Digital Forensics
Geographic Information System.
Artificial Intelligence for Healthcare
Social Media Analytics
Mobile App Development

Automatic Control System

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPC51	Automatic Control System (Theory)	03	-	-	03	-	-	03
NARPC51	Automatic Control System (Lab)	-	02	-	-	01	-	01

Automatic Control System (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPC51	Automatic Control System (Theory)	03	-	-	03	-	-	03

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARPC51	Automatic Control System (Theory)	20	20	60	---	---	100

Course Prerequisite:	
Course Objectives:	
1	The students should be able to learn the type of System, dynamics of physical systems, classification of control systems, analysis and design objectives.
2	The students should learn how to represent the system by transfer function and block diagram reduction method and Mason's gain formula.
3	The students should be able to learn time response analysis and demonstrate their knowledge of frequency response.
4	Students are able to learn stability analysis of systems using Root locus, bode plot, polar plot, and Nyquist plot.
5	Students should able to learn state models for different physical systems
Course Outcomes: After successful completion of the course students will be able to:	
1	Appreciate the role of the control system.
2	Formulate mathematical model and transfer function for physical systems.
3	Use standard test signals to identify performance characteristics of first and second-order systems.
4	Analyze stability of the system using Root Locus..
5	Analyze performance characteristics of the system using Frequency response.
6	Formulate state variable model for mechanical and electrical systems.

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Department of Automation and Robotics

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tut	Total
NARPC51	Automatic Control System (Lab)	---	02	---	---	01	---	01

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARPC51	Automatic Control System (Lab)	---	---	---	25	25	50

Lab Prerequisite:	
Lab Objectives:	
1	The students should be able to examine time response analysis of first and second order systems.
2	Students should inspect the stability of the system using Root locus, Bode plot, polar plot.
3	Students should be able to obtain state space representation and study system properties.
Lab Outcomes: After successful completion of the course students will be able to:	
1	Plot time response of first-order systems and second-order systems.
2	Obtain the transfer function and validate transient and steady-state response using test signals such as step, ramp, and parabolic inputs.
3	Understand the effect of the damping factor on system response.

4	Analyze stability of the system by using root-locus.
5	Analyze stability of systems by using bode-plot, Polar plot, Nyquist-plot techniques.
6	Analyze the control system in state space and check system properties.

Automatic Control System (Theory)

Module	Chapter	Content	Hrs
1		**Introduction**	03
	1.1	Definition of control system , open loop and closed loop systems with examples.	
	1.2	Development of automatic control systems, classification of control systems, examples.	
2		**Mathematical Models of Physical Systems and Transfer function**	08
	2.1	Definition of physical systems, principle of superposition and homogeneity, linear/non-linear, time variant/time invariant systems.	
	2.2	Types of dynamic model, linear elements of electrical and mechanical systems.	
	2.3	Definition of transfer function, transfer functions of physical systems.	
	2.4	Block diagram algebra, reduction rules, signal flow graphs-definition, construction, properties, and Mason's gain formula	
3		**Time Response Analysis**	08
	3.1	Standard test signals.	

	3.2	Transient and steady state behavior of first and second order systems, steady state errors in feedback control systems and their types.	
4		**Stability Analysis and Root Locus**	07
	4.1	Concepts of Stability: Concept of absolute, relative and robust stability, routh stability criterion.	
	4.2	Root-locus concepts, general rules for constructing root-locus, root-locus analysis of control systems	
5		**Frequency Response and Stability Analysis**	07
	5.1	Correlation between time and frequency response, polar plots, Bode plots.	
	5.2	Nyquist stability criterion, frequency response specifications, stability analysis using bode plots, significance of gain margin and phase margin.	
6		**State Space Approach**	06
	6.1	Representation of system in state space, Converting transfer function model into state space model. Non-uniqueness of the state space model.	
	6.2	Canonical representation, Eigenvalues, Solution of state equations, Concept of State feedback control, controllability, Observability.	
		Total	39

Textbooks:	
1	Nagrath I. G., Gopal M., Control System Engineering, New Age International (P) Ltd. Publishers, 2021.
2	Kuo Benjamin C., ―Automatic Control Systems‖,10th Edition, Prentice Hall of India, New Delhi, 2017.
Reference Books:	
1	Gopal M. ―Control Systems Principles and Design‖, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1998.
2	Nise Norman S., ―Control Systems Engineering‖, 3rd.Edition, John Wiley and Sons, Inc.-2000.
3	K. Ogata, Modern Control Engineering, Prentice Hall of India, 4th edition, 2002.
4	Lewis Paul H., Chang Yang, ―Basic Control Systems Engineering‖, Prentice HallInternational, Inc. 1997.
5	Raymond T. Stefani, Bahram Shahian, late Clement J. Savant and, late Gene H. Hostetter, ―Design of Feedback Control Systems‖, 4th Edition., Oxford, University Press, New Delhi, 2001.

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks

4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation the marks can be left blank (with discretion of faculty)	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Automatic Control System (Lab)

Suggested Experiments: Students are required to complete at least 10 experiments.

Sr. No.	**Name of the Experiment**
1	To study the time response of the 1st order system.
2	To obtain the time response of a 2nd order system.
3	To study and perform block diagram reduction using simulation software.
4	To examine steady state errors for Type 0,1,2 systems for given step, ramp and parabolic inputs.
5	To plot pole zero map and root locus of given system.
6	To study frequency response of the system.

7	To study and plot the Bode plot of the system.
8	To study and plot the Nyquist plot of the system.
9	To obtain state model of a system from transfer function
10	To obtain a state model of a system in various canonical forms from transfer function.
11	To check the controllability and observability of the given system

Term Work:	
1	Term work should consist of 8 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks (Experiments: 15-marks, Term work Assessment: 10-marks)

Robot Kinematics

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPC52	Robot Kinematics (Theory)	03	-	-	03	-	-	03
NARPC52	Robot Kinematics (Lab)	-	02	-	-	01	-	01

Robot Kinematics (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPC52	Robot Kinematics (Theory)	03	-	-	03	-	-	03

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARPC52	Robot Kinematics (Theory)	20	20	60	---	---	100

Course Objectives:	
1	Develop a comprehensive understanding of robot components and their respective functionalities.
2	Cultivate the ability to comprehend mapping and transformations between rotated and translated frames.

3	Develop a clear understanding of direct kinematic modeling and inverse kinematics for robots.
Course Outcomes: After successful completion of the course students will be able to:	
1	Recognize the functionalities of different robot components and analyze the degree of freedom of a robot.
2	Comprehend the mapping of translational and rotating frames, as well as vectors in those frames.
3	Construct the direct kinematic model for a robot.
4	Verify the solvability of the inverse kinematic model and successfully solve the inverse kinematic problem.
5	Understand linear and angular differential motions of a manipulator.
6	To develop kinematic models of manipulators.

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tut	Total
NARPC52	Robot Kinematics (Lab)	---	02	---	---	01	---	01

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARPC52	Robot Kinematics (Lab)	---	---	---	25	25	50

Lab Prerequisite:	
Lab Objectives:	
1	To introduce types of mechanisms for various robotic applications.
2	To get knowledge about basic Geometrical and Algebraic approaches to solve forward kinematics of serial manipulators.
3	To get knowledge about advanced forward kinematics of serial manipulators.
4	To get knowledge about inverse kinematics of various serial manipulators.
Lab Outcomes: After successful completion of the course students will be able to:	
1	Select the type of mechanism for robotic applications.
2	Explain and analyze the Coordinate frames, transformations and Forward kinematics of robots.
3	Explain and Analyze the Inverse kinematics of robots.
4	Demonstrate understanding of fundamentals of industrial automation.

Robot Kinematics (Theory)

Module	Chapter	Content	Hrs
1		**INTRODUCTION TO ROBOTICS**	06
	1.1	Evolution of Robots and Robotic Laws of Robotic.	
	1.2	Robot Anatomy: Links, Joints and Joint Notation Scheme, Degrees Of Freedom (DOF), Required DOF in a Manipulator, Arm Configuration, Wrist Configuration, The End-Effector, Human Arm Characteristics.	

	1.3	Design and Control Issues, Manipulation and Control, Sensors and Vision, Programming Robots.	
2		**COORDINATE FRAMES, MAPPING AND TRANSFORMS**	08
	2.1	Coordinate Frames: Mapping, Mapping Between Rotated Frames, Mapping Between Translated Frames, Mapping Between Rotated and Translated Frames.	
	2.2	Description of Objects in Space.	
	2.3	Transformation of Vectors: Rotation of Vectors, Translation of Vectors, Combined Rotation and Translation of Vectors, Composite Transformation.	
	2.4	Inverting a Homogeneous Transform.	
	2.5	Fundamental Rotation Matrices: Principal Axes Rotation, Fixed Angle Representation, Euler Angle Representations, Equivalent Angle Axis Representation.	
3		**SYMBOLIC MODELING OF ROBOTS - DIRECT KINEMATIC MODEL**	08
	3.1	Mechanical Structure and Notations, Description of Links and Joints.	
	3.2	Kinematic Modeling of the Manipulator, Denavit-Hartenberg Notation.	
	3.3	Kinematic Relationship between Adjacent Links, Manipulator Transformation Matrix.	
4		**THE INVERSE KINEMATICS**	07
	4.1	Manipulator Workspace, Solvability of Inverse Kinematic Model.	

	4.2	Existence of Solutions, Multiple Solutions, Solution Techniques, Closed form solutions.	
5		**VELOCITY & ACCELERATION ANALYSIS**	06
	5.1	Differential Motions and Relationships.	
	5.2	Jacobian, Forward and Inverse Velocity Analysis, Acceleration Analysis.	
6		**CASE STUDY**	04
	6.1	2 DOF, 3DOF Robot modelling.	
		Total	39

Textbooks:	
1	Robotics and Control by R. K. Mittal and I. J. Nagrath, Tata McGraw Hill
2	Introduction to Robotics by John J. Craig, Third Ed., Pearson.
Reference Books:	
1	Introduction to Robotics by S K Saha, , Second Ed., Tata McGraw-Hill
2	Industrial Robotics by Mikell P. Groover, McGraw Hill, 2nd edition
3	Introduction to Robotics by Arthor Critchlow, Firtst Ed., Macmillan.
4	Deb S.R., "Robotics Technology and Flexible Automation", 2nd edition, Tata McGraw - Hill Publis Robotics: Control and Programming.
5	J. Srinivas, R. V. Dukkipati, K., "Robotics: Control and Programming", Narosa Publishing House, 2009.

6	Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2001 8. Bijay K. Ghosh, Ning Xi, T.J. Tarn, Control in Robotics and Automation Sensor - Based integration, Academic Press, 1999.

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation the marks can be left blank (with discretion of faculty)	05 Marks

End Semester Theory Examination:	
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Robot Kinematics (Lab)

Suggested Experiments: Students are required to complete at least 10 experiments.	
Sr. No.	**Name of the Experiment**
1	To study different types of robots based on configuration and applications.
2	To study anatomy of different types of robots.
3	To study robot classification based on arm geometry and perform workspace analysis of PUMA 560 using a virtual lab.
4	To use open source software to visualize DH parameters.
5	To use open source software to visualize Forward Kinematics
6	To use MATLAB to visualize Forward Kinematics
7	To use open source software to visualize Inverse Kinematics
8	To use MATLAB to visualize Inverse Kinematics
9	Case study

Term Work:	
1	Term work should consist of 8 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks (Experiments: 15-marks, Term work Assessment: 10-marks)

Process Instrumentation & Drives

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPC53	Process Instrumentation & Drives	03	-	-	03	-	-	03
NARPC53	Process Instrumentation & Drives (Lab)	-	02	-	-	01	-	01

Process Instrumentation & Drives
(Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPC53	Process Instrumentation & Drives (Theory)	03	-	-	03	-	-	03

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARPC53	Process Instrumentation & Drives (Theory)	20	20	60	---	---	100

Course Prerequisite: Fundamentals of transducers and BEE	
Course Objectives:	
1	To create awareness about fundamental knowledge of Process control.
2	To Explore students about the concepts of control actions, controllers and control schemes.
3	To explore the students to the concepts of DC motors, servo motors and their drives
4	To provide knowledge about the AC motors, stepper motors and their drives
Course Outcomes: After successful completion of the course students will be able to:	
1	Understand and develop different processes.
2	Illustrate the different types of controllers and their tuning methods.
3	Discuss the various control schemes for continuous and discrete processes.
4	Discuss the working of DC motors, its characteristics, explain working of electrical drives, and DC motor drives.
5	Describe the working of Stepper motors ,BLDC motors and their respective drives.
6	Illustrate the working of AC motor and its drives

Process Instrumentation & Drives (Lab)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tut	Total
NARPCL53	Process Instrumentation & Drives (Lab)	---	02	---	---	01	---	01

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARPC53	Process Instrumentation & Drives (Lab)	---	---	---	25	25	50

Lab Prerequisite:	
Lab Objectives:	
1	To make students understand the basics of process control loops. Fundamental control actions and controllers.
2	To understand different control schemes.
Lab Outcomes: After successful completion of the course students will be able to:	
1	Explain basic process control loops.
2	Interface Loop instruments and test on pilot plant set ups.
3	Apply knowledge in developing and deciding control actions.
4	Explain the DC motor control techniques

5	Apply knowledge to understand various stepper motor and BLDC motor controls
6	Explain control methods of AC motor control

Process Instrumentation & Drives (Theory)

Module	Chapter	Content	Hrs
1		**Fundamentals of Process Control**	
	1.1	Process Control Terminology, Development of Typical Process control loops like Pressure, Temperature, flow & Level. Process characteristics, control system parameters, Dynamic elements in a control loop	6
	1.2	Dead time processes and smith predictor compensator. Inverse response behavior of processes and compensator. Dynamic Behavior of first and second order systems. Interacting and non-interacting systems	
2		**Process control actions & controller**	7
	2.1	**Control actions:** Need for control action, Types-Discontinuous, continuous (P, I, D) and composite control actions (PI, PD, and PID), Effects of control actions on control loop, selection criteria.	
	2.2	**Controllers:** Need for controller, General features and specifications, classification working of Pneumatic and Electronic controllers. controller Tuning Methods-Process reaction curve, Ziegler-Nichols method.	
3		**Control schemes**	
	3.1	**Continuous process control:** Feedback, Feed forward,	

		cascade, Ratio, split range, selective control, inferential control, and selection Guidelines.	7
	3.2	**Discrete state process control:** Need for Discrete state process control systems, Relay Logic symbols, Development of Relay ladder Logic diagram and case study examples.	
4		**DC Motor and DC Drives**	6
	4.1	Introduction to DC Motor, construction, working,types, Back emf, characteristics of DC shunt and series motor, torques equation, modelling of DC motor.	
	4.2	Introduction,advantages of electrical drives,parts of electrical drives,introduction to drive system. DC drive operation, four quadrant operation-motoring, plugging, dynamic and regenerative,braking using H Bridge L298 and L293 configurations.	
	4.3	Introduction to Servo motors- DC servomotors and its drives	
5		**Special Motors and Drives**	6
	5.1	Introduction to Stepper motor, construction, working, types, stepper motor drives, their types and working.	
	5.2	BLDC motors construction, working, BLDC drivers.	
6		**AC Motors and AC Drives**	

	6.1	3 phase Induction motor, construction, working, RMF, slip, torque slip characteristics, speed control techniques.	7
	6.2	AC drives, Current source inverter fed IM drive,V/f control, PWM control, closed loop control	
		Total	39

Textbooks:	
1	Curtis D. Johnson, "Process Control Instrumentation Technology", PHI /Pearson Education 2002
2	George Stephanopoulos, "Chemical process control", PHI-1999
3	B.L Thereja, Fundamentals of Electrical and Electronics, S. Chand
4	V.K Mehta, Rohit Mehta, Principles of Electrical Engg & Electronics, S.Chand
5	G.K Dubey, Fundamentals of Electrical Drives, Narosa Publication
6	S.K Pillai, First Course on Electrical Drives, New Age International
Reference Books:	
1	Bela G. Liptak, "Instrument Engineer"s Handbook – Process Control", Chilton Company, 1995
2	Bose, Modern Power Electronics and AC drives Pearson Education Inc2002
3	NPTEL LEctures,

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation the marks can be left blank (with discretion of faculty)	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Process Instrumentation & Drives **(Lab)**

Suggested Experiments: Students are required to complete at least 08 experiments.	
Star (*) marked experiments are compulsory.	
Sr. No.	**Name of the Experiment**
1	Study and plot Dynamic behavior of First order Hydraulic systems.
2	Study and plot Dynamic behavior of Second order Hydraulic systems.
3	Study Features and configuration of ON OFF controller.
4	Study Features and configuration of PID controllers.
5	Study of Temperature control Loop using ON OFF controller.
6	Study of Level control Loop using PID controller.
7	Study of AC Motor speed control using VFD.
8	Study of Pressure control Loop using PID controller & VFD.
9	DC Motor control methods
10	BLDC motor control methods
11	Stepper motor control techniques
12	AC motor control

Note: Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Suggested Factory visit to any Manufacturing facility / unit.

Suggested Factories:

Reliance Industries Ltd.

Term Work:	
1	Term work should consist of 10 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks (Experiments: 15-marks, Term work Assessment: 10-marks)

Advanced Sensors

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE51	Advanced Sensors (Theory)	03	-	-	03	-	-	03

Advanced Sensors (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE51	Advanced Sensors (Theory)	03	-	-	03	-	-	03

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARPE51	Advanced Sensors (Theory)	20	20	60	---	---	100

Course Prerequisite: Fundamentals of transducers	
Course Objectives:	
1	To learn the principles of sensors
2	To provide the knowledge about the sensor fabrication
3	To explore the students to the concepts of smart sensors
4	To provide knowledge of micro sensors and its fabrication
Course Outcomes: After successful completion of the course students will be able to:	
1	Explain the various principles employed in sensors
2	Examine the methods of fabricating a sensor.
3	Apply knowledge in designing smart sensors.
4	Discuss the techniques of fabrication and application of MEMS
5	Describe the various applications of smart sensors.
6	Discuss advanced sensing technology

Advanced Sensors (Theory)

Module	Chapter	Content	Hrs
1		**Introduction to Measurement Systems**	06
	1.1	Principle of physical and chemical transduction, sensor classification.	
	1.2	Characterization of mechanical, electrical, optical, thermal, magnetic, chemical and biological sensors, their calibration and determination of static and dynamic characteristics	
2		**Sensor Fabrication**	10
	2.1	Introduction to cleanroom environments and standards, Thick film sensing and thin film sensing Sensor fabrication techniques--deposition, patterning, etching and doping	
	2.2	Sensor fabrication techniques--deposition, patterning, etching and doping	
3		**Smart Sensors**	08
	3.1	Smart sensor features, architecture of smart sensors	
	3.2	signal conditioning: amplifiers, filters and A/D conversion for sensors, IEEE Standards for SMART sensing	
	3.3	Smart analog IC 500 and its applications	
4		**Micro Sensors**	06
	4.1	Introduction, Intrinsic characteristics of MEMS, common fabrication techniques	

	4.2	Application of MEMS in sensing systems including pressure sensors, accelerometers, gyroscopes and strain gauges.	
5		**Advanced Sensor Applications**	05
	5.1	Temperature & Humidity measurement using DHT Sensor in environment monitoring, Acceleration measurement using ADXL345 for automotive industry.	
	5.2	MEMS Temperature sensors for automotive applications, MEMS chemical sensors for survey meters, MEMS pressure sensors for medical applications	
6		**Advanced Sensing Technology**	06
	6.1	Sensors, instruments and measurement techniques for emerging application areas such as environmental measurement like DO (dissolved oxygen),BOD (biological oxygen demand), COD (chemical oxygen demand), TOC (total organic carbon), Cox (carbon dioxides), NOx (nitrogen oxide)	
	6.2	Sensors, instruments and measurement techniques for agricultural measurements such as soil moisture, wind speed, leaf wetness duration, sensors for food processing like smell or odour,taste	
		Total	39

Textbooks:	
1	Jacob Fraden, "Handbook of Modern Sensors", 5th Edition, Springer .
2	Chang Liu, "Foundations of MEMS", Pearson Education Inc.,2012.

3	Tai Ran Hsu, "MEMS & Microsystems Design and Manufacture", Tata Mc Graw Hill, New Delhi, 2002.
4	Stephen D Senturia, Microsystem Design, Springer Publication,2000
5	Randy Frank, " Understanding Smart Sensors", 2nd edition, Artech House, 2000.
Reference Books:	
1	Nadim Maluf, "An Introduction to Micro Electro Mechanical System Design", Artech House, 2000
2	Mohamed Gad-el-Hak, editor, "The MEMS Handbook", CRC press Baco Raton,2001
3	Julian w. Gardner, Vijay K. Varadan, Osama O.Awadelkarim, "Microsensors MEMS and Smart Devices", John Wiley & Son LTD,2002.
4	James J.Allen, "Micro Electro Mechanical System Design", CRC Press Publisher,2005.
5	Thomas M. Adams and Richard A. Layton, "Introduction to MEMS, Fabrication and Application", Springer,2010

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks

4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation the marks can be left blank (with discretion of faculty)	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Analytical Instrumentation

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE52	Analytical Instrumentation (Theory)	03	-	-	03	-	-	03

Analytical Instrumentation (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE52	Analytical Instrumentation (Theory)	03	-	-	03	-	-	03

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARPE52	Analytical Instrumentation (Theory)	20	20	60	---	---	100

Course Objectives:	
1	Introduce the basic concept of qualitative and quantitative analysis of a given sample.
2	Study various spectroscopic techniques and its instrumentation.
3	Study the concept of separation science and its applications
4	Study the concept of radiochemical analysis along with industrial analyzers
Course Outcomes: After successful completion of the course students will be able to:	
1	Define and explain various fundamentals of spectroscopy, qualitative and quantitative analysis.
2	Discuss the terms, principle, instrumentation, operation and applications of Molecular spectroscopic techniques.
3	Explain NMR spectroscopy and ESR spectroscopy
4	Differentiate between principle, instrumentation and operation of Atomic absorption and emission Spectroscopy.
5	Explain the various Separation techniques and its instrumentation.
6	Discuss the principle and working of various Gas analyzers.

Analytical Instrumentation (Theory)

Module	Chapter	Content	Hrs
1		**Introduction:**	9
	1.1	Introduction to Analytical Instrumentation. **Fundamentals of Spectroscopy:** Nature of Electromagnetic Radiation, Electromagnetic spectrum, Beer Lambert's Law statement and derivation. Deviations from Beer's law.	
	1.2	Numerical on EMR and laws of photometry.	
	1.3	Interaction of radiation with matter. Instrumentation of spectroscopic analytical system	9
	1.4	Radiation sources,Wavelength selectors, Detectors, signal processors and readout modules. Scintillation detector	
2		**Molecular Spectroscopy:**	
	2.1	Molecular Energy levels, correlation of energy levels with transitions. Electronic transitions and Vibrational transitions	
	2.2	Introduction to UV-VIS molecular spectroscopy – basics of single beam, double beam spectrophotometer and filter photometer, its instrumentation and applications.	
	2.3	Basic principle,components and instrumentation of Fluorimeters, Phosphorimeters and Raman spectrometers.	
3		**Molecular Spectroscopy**	4
	3.1	**Nuclear/Rotational transitions** – Nuclear Magnetic Resonance (NMR) spectroscopy, basic principle and numerical problems based	

		on NMR principle, instrumentation and constructional details of NMR Spectrometer.	
	3.2	**Electron Spin Resonance (ESR) Spectroscopy** – Basic principle and construction of ESR spectrometer.	
4		**Atomic Spectroscopy:**	03
	4.1	**Atomic Absorption Spectroscopy:** Atomic Energy levels, Atomic absorption spectrometers- components, working and absorption spectra	
	4.2	**Atomic Emission Spectroscopy:**Atomic Emission spectrometers – components, working and emission spectra, comparison between AAS and AES.	
5		**Separation Science:**	09
	5.1	**Chromatography:** Fundamentals of chromatographic Separations, Classification, Gas chromatographic system with components, factors affecting separation, applications. Analysis of Gas Chromatogram. HPLC – Its principle and instrumentation.	
	5.2	**Mass Spectrometers:** Basic principle, components and types of mass spectrometers, sample handling techniques for liquids and solids, resolution and numerical problems based on resolution.	
6		**Industrial Gas Analyzers:**	05
	6.1	Oxygen Analyzer, Combustion Gas Analyzers (COX, NOX, SOX, hydrocarbons), Gas density analyzer	
		Total	39

Textbooks:	
1	Willard, Merritt, Dean, Settle, Instrumental Methods of Analysis, CBS Publishers & Distributors, New Delhi, 7th Edition.
2	Khandpur R. S., Handbook of Analytical Instruments, Tata McGraw–Hill Publications, 3rd Edition.
Reference Books:	
1	Skoog, Holler, Niemen, Thomson Principles of Instrumental Analysis, Books-Cole Publications, 5th Edition.
2	Ewing Galen W., Instrumental Methods of Chemical Analysis, McGraw-Hill Book Company, 5th Edition
3	Braun Robert D., Introduction to Instrumental Analysis, McGraw-Hill Book Company
4	Sherman R.E., Analytical Instrumentation, ISA Publication.
5	B. R. Bairi, Balvinder Singh, N.C.Rathod, P.V.Narurkar, Handbook nuclear medical Instruments, McGraw Hill Book Company.

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks

2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation the marks can be left blank (with discretion of faculty)	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Digital Signal Processing

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE53	Digital Signal processing (Theory)	03	-	-	03	-	-	03

Digital Signal Processing (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE53	Digital Signal processing (Theory)	03	-	-	03	-	-	**03**

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARPE53	Digital Signal processing (Theory)	20	20	60	---	---	100

Course Prerequisite:	
Course Objectives:	
1	To make conversation with the fundamentals of digital signal processing.
2	To familiarize students with the Transforms used in Digital Signal Processing.
3	To familiarize students with the design techniques and performance analysis of digital filters.
4	To introduce digital signal processors and applications.
Course Outcomes: After successful completion of the course students will be able to:	
1	Apply the concept of DT Signal and DT Systems.
2	Classify and analyze discrete time signals and systems.
3	Implement Digital Signal Transform techniques DTFT, DFT and FFT.
4	Design IIR digital filters to meet arbitrary specifications and Develop algorithms for implementation.
5	Design FIR digital filters to meet arbitrary specifications and Develop algorithms for implementation.
6	Use signal processing techniques and digital signal processors in various applications.

Digital Signal Processing (Theory)

Module	Chapter	Content	Hrs
1		**Discrete-Time Signal and Discrete-Time Systems**	08
	1.1	Introduction to Digital Signal Processing, Sampling and Reconstruction, Standard DT Signals, Concept of Digital Frequency, Representation of DT signal using Standard DT Signals, Signal Manipulations-shifting, reversal, scaling, addition, multiplication.	
	1.2	Classification of Discrete-Time Signals, Classification of Discrete-Systems, LTI system, Impulse Response.	
	1.3	Linear Convolution, Circular Convolution- Emphasis on graphical method, linear convolution using Circular Convolution. Software simulation - Impulse Response, Step Response, convolution, Correlation.	
2		**Frequency Domain Analysis using DTFT and Z Transform**	07
	2.1	Introduction to DTFT. Properties of DTFT.	
	2.2	Z transform - definition, properties of unilateral and bilateral Z Transform, Z transform of standard signals, ROC, poles and zeros of transfer function, Inverse Z transform.	
	2.3	Analysis and characterization of LTI system using Z transform, impulse and step response, causality, stability, stability of causal system.	

3		**Discrete Fourier Transform and Fast Fourier Transform**	06
	3.1	DFT, Relation between DFT and DTFT, IDFT.	
	3.2	Properties of DFT, circular convolution of sequences using DFT.	
	3.3	Fast Fourier transforms (FFT), Radix-2 decimation in time and decimation in frequency FFT algorithms, inverse FFT.	
4		**IIR Digital Filters**	08
	4.1	Comparison of IIR and FIR filters, Types of IIR Filters, Analog filter approximations Butterworth, Chebyshev I and II.	
	4.2	Mapping of S-plane to Z-plane, impulse invariance method, bilinear transformation method.	
	4.3	Design of IIR digital filters from analog filters with examples, Software simulation – Design of IIR Filters. Analog and digital frequency transformations.	
5		**FIR Digital Filters**	06
	5.1	Characteristics of FIR digital filters, Minimum Phase, Maximum Phase, Mixed Phase and Linear Phase Filters Frequency response, location of the zero of linear phase FIR filters	
	5.2	Design of FIR filters using window techniques -Rectangular, Hamming, Hanning, Blackman, Bartlett, Software simulation – Design of FIR Filters.	
6		**DSP Processors and Applications**	04

	6.1	General purpose digital signal processors, DSP processor architecture, Selecting digital signal processors, Special purpose DSP hardware.	
	6.2	Applications of DSP: Radar Signal Processing and Speech Processing.	
		Total	39

Textbooks:	
1	Emmanuel C. Ifeachor, Barrie W. Jervis, "Digital Signal Processing", A Practical Approach by, Pearson Education – Second edition
2	Tarun Kumar Rawat, "Digital Signal Processing", Oxford University Press, 2015
3	S Salivahanan, A Vallavaraj, C Gnanapriya. "Digital Signal Processing" – TMH, 2007
Reference Books:	
1	Proakis J., Manolakis D., Digital Signal Processing, 4th Edition, Pearson Education
2	Sanjit K. Mitra, "Digital Signal Processing – A Computer Based Approach", edition 4e McGraw Hill Education (India) Private Limited.

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation the marks can be left blank (with discretion of faculty)	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Artificial Intelligence

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARMM51	Artificial Intelligence	03	-	-	03	-	-	03

Artificial Intelligence (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARMM51	Artificial Intelligence	03	-	-	03	-	-	03

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARMM51	Artificial Intelligence	20	20	60	---	---	100

Artificial Intelligence (Theory)

Course Prerequisite: Knowledge about Linear algebra and probability	
Course Objectives:	
1	To familiarize the students' with specific, well known Artificial Intelligence methods, algorithms and knowledge representation schemes.
2	To introduce students' different techniques which will help them build simple intelligent systems based on AI concepts.
3	To familiarize the students' with Fuzzy Logic Systems and Fuzzy Logic Controllers.
Course Outcomes: After successful completion of the course students will be able to:	
1	Develop a basic understanding of the building blocks of AI systems.
2	Apply an appropriate problem-solving method for knowledge engineering.
3	Apply an appropriate reasoning and logic method for knowledge engineering.
4	Describe the basic concepts of Fuzzy Logic and Fuzzy Systems.
5	Demonstrate and Evaluate various Fuzzy Logic Controllers and their applications.
6	Apply AI and Fuzzy system algorithms for automation and robotics.

Artificial Intelligence (Theory)			
Module	**Chapter**	**Content**	**Hrs**
1		**Introduction to Artificial Intelligence:**	04
	1.1	The Foundations of Artificial Intelligence	
	1.2	The History of Artificial Intelligence	
	1.3	Risks and Benefits of AI	
	1.4	AI problem examples (Tic-Tac-Toe, Water jug, 8 puzzle, 8 queens, Missionaries and Cannibals, etc)	
2		**Problem Solving and Searching:**	08
	2.1	Problem-Solving Agents.	
	2.2	Search Algorithms	
	2.3	Uninformed Search methods (breadth-first, depth-first, bidirectional search)	
	2.4	Informed Search methods (A*, Best First Search, heuristic functions, Hill Climbing)	
	2.5	Local Search and Optimization Problems	
	2.6	Comparing Different Techniques	
3		**Knowledge, reasoning, and planning:**	08
	3.1	Knowledge-Based Agents	

	3.2	The Wumpus World	
	3.3	Propositional Logic	
	3.4	Syntax and Semantics of First-Order Logic	
	3.5	Knowledge Engineering in First-Order Logic	
	3.6	Propositional vs. First-Order Inference	
	3.7	Forward and Backward Chaining	
4		**Introduction to Fuzzy Logic:**	08
	4.1	Classical and Fuzzy sets: Operations, Properties, Mapping	
	4.2	Classical and Fuzzy Relations: Cartesian Product of relation, classical relation, fuzzy relations, tolerance and equivalence relations, non-iterative fuzzy sets	
	4.3	Membership Function: features of the membership functions, fuzzification, methods of membership value assignments	
	4.4	Defuzzification methods	
5		**Fuzzy logic controllers:**	05
	5.1	Components of a fuzzy controller	
	5.2	Architecture and applications of Mamdani Systems	
	5.3	Architecture and applications of Takagi-Sugeno Systems	
6		**Application case studies:**	06
	6.1	Washing Machine Controller, Water Purifier Controller, Domestic Shower Controller, Electric Vehicle Battery	

		Charging Controller, Home Heating System, Fuzzy PID Controllers, etc.	
		Total	39

Textbooks:	
1	Kumar, Ela. Artificial intelligence. IK International Pvt Ltd, 2013
2	Elaine Rich, Kevin Knight, Shivshankar B Nair, Artificial Intelligence, McGraw Hill, 3rd Edition.
3	S.N. Sivanandam, S.N. Deepa, "Principles of Soft Computing", Wiley Publication.
4	Gupta, Itisha, and Garima Nagpal. Artificial Intelligence and Expert Systems. Stylus Publishing, LLC, 2020.
Reference Books:	
1	Russell, Peter Norvig. "Artificial intelligence: a modern approach by stuart." Russell and Peter Norvig contributing writers, Ernest Davis...[et al.] (2010).
2	Deepak Khemani, A First Course in Artificial Intelligence, McGraw Hill Publication.
3	Ross, Timothy J. Fuzzy logic with engineering applications. John Wiley & Sons, 2005.

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc.	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation the marks can be left blank (with discretion of faculty)	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Cyber Laws & Digital Forensics

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NOE501	Cyber Laws & Digital Forensics	03	-	01	03	-	01	04

Cyber Laws & Digital Forensics (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NOE501	Cyber Laws & Digital Forensics	03	-	01	03	-	01	04

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NOE501	Cyber Laws & Digital Forensics	20	20	60	-	---	100

Cyber Laws & Digital Forensics (Theory)

Course Prerequisite: Computer Communication Networks CSS	
Course Objectives:	
1	To understand various cyber-attacks and different categories of Cybercrime.
2	To explore the procedures for identification, preservation, and extraction of digital evidence.
3	To discuss the need of digital forensics and procedure for the same along with understanding Incident Response Methodology.
4	To explore techniques and tools used in digital forensics for system investigation.
5	To understand the laws related to Cybercrime.
Course Outcomes: After successful completion of the course students will be able to:	
1	Comprehend the various types of cyber-attacks and categories of cybercrime, enabling effective identification and understanding of emerging threats.
2	Understand the importance of digital forensics and apply standard procedures and incident response methodologies for effective investigation and evidence management.
3	Demonstrate the ability to identify, preserve, and extract digital evidence from different digital devices and systems following established forensic protocols.
4	Utilize appropriate techniques and tools to conduct system investigations, including analyzing data from various digital sources.
5	Execute investigations of network and host-based system intrusions, identifying attack vectors and relevant evidence.

Module No.	Unit No.	Topics	Hrs.
1		**Introduction to Cybercrime and Hacking**	08
	1.1	Cybercrime, Categories of Cybercrime (Cybercrime against people, Cybercrime Against property, Cybercrime Against Government).Types of cybercrime (Violent- Cyber terrorism, Assault by Threat, Cyberstalking, Child Pornography, Non-violent - Cybertrespass, Cyber Theft, Cyber Fraud, Destructive Cybercrimes), Computers' role in crimes.	
	1.2	Hacking, Life cycle of Hacking, Types of Hackers (White Hat hackers, Black Hat hackers, Grey Hat hackers), Hacking techniques Passive and Active Attacks, Social Engineering, Attacks vs Vulnerabilities, Prevention of Cybercrime	
	1.3	torial 1: Distinction between computer crimes and conventional crimes.	
2.0		**Introduction to Digital Forensics**	07
	2.1	Objectives of digital forensics, Process of digital forensics, Types of digital forensics, Challenges faced by digital forensics.	
	2.2	Incident Response - Introduction to Incident Response, Computer Security 2.2 Incident, Goals of Incident Response, CSIRT, Incident Response Methodology, Phases after incident notification and Detection.	
	2.3	Tutorial 2: Distinction between Computer virus, worm, Trojan horse and trap door, IOT Security, Forensic Linguistics.	
3		**Digital Evidence and Forensics Duplication**	07
	3.1	Digital evidence, Admissibility of evidence, Challenges in evidence handling,	

		collecting digital evidence, Preserving digital evidence, Documenting evidence.	
	3.2	Necessity of forensic duplication, Forensic duplicates as admissible evidence, Forensic image formats, Forensic duplication techniques, Disk imaging.	
	3.3	torial 3:Forensic duplication techniques	
4.0		**System Investigation**	08
	4.1	Live/volatile data collection from Windows and Unix Systems	
	4.2	Investigating Windows systems, Investigating UNIX systems, Investigating applications, Web browsers.	
	4.3	Recovering digital evidence, Acquiring, Analyzing and duplicating data: dd, dcfldd, foremost, scalpel (Demonstration)	
		torial 4: Methods of storing data (RAM and Hard disk)	
5.0		**Network Forensics**	05
	5.1	Introduction to intrusion detection systems, Types of IDS, Understanding network intrusion and attacks.	
	5.2	Analyzing network traffic, collecting network-based evidence, Evidence handling. Investigating routers	
	5.3	torial 5: Evidence handling. Investigating routers	
6.0		**Laws related to Cyber Crime**	04
	6.1	Constitutional law, Criminal law, Civil law, Levels of law: Local laws, State	

		laws, Federal laws, International laws. Levels of culpability: Intent, Knowledge, Recklessness, Negligence. CFAA, DMCA, CAN Spam.	
	6.2	Indian National Cyber Law: Various sections in National Cyber Law to mitigate Cyber Crime ,National Cyber Security Policy, IT Act 2000, Digital personal Data Protection Act 2023 (DPDPA-23)	
	6.3	Tutorial 6: Relevant law to combat computer crime –Information Technology Act, Cyber Regulations Appellate Tribunal (CRAT)	
Total			39

Textbooks:	
1	Kevin Mandia, Chris Prosise, "Incident Response and computer forensics", Tata McGrawHill, 2006
2	"Scene of the Cybercrime: Computer Forensics" Handbook 1st Edition, Kindle Edition
3	"Digital Forensics", Nilakshi Jain & Kalbande, Wiley Publication
4	"Cyber Security", Nina Godbole, Sunit Belapure, Wiley Publication
Reference Books:	
1	Bill Nelson,Amelia Phillips,Christopher Steuart, "Guide to Computer Forensics and Investigations" . Cengage Learning, 2014
2	Debra Littlejohn Shinder Michael Cross "Scene of the Cybercrime: Computer Forensics Handbook", 2nd Edition Syngress Publishing, Inc.2008.

3	Course on "Ethical Hacking" https://nptel.ac.in/courses/106/105/106105217/ Course on "Digital Forensics" https://onlinecourses.swayam2.ac.in/cec20_lb06/preview Course on "Computer Forensics" https://www.edx.org/course/computer-forensics Course on Cyber Incident Response https://www.coursera.org/learn/incident-response Course on "Penetration Testing, Incident Responses and Forensics" https://www.coursera.org/learn/ibm-penetration-testing-incident-response-forensics Comparison of Cyber Security (Case Study by PWC) https://www.pwc.com/id/en/pwc-publications/services-publications/legal-publications/a-comparison-of-cybersecurity-regulations/india.html#:~:text=Overviews,aspects%20of%20cybersecurity%20as%20follows:

Internal Assessment
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. The Mid Term test is to be conducted when approximately 50% syllabus is completed and its duration will be one hour.
Continuous Assessment :-
Continuous Assessment will be based on the tutorials undertaken

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Geographical Information Systems

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NOE502	Geographical Information Systems (Theory)	03	-	-	03	-	-	03
NOE502	Geographical Information Systems (Lab)	-	02	-	-	01	-	01

Geographical Information Systems (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NOE502	Geographical Information Systems (Theory)	03	-	-	03	-	-	03

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NOE502	Geographical Information Systems	20	20	60	-	---	100

Course Prerequisite:	
Course Objectives:	
1	Provide fundamental understanding of Geographic Information Systems (GIS) and Remote Sensing (RS) technologies
2	Introduce concepts of geospatial data, spatial data models, and data quality
3	Teach spatial analysis methods and GIS data visualization techniques
4	Explore principles of remote sensing, image interpretation, and sensor systems
5	Familiarize students with map projections, coordinate systems, and cartographic design
6	Equip students with the knowledge to apply GIS in urban planning, infrastructure,disaster management, and environmental monitoring.
Course Outcomes: After successful completion of the course students will be able to:	
1	Define the core concepts of GIS and Remote Sensing, and explain their components, structure, and applications
2	Differentiate between spatial data models and understand data input, storage,quality issues
3	Interpret geospatial data using map projections, coordinate systems, and cartographic principles
4	Perform vector and raster-based spatial analyses including buffering, overlay,and spatial interpolation
5	Explain the principles of remote sensing, energy interactions, satellite platforms,and image interpretation
6	Apply GIS and RS techniques in real-world applications such as urban planning,environmental monitoring, and disaster management

Lab Prerequisite:	
Lab Objectives:	
1	To provide hands-on experience with GIS software for spatial data handling and visualization.
2	To enable students to perform spatial queries and analysis using vector and raster data.
3	To introduce georeferencing, digitization, and cartographic design principles in a GIS environment.
4	To develop skills in satellite image interpretation and remote sensing data processing.
5	To apply GIS techniques in real-world thematic mapping and project-based scenarios.
Lab Outcomes: After successful completion of the course students will be able to:	
1	Use GIS software tools to load, manage, and visualize spatial data effectively.
2	Perform georeferencing and digitization of raster and scanned maps.
3	Apply spatial queries and attribute operations on vector data.
4	Conduct basic spatial analysis including buffering, overlay, and terrain analysis.
5	Interpret satellite images and perform basic image classification techniques.
6	Design thematic maps with proper cartographic elements and export them for reporting.

Geographical Information Systems **(Theory)**

Sr. No.	Module	Detailed Content	Hours
I	Introduction to GIS	Defining GIS, GIS-Systems, GIS Applications, Spatial data, Geoinformation, Understanding maps and data, Data layers, Spatial data types, Characteristics of spatial data, Metadata, Making great maps, Data visualization principles, GIS software, GIS architecture and functionality, Spatial Data Infrastructure (SDI), Spatial data handling and preparation, Spatial data storage and maintenance, Spatial query and analysis, Spatial data presentation, Linking GIS and DBMS, Spatial database functionality	6
II	Geospatial Data and Mapping Concepts	Geospatial data, Geographic coordinate system, Datum and reference systems, Map projections, Commonly used map projections, UTM grid system, Map scale, Types of maps, Cartographic symbolization, Typography in maps, Map design principles, Map production techniques, Layout design, Cartographic generalization, Interpretation of topographic maps	6

III	Data Models and Quality Issues	Vector data model, Topological models, Non- topological models, Attribute data entry, Vector data query, Field and attribute manipulation, Raster data model, Elements of raster structure, Types of raster data, Raster queries, Data compression, Data conversion, Raster-vector integration, Data input methods, Data editing techniques, Data quality components, Accuracy, Precision, Resolution, Consistency, Completeness, Common sources of error in GIS	6
IV	GIS Data Analysis and Spatial Modelling	Data exploration, Descriptive statistics, Graphical data representation, Dynamic graphics, Vector data analysis, Buffering, Overlay, Distance measurement, Pattern analysis, Map manipulation, Raster data analysis, Local operations, Neighborhood operations, Zonal operations, Data extraction, Data generalization, Comparison of raster and vector analysis, Spatial interpolation, Global interpolation methods, Local interpolation methods, Slope analysis, Aspect analysis,	7
V	GIS Project Planning and Applications	Principles of remote sensing, Electromagnetic spectrum basics, Energy sources in remote sensing, Interaction of energy with Earth's surface, Atmospheric interaction, Spectral reflectance characteristics, Remote sensing platforms, Satellite systems, Sensor parameters, Imaging sensors, Earth resource satellites, Meteorological satellites, Remote sensing data formats, Standard products, Image interpretation, Elements of image interpretation	7

VI	GIS Project Planning and Applications	GIS project planning, Project implementation stages, Project management in GIS, Case study of GIS application, Multimedia GIS, Internet GIS, Web-based GIS, Mobile GIS, GIS in urban planning, GIS in municipal applications, GIS for infrastructure development, GIS for disaster management, GIS for environmental monitoring	7
		Total	39

Textbooks:	
1	Kang-tsung Chang, *Introduction to Geographic Information Systems*, Tata McGraw-Hill,3rd Edition, 2003
2	M. Anji Reddy, *Remote Sensing and Geographical Information Systems*, B.S. Publications, 2nd Edition, 2001
3	Basudeb Bhatta, *Remote Sensing and GIS*, Oxford University Press, 2nd Edition
4	Ian Heywood, Sarah Cornelius, et al., *An Introduction to Geographical Information Systems*, Pearson Education, 2nd Edition
Reference Books:	
1	C.P. Lo and Albert K.W. Yeung, Concepts and Techniques of Geographic Information Systems, Prentice 2nd Edition
2	Paul A. Longley, Michael F. Goodchild, David J. Maguire, and David W. Rhind, *Geographic Information Systems and Science*, Wiley, 3rd Edition
3	Online QGIS Documentation: https://docs.qgis.org
4	India Geospatial Education Portal (IGET): https://dst-iget.in
5	GitHub: *Learning Geospatial Analysis with Python* - https://github.com/PacktPublishing/Learning-Geospatial-Analysis-with-Python-Third-Edition

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment will be based on the Labs undertaken.

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Geographical Information Systems **(Lab)**

Suggested Experiments: Students are required to complete at least 10 experiments.	
Star (*) marked experiments are compulsory.	
Sr. No.	**Name of the Experiment**
1*	Introduction to GIS Software: Exploring QGIS/ArcGIS interface and tools
2*	Georeferencing: Scanned maps using control points and coordinate systems
3*	Digitization: Creating vector layers (point, line, polygon) from raster base maps
4*	Working with Coordinate Systems: Assigning and transforming projections
5*	Attribute Table and Queries: Managing data and SQL-based queries
6*	Buffer and Overlay Analysis: Buffering, intersect, and union operations
7*	Raster Data Handling: Loading imagery and raster calculations
8*	Terrain Analysis: Generating slope, aspect, hillshade from DEM
9*	Map Layout Design: Creating layouts with legends, scale bar, and title
10*	Image Interpretation: Visual interpretation using tone, pattern, and texture
11*	Supervised and Unsupervised Classification: Image classification techniques

Note: Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Term Work:	
1	Term work should consist of 8 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks (Experiments: 15-marks, Term work Assessment: 10-marks)

Artificial Intelligence for Healthcare

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NOE503	Artificial Intelligence for Healthcare	03	-	01	03	-	01	04

Artificial Intelligence for Healthcare (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NOE503	Artificial Intelligence for Healthcare	03	-	01	03	-	01	04

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NOE503	Artificial Intelligence for Healthcare	20	20	60	-	---	100

Artificial Intelligence for Healthcare (Theory)

Course Prerequisite:	
Course Objectives:	
1	Desire to learn Artificial Intelligence and machine learning
2	Knowledge of higher school level math
3	Learn AI applications in medical imaging, diagnostics, disease prediction, and treatment planning
4	Examine ethical, legal, and social issues of AI in medicine.
5	Gain hands-on experience through tools and projects.
6	Critically evaluate AI research and real-world applications in healthcare.
Course Outcomes: After successful completion of the course students will be able to:	
1	To understand the fundamentals of artificial intelligence and machine learning and their applications in medicine.
2	To explore advanced AI techniques, including deep learning, reinforcement learning, and natural language processing.
3	To learn about the use of AI in medical imaging, diagnostics, disease prediction, and treatment planning.
4	To examine the ethical, legal, and social implications of AI in medicine, including issues of bias, privacy, and equity.
5	To gain hands-on experience with AI tools and platforms through practical exercises and projects.
6	To critically evaluate research studies and applications of AI in healthcare.

Artificial Intelligence for Healthcare (Theory)

Unit No.	Module Title	Course Content (Topics and Subtopics)	Hours
1	Introduction to AI in Healthcare	Definition and scope of AI in healthcare, Role of AI in modern healthcare systems, AI-assisted diagnostics and treatments, Applications of AI in clinical decision support systems (CDSS),AI in medical research and drug discovery, Examples of AI-powered healthcare systems	6
2	AI for Medical Diagnostics and Imaging	Overview of Machine Learning and Deep Learning, Basics of medical image analysis, Image classification and segmentation using AI, Computer Vision applications in radiology and pathology, AI-assisted diagnosis for diseases, Introduction to Generative AI in medical imaging	7
3	Predictive Analytics and Disease Management	AI models for disease prediction and prognosis,Predictive modeling for early disease detection,Personalized healthcare using AI, Monitoring chronic diseases using AI-based wearable devices,Case studies on AI in disease management (e.g., Diabetes, Heart disease)	6
4	Natural Language Processing (NLP) in Healthcare	Fundamentals of NLP in medical data analysis,Clinical text processing and medical report analysis, Information extraction from Electronic Health Records (EHR),AI chatbots and virtual assistants for patient support Applications of NLP in medical analysis	7

5	Data Mining and Big Data Analytics in Healthcare	Introduction to Data Mining in Healthcare,Techniques for data extraction, preprocessing, and cleansing, Big Data Analytics in Healthcare: Characteristics of big data in healthcare,Tools for big data management (e.g., Hadoop, Spark) IBM Watson in Healthcare: Watson's role in medical diagnostics and decision-making,Case studies of IBM Watson applications	7
6	Ethics, Challenges, and Future Trends in AI Healthcare	Ethical considerations in AI healthcare applications,Bias, fairness, and explainability in medical AI,Data privacy and security concerns (HIPAA, GDPR compliance),Regulatory frameworks for AI in healthcare,Emerging trends: Generative AI, Digital Twins, Federated Learning in healthcare	6

Reference Books:	
1	Russell, S. and Norvig, N. Artificial Intelligence: A Modern Approach. Prentice Hall Series in Artificial Intelligence 3
2	AI-First Healthcare by Kerrie L. Holley, Siupo Becker Released April 2021, Publisher(s): O'Reilly Media, Inc.ISBN: 9781492063155
3	"AI and Machine Learning for Healthcare" – Arvind Rajan (O'Reilly)
4	"Machine Learning and AI for Healthcare: Big Data for Improved Health Outcomes" – by ArjunPanesar
5	"Healthcare Analytics Made Simple: Techniques in Healthcare Computing Using MachineLearningand Python" – by Vikas (Vik) Kumar

Useful Links:	
1	https://onlinecourses.nptel.ac.in/noc21_cs84/preview – NPTEL: AI for Healthcare by IIT Madras
2	https://ai4health-course.github.io/ – AI for Health Course (MIT, Harvard, Stanford inspired)
3	https://monai.io/ – MONAI: Medical Open Network for AI (PyTorch framework for healthcare)
4	https://www.deeplearning.ai/programs/ai-for-medicine/ – DeepLearning.AI: AI for Medicine Specialization
5	https://mimic.physionet.org/ – MIMIC-III: Medical Information Mart for Intensive Care (Clinical Dataset)

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment will be based on the tutorials undertaken.

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Social Media Analytics

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NOE504	Social Media Analytics	03	-	01	03	-	01	04

Social Media Analytics (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NOE504	Social Media Analytics	03	-	01	03	-	01	04

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NOE504	Social Media Analytics	20	20	60	---	---	100

Social Media Analytics (Theory)

Course Prerequisite: 1. Desire to learn Artificial Intelligence and machine learning 2. Knowledge of higher school level math	
Course Objectives:	
1	To introduce and familiarize learners with the basics of social networks (nodes, edges, graph paths).
2	To Introduce various fundamental measures in social networks (centrality, density,clustering)
3	To Explore various community detection and network clustering techniques.
4	To Familiarize the learners with concepts of link analysis and prediction.
5	Familiarize the learner with advanced social network topics like text analytics and social information filtering.
6	To introduce the concept of Social media analytics and its various applications across popular social media.
Course Outcomes: After successful completion of the course students will be able to:	
1	Understand the concept of Social networks and how to represent them.
2	Analyze and interpret social networks using different Social network measures.
3	Detect and analyze communities in Social networks.
4	Implement and design algorithms for Link analysis and link prediction Social networks.
5	Analyze the effectiveness of social media for business applications.
6	Interpret the social media landscape and implement projects for real life social media applica

Module	Detailed Content	Hrs.
1.	**Introduction to Social Networks/Media**	
	Overview and Basic Concepts, Definition and importance of Social Networks andSocial Network Analysis.(SNA), Historical background and evolution of SNA. Three Levels of SNA, Applications and tools. Preliminaries and Basic concepts: nodes, edges, graphs, networks. GraphVisualisation Tools, Social Media Analytics (SMA) Cycle, Challenges to SocialMedia Analytics, SMA Tools.	6
2.	**Network Measures**	
	Network Basics - Degree and Degree Distributions, Paths, Clustering Coefficient, Connected Components **Node Centrality** – Degree centrality, Closeness Centrality, Betweenness centrality, Edge Betweenness centrality, Assortativity, Transitivity and Reciprocity, Similarity. **Properties of Real-World Networks –** High Average Local Clustering Coefficient, Small-world Property, Scale-free Property. **Random Network Model**- Degree Distribution of Random Network, Evolution of a Random Network, Average Path Length, Clustering Coefficient, Random Network vs. Real-world Network.	8
3.	**Community Structure in Networks**	7
	Definition of Communities in social networks, Applications of Community Detection, Types of Communities. **Community Detection Methods:** Disjoint Community Detection- Node-Centric Community Detection, Modularity and Community Detection- Louvain Algorithm, Girvan Newman; Overlapping Community Detection: Clique Percolation, Link Partition; Local Community Detection.	

4.	**Link Analysis**	6
	Applications of Link Analysis, **Signed Networks** - Balance Theory of Undirected Signed Networks, Status Theoryof Signed Networks, Triad Balance vs Status, **Strong and Weak Ties** - Strength of a Ties, Triadic Closure, Dunbar Number,Local Bridges and Importance of Weak Ties. **Link Prediction** Applications of Link Prediction, Temporal Changes in a Network, HeuristicModels, Probabilistic Models, Latest Trends in Link Prediction.	
5.	**Social Information Filtering**	4
	Social Media Text Analytics- Types of Social Media Text, Purpose of TextAnalytics, Steps in Text Analytics, Social Media Text Analysis. **Social Information Filtering**- Social Sharing and filtering , AutomatedRecommendation systems, Traditional Vs social Recommendation Systems. Understanding Social Media and Business Alignment, Social Media KPI,Formulating a Social Media Strategy, Managing Social Media Risks.	
6.	**Social Media Analytics and Applications**	8
	Introduction to popular social media platforms, (Facebook, Twitter, Instagram,LinkedIn etc), Key characteristics of social media data, (unstructured, large-scale,user-generated). Differences between traditional data and social media data. Tools for Social media Analytics Applications of Social media Analytics with Case studies - Mining Twitter (X),Facebook, Instagram, LinkedIn, Github	
	Total	39

Textbooks:	
1	Social Network Analysis, Tanmoy Chakraborty, Wiley Publications 2021
2	Mining the Social Web, 3rd Edition, by Matthew A. Russell, Mikhail Klassen
3	Analyzing the Social Web 1st Edition by Jennifer Golbeck

	Reference:
1	P.M., Krishna & Mohan, Ankith & Srinivasa, K..Practical Social Network Analysis with Python. Springer
2	Mining the Social Web, 3rd Edition, by Matthew A. Russell, Mikhail Klassen
3	Social Media Analytics: Techniques and Insights for Extracting Business Value Out of Social Media, Matthew Ganis, Avinash Kohirkar, IBM Press
4	Python Social Media Analytics: Analyze and visualize data from Twitter, YouTube, GitHub, and more Kindle Edition by Siddhartha Chatterjee, Michal Krystyanczuk
5.	Learning Social Media Analytics with R, byRaghav Bali, Dipanjan Sarkar, Tushar Sharma.

	Useful Links
1	https://cse.iitkgp.ac.in/~pawang/courses/SC16.html
2	https://onlinecourses.nptel.ac.in/noc20_cs78/preview
3	https://nptel.ac.in/courses/106106146
4	https://www.cs.cornell.edu/home/kleinber/networks-book
5	https://networksciencebook.com/ - Albert-László Barabási

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment will be based on the tutorials undertaken.

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Mobile App Development

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NOE505	Mobile App Development (Theory)	03	-	-	03	-	-	03
NOE505	Mobile App Development (Lab)	-	02	-	-	01	-	01

Mobile App Development
(Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NOE505	Mobile App Development (Theory)	03	-	-	03	-	-	03

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NOE505	Mobile App Development (Theory)	20	20	60	-	---	100

Course Prerequisite:	
Course Objectives:	
1	Learn the basics of the Flutter framework.
2	Develop the App UI by incorporating widgets, layouts, gestures and animation
3	Create a production ready Flutter App by including files and firebase backend service.
4	To equip learners with skills to implement effective unit, widget, and integration testing in Flutter applications, ensuring code reliability and maintainability.
5	To provide hands-on knowledge of deploying Flutter apps to Android and iOS platforms, configuring CI/CD pipelines, and managing post-deployment analytics.
6	To introduce Flutter Web development, focusing on responsive UI, state management, performance optimization, and deployment on modern hosting platforms.
Course Outcomes: After successful completion of the course students will be able to:	
1	Understand cross platform mobile application development using Flutter framework
2	Design and Develop interactive Flutter App by using widgets, layouts, gestures and animation
3	Analyze and Build production ready Flutter App by incorporating backend services and deploying on Android / iOS
4	Learners will be able to design, write, and automate Flutter tests across various levels, analyze failures, and improve code quality using modern testing tools and practices.
5	Learners will be capable of preparing production-ready Flutter apps, deploying them to app stores, automating releases with CI/CD tools, and handling real-time user feedback.
6	Learners will gain the ability to build and deploy responsive, performant Flutter web applications with PWA features, API integrations, and SEO considerations.

Module	Contents	Hrs
1	**Cross-Platform Development:** **Understanding Flutter:** Introduction of Flutter, Understanding Widget Lifecycle Events, Dart Basics, Widget Tree and Element Tree, Basics of Flutter installation, Flutter Hello World App. **Dart Programming:** main() function, Dart Variables, Dart Data Types, Dart Conditional Operators, Control Flow & Loops. Dart Functions - Functions, Function Structure, creating a Function, Function Returning Expression. Object-Oriented Programming (OOP) - Creating a Class, Adding Methods to Classes, Class — Getters and Setters, Class Inheritance, Abstract Class.	7
2	**Developing Flutter UI: Widgets, Layouts, Gestures, Animation:** USING COMMON WIDGETS: Safe Area, Appbar, Column, Row, Container, Buttons, Text , Richtext, Form ,Images and Icon. BUILDING LAYOUTS : high level view of layouts, Creating the layout, Types of layout widgets APPLYING GESTURES: Setting Up Gesture Detector, Implementing the Draggable and Drag target Widgets, Using the Gesture Detector for Moving and Scaling ADDING ANIMATION TO AN APP :Using Animated Container, Using Animated Cross Fade, Using Animated Opacity, Using Animation Controller, Using Staggered Animation CREATING AN APP'S NAVIGATION: Using the Navigator, Using the Named Navigator Route, Using the Bottom Navigation Bar, Using the Tab Bar and Tab Bar View.	7
3	**Creating Production Ready Apps:** Working with files : Including libraries in your Flutter app, Including a file with your app, Reading/Writing to files, Using JSON. Using Firebase with Flutter: Adding the Firebase and Fire store Backend, Configuring the Firebase Project, Adding a Cloud Fire store Database and Implementing Security Testing and Deploying of Flutter Application: Widget testing, Deploying Flutter Apps on Android / iOS.	6

4	**Flutter Testing: Introduction to Testing in Flutter:** Importance of Testing in App Development,Types of Testing: Unit, Widget, and Integration,Setting Up Flutter Testing Environment **Unit Testing:** Writing Unit Tests for Dart Functions and Classes,Using test package,Mocking Dependencies using mockito,Best Practices in Unit Testing **Widget Testing:** Testing Widgets in Isolation,Using flutter_test Package,Simulating User Interactions,Golden Tests for UI validation **Integration Testing:**Setting Up Integration Tests,Using integration_test Package,Running Tests on Emulators and Real Devices,Automating Tests with CI/CD Pipelines (GitHub Actions/GitLab CI) **Debugging and Coverage:** Analyzing Test Failures,Improving Test Coverage,Using Code Coverage Tools like lcov and flutter_coverage.	05
5	**Flutter Deployment:** **Preparing for Deployment:** Preparing for Deployment, App Versioning and Build Flavors, Managing Secrets & Environment Variables, Generating Keystore for Android, Setting up iOS Certificates and Profiles **Android Deployment:**Building APKs and AABs, Signing & Obfuscating Builds, Uploading to Google Play Store, Using Play Console Features (Testing Tracks, Release Management) **iOS Deployment:**Building and Signing iOS Apps, Using Xcode for Archive and Distribution, Uploading to App Store using Transporter or Xcode, TestFlight for Beta Testing **CI/CD for Flutter Deployment**: Automating Build and Release (Codemagic, GitHub Actions, Bitrise), Integrating Fastlane for Flutter Projects **Post-Deployment:** Crash Reporting & Analytics (Firebase Crashlytics), In-App Updates, Feedback Collection	07
6	**Flutter for Web:** **Introduction to Flutter Web**: Flutter Web Architecture,Differences from Mobile Development, Setting up for Web Development **Building Web UI:** Responsive Design with Flutter, Navigation with go_router or Navigator 2.0, Web-specific Widgets and Customizations, **State Management:** Choosing the Right State Management for Web (Provider, Riverpod, Bloc), Web Performance Optimization Techniques **Web Deployment:** Building for Web (flutter build web), Hosting on Firebase Hosting,	7

	GitHub Pages, Netlify, Vercel, SEO Considerations for Flutter Web **Advanced Topics, Progressive Web App (PWA) with Flutter:** Offline Support and Caching, Integrating REST APIs and WebSockets	
	Total	39

Mobile App Development (Lab)

Lab Prerequisite:	
Lab Objectives:	
1	Learn the basics of the Flutter framework.
2	Develop the App UI by incorporating widgets, layouts, gestures and animation
3	Create a production ready Flutter App by including files and firebase backend service.
4	To equip learners with skills to implement effective unit, widget, and integration testing in Flutter applications, ensuring code reliability and maintainability.
5	To provide hands-on knowledge of deploying Flutter apps to Android and iOS platforms, configuring CI/CD pipelines, and managing post-deployment analytics.
6	To introduce Flutter Web development, focusing on responsive UI, state management, performance optimization, and deployment on modern hosting platforms.
Lab Outcomes: After successful completion of the course students will be able to:	
1	Understand cross platform mobile application development using Flutter framework
2	Design and Develop interactive Flutter App by using widgets, layouts, gestures and animation
3	Analyze and Build production ready Flutter App by incorporating backend services and deploying on

	Android / iOS
4	Learners will be able to design, write, and automate Flutter tests across various levels, analyze failures, and improve code quality using modern testing tools and practices.
5	Learners will be capable of preparing production-ready Flutter apps, deploying them to app stores, automating releases with CI/CD tools, and handling real-time user feedback.
6	Learners will gain the ability to build and deploy responsive, performant Flutter web applications with PWA features, API integrations, and SEO considerations.

Suggested Experiments: Students are required to complete at least 10 experiments.

Sr. No.	Name of the Experiment
1	To install and configure the Flutter Environment
2	To design Flutter UI by including common widgets.
3	To include icons, images, fonts in Flutter app
4	To create an interactive Form using form widget
5	To apply navigation, routing and gestures in Flutter App
6	To Connect Flutter UI with fireBase database
7	Write and execute unit and widget tests for a simple Flutter app to validate business logic and UI behavior
8	Perform integration testing on a multi-screen Flutter app by automating navigation and simulating user interactions.
9	Build, sign, and upload a Flutter Android app to the Google Play Console for internal testing.

10	Build and deploy a Flutter Web app using Firebase Hosting to make it accessible online.
11	Develop a responsive Progressive Web App (PWA) using Flutter Web and validate it with Lighthouse.

Textbooks:	
1	Beginning Flutter a Hands-on Guide to App Development, Marco L. Napoli, Wiley, 2020.
2	Beginning App Development with Flutter: Create Cross-Platform Mobile Apps, By Rap Payne, 2019
Reference Books:	
1	Google Flutter Mobile Development Quick Start Guide.Packt,2019
Access to software and virtual labs:	
1	Google Cloud Labs & Qwiklabs: Access to Android Studio, Firebase, TensorFlow Lite via cloud-based labs.
2	AWS Educate/AWS Academy : Free credits for AWS Amplify, Lambda, and IoT integrations.
Industry articles and case studies :	
1	Article: Rise of Flutter in FinTech – Insights on why Flutter is chosen for fast MVP development and lower maintenance in financial startups.
2	Trends Report – Mobile App Development Trends (e.g., Flutter vs. React Native, Kotlin Multiplatform Mobile).

Any other (Access to AI tools / Data driven insights (if applicable) or any other):	
1	AI-powered Mobile App Features: Hands-on modules using Google ML Kit for image labeling, text recognition, barcode scanning, and language translation in Android apps.
2	Chatbot Integration Labs: Building intelligent chatbots using Dialog Flow and integrating with Android/Flutter frontends.
3	Analytics with Firebase and Google Analytics: Gain data-driven insights on user engagement, retention, crash reports, and app performance.
4	Recommendation Engines: Introduction to building simple recommendation models in apps (e.g., product or content recommendations).
5	AI Tools: Exposure to tools like OpenAI APIs for generating text-based content within apps or integrating natural language features.

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment will be based on the Labs undertaken.

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Note: Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Term Work:	
1	Term work should consist of 8 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks (Experiments: 15-marks, Term work Assessment: 10-marks)

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Department of Automation and Robotics

Department of Automation and Robotics Syllabus (NEP Scheme)

Sem -VI
w.e.f. A.Y. 2025-26

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Department of Automation and Robotics

Semester VI
Syllabus

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Department of Automation and Robotics

Semester VI Scheme									
Course Type	**Course Code**	**Course Name**	**Teaching scheme (Contact Hours)**			**Credits Assigned**			
			Th	**Pr**	**Tut**	**Th**	**Pr**	**Tut**	**Total**
Programme Core Course (PCC)	NARPC61	Dynamics and Trajectory Planning	3	2	-	3	1	-	4
	NARPC62	Process Control & Data Communication	3	2	-	3	1	-	4
Program Elective Course (PEC)	NARPE61	PEC-2	3	2	-	3	1	-	4
	NARPE62	PEC-3	3	2	-	3	1	-	4
Multidisciplinary Minor (MDM)	NARMM61	Course -4	3	2	-	3	1	-	4
Skill Course (VSEC)	NARVSL61	Skill Lab - II: 3-D Printing with CAD/CAM	-	4	-	-	2	-	2
Total Credits			15	14	-	15	7	-	22

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Department of Automation and Robotics

Semester VI Scheme								
Course Type	**Course Code**	**Course Name**	**TH**	**MT**	**CA**	**TW**	**PR / OR**	**Total**
Programme Core Course (PCC)	NARPC61	Dynamics and Trajectory Planning	60	20	20	25	25	150
	NARPC62	Process Control & Data Communication	60	20	20	25	25	150
Program Elective Course (PEC)	NARPE61	PEC-2	60	20	20	-	25	125
	NARPE62	PEC-3	60	20	20	-	25	125
Multidisciplinary Minor (MDM)	NARMM61	Course -4	60	20	20	25	25	150
Skill Course (VSEC)	NARVSL61	Skill Lab - II: 3-D Printing with CAD/CAM	-	-	-	-	25	25
Total Credits			300	100	100	75	150	725

* Code for subject Lab

Sem VI **Program Electives (PEC-2)**
Instrument System Design
Data structures and Algorithms
Biomedical Instrumentation

Sem VI **Program Electives (PEC-3)**
Functional Safety
Mobile Wheeled Robots
Advanced Embedded System

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Department of Automation and Robotics

Dynamics and Trajectory Planning

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPC61	Dynamics and Trajectory Planning (Theory)	03	-	-	03	-	-	03
NARPC61	Dynamics and Trajectory Planning (Lab)	-	02	-	-	01	-	01

Dynamics and Trajectory Planning (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPC61	Dynamics and Trajectory Planning (Theory)	03	-	-	03	-	-	**03**

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARPC61	Dynamics and Trajectory Planning (Theory)	20	20	60	---	---	100

Course Prerequisite: Robot Kinematics and Basic Engineering Mathematics	
Course Objectives:	
1	Disseminate the fundamental principles of dynamic modeling for robots.
2	To provide knowledge about robot trajectory.
3	To make the students understand Linear and Nonlinear control of manipulators.
4	To make students understand Force control of manipulators.
5	To make students understand PID control of manipulators.
Course Outcomes: After successful completion of the course students will be able to:	
1	Understand statistics and manipulator design.
2	Model the dynamics of a robot using Lagrange-Euler and Newton's methods.
3	Formulate robot motion planning models using different schemes.
4	Understand and design Linear as well as Nonlinear control of manipulators.
5	Design Force control of manipulators.
6	Design PID control of single link manipulator and planar 2R manipulator.

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Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tut	Total
NARPC61	Dynamics and Trajectory Planning (Lab)	---	02	---	---	01	---	01

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid- Term Test	Continuous Assessment				
NARPC61	Dynamics and Trajectory Planning (Lab)	---	---	---	25	25	50

Lab Prerequisite:	
Lab Objectives:	
1	Disseminate the fundamental principles of dynamic modeling for robots.
2	To provide knowledge about robot trajectory.
3	To make the students understand Linear and Nonlinear control of manipulators.
4	To make students understand Force control of manipulators.
5	To make students understand PID control of manipulators.
Lab Outcomes: After successful completion of the course students will be able to:	
1	Understand statistics and manipulator design.

2	Model the dynamics of a robot using Lagrange-Euler and Newton's methods.
3	Formulate robot motion planning models using different schemes.
4	Understand and design Linear as well as Nonlinear control of manipulators.
5	Design Force control of manipulators.
6	Design PID control of single link manipulator and planar 2R manipulator.

Dynamics and Trajectory Planning (Theory)

Module	Chapter	Content	Hrs
1		**STATICS AND MANIPULATOR DESIGN**	**04**
	1.1	Forces and Moments Balance, Equivalent Joint Torques, Role of Jacobian in Statics, Manipulator Design.	
2		**DYNAMIC MODELING**	**08**
	2.1	Lagrangian Mechanics, Two Degrees of Freedom Manipulator-Dynamic Model.	
	2.2	Lagrange-Euler Formulation: Velocity of a Point on the Manipulator, The Inertia Tensor, The Kinetic Energy, The Potential Energy, Equations of Motion, The LE Dynamic Model Algorithm.	
	2.3	Newton-Euler Formulation: Newton's Equation, Euler's Equation, Kinematics of Links, Link Acceleration, Recursive Newton-Euler Formulation, Forward Iteration, Backward Iteration.	
	2.4	Comparison of Lagrange-Euler and Newton-Euler Formulations.	
	2.5	Inverse Dynamics.	

3		**TRAJECTORY PLANNING**	**08**
	3.1	Path and Trajectory, Basics of Trajectory Planning, Joint Space Trajectory Planning.	
	3.2	Cartesian Space Trajectory Planning, Point-to-Point vs Continuous Path Planning.	
4		**MOTION CONTROL OF MANIPULATORS**	**08**
	4.1	Open and Closed Loop Control, Linear Control Schemes, Joint Actuators.	
	4.2	Characteristics of Dynamic Systems, Partitioned PD control scheme, Proportional-Integral-Derivative Controllers, Computed torque control .	
		Nonlinear control of manipulators, Lyapunov stability analysis.	
5		**FORCE CONTROL OF MANIPULATORS**	**08**
	5.1	Description of Force-Control tasks, Force control strategies, Types of constraints in controller design.	
	5.2	Hybrid Position/Force control.	
	5.3	Impedance Force/Torque control.	
6		**CASE STUDY**	**03**
	6.1	Dynamic modelling and controller design for 2 DOF, 3 DOf manipulators.	
		Total	**39**

Textbooks:	
1	Robotics and Control by R. K. Mittal and I. J. Nagrath, Tata McGraw Hill
2	Introduction to Robotics by John J. Craig, Third Ed., Pearson.
3	Introduction to Robotics - Analysis, control, applications by Saeed B. Niku, Wiley Publications.
Reference Books:	
1	Introduction to Robotics by S K Saha, , Second Ed., Tata McGraw-Hill
2	Industrial Robotics by Mikell P. Groover, McGraw Hill, 2nd edition
3	Introduction to Robotics by Arthor Critchlow, Firtst Ed., Macmillan.
4	Deb S.R., "Robotics Technology and Flexible Automation", 2nd edition, Tata McGraw - Hill Publis Robotics: Control and Programming.
5	J. Srinivas, R. V. Dukkipati, K., "Robotics: Control and Programming", Narosa Publishing House, 2009.

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

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Department of Automation and Robotics

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation the marks can be left blank (with discretion of faculty)	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

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Department of Automation and Robotics

Dynamics and Trajectory Planning(Lab)

Suggested Experiments: Students are required to complete at least 10 experiments.	
Sr. No.	**Name of the Experiment**
1	Obtain a dynamic model and simulation of simple mechanical systems.
2	To perform straight line trajectory control using ROS.
3	To perform trajectory planning using ROS.
4	To solve differential equations using laplace transform for a given dynamical system.
5	To solve differential equations using numerical methods for a given dynamical system.
6	To solve differential equations using a symbolic toolbox of MATLAB.
7	To design a PID controller for a given second order system.
8	To design a PID controller for speed control of a DC motor
9	To analyse the stability of a given system using the Lyapunov function.
10	To compute the rate of change of Lyapunov function using the jacobian matrix.
11	To design a PID controller for a 3DOF robot manipulator.
12	To design an impedance controller for a robot manipulator.
13	To design a force controller for a robot manipulator.
14	To design a Hybrid controller for a robot manipulator.

Term Work:	
1	Term work should consist of 8 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks (Experiments: 15-marks, Term work Assessment: 10-marks)

Process Control & Data Communication

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPC62	Process Control & Data Communication	03	-	-	03	-	-	03
NARPC62	Process Control & Data Communication(Lab)	-	02	-	-	01	-	01

Process Control & Data Communication(Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPC62	Process Control & data Communication (Theory)	03	-	-	03	-	-	03

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				

NARPC62	Process Control & data Communication (Theory)	20	20	60	---	---	100

Course Prerequisite: Awareness of transmitters, different process loops, Basics of communication system.	
Course Objectives:	
1	To provide required knowledge about Heat transfer unit operations.
2	To provide required knowledge about Mass & Heat transfer unit operations
3	To create awareness about process industries
4	To create awareness about the the OSI reference model
5	To provide sufficient knowledge about the HART
6	To impart the fundamentals of foundation field bus.
Course Outcomes: After successful completion of the course students will be able to:	
1	Understand and implement control schemes for Heat transfer unit operations
2	Understand and implement control schemes for Mass and Heat transfer unit operations
3	Understand industrial operations
4	Examine the importance of OSI,TCP/IP model, various networking components
5	Use HART for communication

6	Establish Foundation fieldbus communication

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tut	Total
NARPC62	Process Control & data Communication (Lab)	---	02	---	---	01	---	01

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARPC62	Process Control & data Communication (Lab)	---	---	---	25	25	50

Lab Prerequisite:	
Lab Objectives:	
1	To provide Hands on Exposure to students
2	To provide sufficient knowledge about the HART & to impart the fundamentals of foundation field bus
Lab Outcomes: After successful completion of the course students will be able to:	

1	Differentiate various control schemes of HT unit operations
2	Differentiate various control schemes M& HT unit operations
3	Analyse industrial operations
4	Examine the importance of OSI,TCP/IP model,and various networking components.
5	Use HART for communication
6	Establish Foundation fieldbus communication.

Process Control & Data Communication (Theory)

Module	Chapter	Content	Hrs
1		**Heat Transfer Unit**	**08**
	1.1	**Heat exchanger & Furnace controls**: Heat Exchanger Equipment and types.control schemes for heat exchanger:feedback, feed-forward, bypass . Start- up heaters, fired reboilers, process and safety controls.	
	1.2	**Evaporator control**: Evaporator Equipment and its performance ,control schemes of Evaporator : feedback, cascade, and selective control.	
	1.3	**Boiler controls**- Overview of Boiler Equipment and types. Drum level control- Single, two and three elements, and Combustion Control, Boiler operational Interlocks.	07
2		**Heat and Mass Transfer Unit**	

	2.1	**Crystallizers control:** Process of crystallization, Super-saturation methods, types of crystallizer and control strategies- evaporating crystallizer, cooling crystallizers,	
	2.2	**Dryer control:** Process of drying, types and control strategies of dryer- Tray , fluidized bed,	
	2.3	**Reactor control:** Types of reactors, feedback, cascade schemes of reactors.	
3		**Process Industry**	05
	3.1	**Refinery Industry**- Process flow diagram, separation, conversion and blending.	
	3.2	**Major unit operation Distillation**- overview and operation of distillation equipment and accessories.,control schemes: Top and bottom product composition ,Pressure controls, Feed controls- Column feed controls.	
4		**Introduction to Networks**	06
	4.1	Simplex & Duplex communication modes-OSI reference model, TCP/IP model, Transmission media, UTP-STP cable, coaxial cable, N/W components: Repeaters, bridge, hub, switch, router, gateways	
	4.2	Open Control N/W: RS232, RS422,EIA485	
	4.3	Modbus Structure, Implementation, GPIB. Proprietary Control N/W:Modbus Plus	
5		**HART**	

	5.1	FSK mode of communication, HART Architecture, Physical, Data Link, Application, Communication Technique, Normal and burst mode of communication, Troubleshooting, Benefits of HART, HART commands	07
	5.2	Networks at different levels: Sensor level network: AS-i, CAN, Control Network: BACnet,control-net	
	5.3	**Profibus**- PA, FMS, DP	
6		**Foundation Fieldbus**	06
	6.1	Fieldbus requirement, features, advantages, Comparison between traditional and field bus system- fieldbus components, types- H1 & HSE - different topologies - Point to Point, Multidrop- Bus, Daisy Chain, Mixed	
	6.2	Manchester encoding Signaling technique -architecture–physical, data link, application layer, User application layer, Function block Model- Transducer Block, Resource Block-Function Block	
	6.3	system and network management, wiring, segment functionality checking, installation in safe and hazardous area and troubleshooting	
		Total	39

Textbooks:	
1	George Stephanopoulos, "Chemical process control", PHI-1999

2	Deon Reynders, Steve Mackay, Edwin Wright, Practical Industrial Data Communications, 1 st edition ELSEVEIR,2005.
3	Lawrence M Thompson, Industrial Data Communication, 2nd sedition , 1997.
Reference Books:	
1	Bela G. Liptak, "Instrument Engineer"s Handbook – Process Control", Chilton Company, 1995
2	G. F. (Jerry) Gilman, "Boiler control system Engineering" Second Edition.
3	Behrouz A. Forouzan, Data Communications and Networking, 2nd update edition, Tata McGraw Hill Publishing Company, New Delhi,2000.
4	Applying Foundation Fieldbus- B.R. Mehta and Y.J. Reddy
5	Fieldbus & Networking in Process Automation- Sunit Kumar Sen
6	Bela G Liptak, "Process Software and Digital Networks",3rd edition2002.
7	Andrew S. Tanenbaum, "Computer Networks", 4th edition, PHI/Pearson Education,2002.

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Process Control & Data Communication (Lab)

Suggested Experiments: Students are required to complete at least 10 experiments.	
Star (*) marked experiments are compulsory.	
Sr. No.	**Name of the Experiment**
1*	Study of Process Equipment and basic Unit operations.

2*	Study of Temperature control system using Heat Exchanger
3*	Study of Batch reactors.
4	Assignment based on Boiler control system
5*	Assignment based on Evaporator control system
6*	Assignment based on Distillation column control system.
7*	To Study the networking components
8*	To understand LAN
9*	To study the HART Protocol.
10	To calibrate various transmitters using HART
11.	To study the components of Foundation Field Bus.
12	Simulate different topologies of LAN using software
13	Assignment on MODBUS protocol
14	Assignment on PROFIBUS protocol

Note: Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

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2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks (Experiments: 15-marks, Term work Assessment: 10-marks)

Instrument and System Design

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NERPE61	Instrument and System Design (Theory)	03	-	-	03	-	-	03
NERPE61	Instrument and System Design (Lab)	-	02	-	-	01	-	01

Instrument and System Design (Theory)

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Department of Automation and Robotics

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NERPE61	Instrument and System Design (Theory)	03	-	-	03	-	-	**03**

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NERPE61	Instrument and System Design (Theory)	20	20	60	---	---	100

Course Prerequisite:	
Course Objectives:	
1	To impart knowledge of selection and design considerations of transducers along with their calibration techniques.
2	To make the students capable of sizing the control valve.
3	To create awareness about control valve problems.
4	To impart the students' knowledge about the types, sizing of control panels, and standards.

5	To make the students capable of designing electronic products, control room layout, and its environment.
6	To familiarize students with the concept of reliability engineering.
Course Outcomes: After successful completion of the course students will be able to:	
1	Select, design and calibrate transducers
2	Select and size the control valves and actuators.
3	Estimate valve noise and predict cavitation.
4	Apply knowledge to design the control panels and control room.
5	Design electronic products and enclosures.
6	Define the terms used in Reliability engineering.

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tut	Total
NERPE61	Instrument and System Design (Lab)	---	02	---	---	01	---	01

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-T	Continuo				

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Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tut	Total
		erm Test	us Assessment					
NERPE61	Instrument and System Design (Lab)	---	---	---	25	25	50	

Lab Prerequisite:	
Lab Objectives:	
1	To impart knowledge of selection and design considerations of transducers along with its calibration techniques.
2	To make the students capable of sizing the control valve.
3	To give the students' knowledge about the types, sizing of control panels and standards
4	To make the students capable to apply knowledge to design electronic product, control room layout and its environment
5	To give the students a comprehension of the aspects of reliability engineering.
Lab Outcomes: After successful completion of the course students will be able to:	
1	Calculate performance characteristics of a given transducer and calibrate transducers.
2	Select and size the control valves and actuators.
3	Estimate valve noise and predict cavitation

4	Apply knowledge to design the control panels and control room.
5	Apply knowledge to design electronic product
6	Calculate Reliability engineering terms

Instrument and System Design (Theory)

Module	Detailed Content	No. of Hours
1	**Design of sensors and transducers** An overview of static and dynamic performance characteristics of sensors and transducers. Selection guidelines, design considerations, calibration and installation for flow, temperature, pressure and level transducers.	7
2	**Design of Control Valve:** Control valve terminology, Review of flow equations. Valve selection and sizing for liquid service, gas or vapor service, flashing liquids and mixed phase flow, Actuator sizing. Selection criteria and design consideration of pressure safety relief valves and rupture discs.	8
3	**Cavitation , Flashing and Noise estimation** Control valve noise, sources of noise, noise prediction, abatement of noise. Control valve cavitation and flashing and its effects, preventing cavitation, Prediction of cavitation.	6
4	**Control Panel and Control room design**	6

	Need for control panel, Types, selection guidelines, Design considerations -size, construction and IP classification, NEMA standard. GA Diagrams, Power wiring and distribution, Earthing scheme. Panel ventilation, cooling and illumination. Operating consoles- ergonomics. Wiring accessories- ferrules, lugs, PVC ducts, spiral etc. Wire sizes and color coding. Packing, Pressurized panels- X, Y, and Z Purging for installation in hazardous areas. Ex-proof panels. Intrinsic safe (IS) and non-intrinsic safe (non-IS) cabinet design. Control Room Design: Need for control room,conventional and modern control room Layout, Design considerations.	
5	**Electronic product design** System Engineering, Ergonomics, phases involved in electronic product design. Enclosure Design: Packing and enclosures design guidelines, Grounding and shielding, front panel and cabinet design of an electronic product.	6
6	**Reliability engineering** Reliability concepts, causes of failures, bathtub curve, Quality and reliability, MTTF, MTBF, and MTTR. Availability and Maintainability. Redundancy and redundant systems.	6
	Total	39

Textbooks:	
1	Curtis Johnson, "Process Control Instrumentation Technology", PHI/Pearson Education2002.

2	Les Driskell, " Control Valve sizing" ISA Publication
3	Kim R Fowler, Electronic Instrument Design, Oxford University-1996.
4	B.C Nakra, K.K. Chaudhary, Instrumentation, Measurement and Analysis, Tata McGraw-Hill Education, 01-Oct-2003 - Electronic instruments - 632 page.
5	Patranabis D, Sensors and Transducers, Prentice Hall India Learning Private Limited; 2 edition (2003) - 344 pages.
6	A. K. Sawhney, Puneet Sawhney,A course in Electrical and Electronic Measurement and Instrumentation, Dhanpat Rai and Co. Rai, 1996
7	Rangan, Mani, Sharma. Instrumentation systems and Devices, 2 nd Ed.,Tata McGraw Hill.
8	D.V.S. Murthi, ―Instrumentation and Measurement Principles‖, PHI, New Delhi, Second ed. 2003.
Reference Books:	
1	Doeblin E.D., Measurement system, Tata McGraw Hill., 4th ed, 2003.
2	Bela G. Liptak, Instrument Engineers' Handbook, Fourth Edition, Volume One: Process Measurement and Analysis, June 27, 2003.
3	Neubert Hermann K. P., Instrument Transducer, 2nd ed., Oxford University Press, New Delhi, 2003.
4	Johnson Curtis D., Process Control Instrumentation Technology, 8th Ed., 2005
5	S.P. Sukhatme, Heat Transfer, 3rd edition, University Press.
6	B.E. Jones, Instrument Technology.
7	Chortle Keith R., Fundamentals of Test, Measurement Instrument Instrumentation, ISA Publication.
8	Alan S Morris, Measurement and Instrumentation Principles; 3rd Edition

Internal Assessment:

1)Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.

2) Mid Term test is to be conducted when approx. 50% syllabus is completed.

3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation the marks can be left blank (with discretion of faculty)	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Instrument and System Design (Lab)

Suggested Experiments: Students are required to complete at least 10 experiments.	
Sr. No.	**Name of the Experiment**
1	Study the performance characteristics of Flow instruments.
2	Study the performance characteristics of Level instruments
3	Study the performance characteristics of Pressure instruments
4	Study the performance characteristics of Temperature instruments
5	To verify flow capacity of a given valve. (use Cv characteristic set up)
6	Study of control panel and its GA / wiring drawings
7	To develop laboratory control room layout.
8	Study and familiarization of Installations of Field instruments.
9	Study and familiarization of valve actuators and positioners..
10	To study control valve performance.
11	Perform Hydro and seat Leakage test for control valves.

12	Study operation of Field instruments and its specifications
13	Study and testing of controller configuration.
14	Any other Experiment as per syllabus requirements.

Term Work:	
1	Term work should consist of 8 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks (Experiments: 15-marks, Term work Assessment: 10-marks)

Data Structures and Algorithms

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE62	Data structures and Algorithms (Theory)	03	-	-	03	-	-	03

Data Structures and Algorithms

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE62	Data structures and Algorithms (Theory)	03	-	-	03	-	-	03

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARPE62	Data structures and Algorithms (Theory)	20	20	60	---	---	100

Course Objective :	
1	Explain fundamentals of data structures and their applications essential for programming/problem solving
2	Illustrate linear representation of data structures: Stack, Queues, Lists, Trees and Graphs.
3	Demonstrate sorting and searching algorithms
4	Find suitable data structure during application development/Problem Solving
Course Outcome :	
1	Use different types of data structures, operations and algorithms
2	Apply searching and sorting operations on files
3	Use stack, Queue, Lists, Trees and Graphs in problem solving
4	Implement all data structures in a high-level language for problem solving.

Data structures and Algorithms (Theory)

Module	Chapter	Content	Hrs
1		**Introduction & Arrays**	
	1.1	Introduction: Data Structures, Classifications (Primitive & Non Primitive), Data structure Operations, Mathematics Review, Exponents, Logarithms, Series,Modular Arithmetic	6
	1.2	Review of Arrays, Structures, Self-Referential Structures, and Unions. Pointers and Dynamic Memory	
	1.3	Allocation Functions. Representation of Linear Arrays in Memory, Dynamically allocated arrays	
	1.4	Array Operations: Traversing, inserting, deleting, searching, and sorting. Multidimensional Arrays, Polynomials and Sparse Matrices.	
	1.5	Strings: Basic Terminology, Storing, Operations and Pattern Matching algorithms. Programming Examples.	
2		**Stacks & Queues**	6
	2.1	**Stacks:** Definition, Stack Operations, Array Representation of Stacks, Stacks using Dynamic Arrays, **Stack Applications:** Polish notation, Infix to postfix conversion, evaluation of postfix expression. Recursion - Factorial, GCD, Fibonacci Sequence, Tower of Hanoi, Ackerman's function.	
	2.2	**Queues:** Definition, Array Representation, Queue Operations, Circular Queues,	

		Circular queues using Dynamic arrays, Dequeues, Priority Queues, A Mazing Problem.	
3		**Linked List**	
	3.1	Linked Lists: Definition, Representation of linked lists in Memory, Memory allocation; Garbage Collection.	7
	3.2	Linked list operations: Traversing, Searching, Insertion, and Deletion.	
	3.3	Doubly Linked lists, Circular linked lists, and header linked lists. Linked Stacks and Queues.	
	3.4	Applications of Linked lists – Polynomials, Sparse matrix representation. Programming Examples.	
4		**Binary Search Trees**	
	4.1	Trees: Terminology, Binary Trees, Properties of Binary trees, Array and linked Representation of Binary Trees,	6
	4.2	Binary Tree Traversals – In order, post order, pre order; Additional Binary tree operations. Threaded binary trees,	
	4.3	Binary Search Trees – Definition, Insertion, Deletion, Traversal, Searching, Application of Trees-Evaluation of Expression, Programming Examples.	
5		**Sorting**	
	5.1	Sorting Sets, and Selection: Insertion Sort, Shell sort, Heapsort, Quicksort, Bucket Sort, Merge Sort and radix Sort, and A Lower Bound on comparison-based Sorting and radix Sort	7
	5.2	Static and Dynamic Hashing: Files and Their Organization: Data Hierarchy, File Attributes, Text Files and Binary Files, Basic File Operations, File Organizations and Indexing	

6		**Graphs**	
	6.1	Graphs: Definitions, Terminologies, Matrix and Adjacency List Representation Of Graphs, Elementary Graph operations,	**7**
	6.2	Directed Graphs, Weighted Graphs, Shortest Paths, and Minimum spanning Trees.	
	6.3	Shortest-Path Algorithms, Dijkstra's Algorithm, Graphs with Negative Edge Costs, Acyclic Graphs, Network Flow Problems, Minimum Spanning Tree	
		Total	39

Textbooks:	
1	Ellis Horowitz and Sartaj Sahni, Fundamentals of Data Structures in C, 2nd Ed,Universities Press, 2014.
2	Seymour Lipschutz, Data Structures Schaum's Outlines, Revised 1st Ed, McGraw Hill,2014.
Reference Books:	
1	Gilberg & Forouzan, Data Structures: A Pseudo-code approach with C, 2nd Ed, Cengag Learning,2014.
2	Reema Thareja, Data Structures using C, 3rd Ed, Oxford press, 2012.
3	Jean-Paul Tremblay & Paul G. Sorenson, An Introduction to Data Structures withApplications, 2 nd Ed, McGraw Hill, 2013.
4	A M Tenenbaum, Data Structures using C, PHI, 1989 5. Robert Kruse, Data Structures and Program Design in C, 2nd Ed, PHI, 1996
5	https://nptel.ac.in/courses/106102064

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation the marks can be left blank (with discretion of faculty)	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

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Department of Automation and Robotics

Biomedical Instrumentation

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE63	Biomedical Instrumentation (Theory)	03	-	-	03	-	-	03
NARPE63	Biomedical Instrumentation (Lab)	-	02	-	-	01	-	01

Biomedical Instrumentation (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE63	Biomedical Instrumentation (Theory)	03	-	-	03	-	-	03

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid Term Test	Continuous Asses				

			sment				
NARPE63	Biomedical Instrumentation (Theory)	20	20	60	---	---	100

Course Prerequisite: Knowledge about anatomy and physiology of human systems	
Course Objectives:	
1	To make students identify the various bio-signals from the human body.
2	To learn about the working of different physiological systems in the body.
3	To provide skills to measure various physiological parameters, from these systems.
4	To make students understand the application of the various biomedical instruments in diagnosis.
5	To learn about the different medical imaging methods.
6	To make students understand the working of therapeutic instruments in the biomedical field.
Course Outcomes: After successful completion of the course students will be able to:	
1	Identify various Bio-potentials with their specifications and perform their measurements.
2	Identify their parameters and related measurements for various physiological systems.
3	Explain the principle and working of various cardiovascular parameters and their measurement techniques with applications.

4	Distinguish between the various medical imaging techniques based on the principles and concepts involved in them.
5	Relate between the different life support instruments and to describe their applications.
6	Describe the significance of electrical safety in biomedical measurement.

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tut	Total
NARPE63	Biomedical Instrumentation (Lab)	---	02	---	---	01	---	01

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid Term Test	Continuous Assessment				
NARPE63	Biomedical Instrumentation (Lab)	---	---	---	25	25	50

Lab Prerequisite:	
Lab Objectives:	
1	To make students perform experiments based on the principle and working of various Biomedical Instruments used for Bio-potential measurements.
2	To develop skills in the design of various biomedical instruments used in diagnosis and life support.
3	To develop knowledge on application of various medical imaging methods.
Lab Outcomes: After successful completion of the course, students will be able to:	
1	Measure and identify various Bio-potentials with their specifications.
2	Observe and plot various physiological parameters with their specifications.
3	Measure the various cardiovascular parameters by designing the related circuitry.
4	Realize the circuitry of different life support instruments, like pacemaker, defibrillator.
5	Distinguish between the various medical imaging techniques by comparing, principle and concept involved in each of the techniques.
6	Describe the significance of electrical safety in biomedical measurement.

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Department of Automation and Robotics

Biomedical Instrumentation (Theory)

Module	Chapter	Content	Hrs
1		**Bio-Potentials and their Measurement:**	**04**
	1.1	Structure of Cell, Origin of Bio-potential, electrical activity of cell and its characteristics and specifications.	
	1.2	Measurement of RMP and AP. Electrode-Electrolyte interface and types of bio-potential electrodes.	
2		**Physiological Systems and Related Measurement:**	**10**
	2.1	**Cardiovascular system-** Structure of Heart, Electrical and Mechanical activity of Heart, ECG measurements and Cardiac arrhythmias, Heart sound measurement. First aid to be given for heart attack patients, Design of ECG amplifier circuit.	
	2.2	**Nervous system-** Nerve cell, neuronal communication, nerve-muscle physiology, Generation of EEG and study of its characteristics. Normal and abnormal EEG, 10-20 electrode placement system and EEG amplifier.	
	2.3	**Muscular system-** Generation of EMG signal, specification and measurement, EMG amplifier system.	
	2.4	**Respiratory system-** Physiology of respiration and measurements of respiration related parameters, Spirometer.	

3		**Cardiovascular Measurement:**	**06**
	3.1	Blood Volume measurement - Plethysmograph (True and Impedance).	
	3.2	Blood Pressure measurement – Direct, Indirect and Automated.	
	3.3	Blood Flow measurements - Electromagnetic and Ultrasonic.	
	3.4	Cardiac Output measurements - Fick's method, Dye dilution and Thermodilution.	
4		**Life support Instruments:**	**09**
	4.1	Pacemaker- Types of Pacemakers, mode of pacing and its application.	
	4.2	Defibrillator- AC and DC Defibrillators and their application.	
	4.3	Heart Lung machine and its application during surgery.	
	4.4	Hemodialysis system and the precautions to be taken during dialysis.	
	4.5	Ventilator system and its important parameters for monitoring.	
5		**Medical Imaging techniques:**	**08**
	5.1	X-Ray tube, X ray machine, Digital X Ray and its application.	

	5.2	Computed Tomography (CT) Machine – Block Diagram, scanning system and application.	
	5.3	Ultrasound Imaging- Modes of scanning and their application.	
	5.4	Magnetic Resonance Imaging (MRI) – Principle, block diagram and application.	
6		**Electrical Safety in Biomedical field:**	**02**
	6.1	Physiological effects of electrical current.	
	6.2	Shock Hazards from electrical equipment and methods of accident prevention.	
		Total	**39**

Textbooks:	
1	Leslie Cromwell, Biomedical Instrumentation and Measurements, 2nd Edition, Pearson Education, 1980.
2	R. S. Khandpur, Biomedical Instrumentation, TMH, 2004.
3	John G. Webster, Medical Instrumentation, John Wiley and Sons, 4th edition, 2010.
Reference Books:	
1	Joseph J. Carr and John M. Brown, -Introduction to Biomedical Equipment Technology, PHI/Pearson Education, 4th edition, 2001.
2	Richard Aston, - Principles of Biomedical Instrumentation and Instruments‖, PH, 1991.

3	John E Hall, Gyton's- Medical Physiology, 12th edition, 2011.

Internal Assessment:
1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:
Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc.	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation the marks can be left	05 Marks

	blank (with discretion of faculty)	

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Biomedical Instrumentation (Lab)

Suggested Experiments: Students are required to complete at least 08 experiments.	
Sr. No.	**Name of the Experiment**
1.	Study of electrodes for various biomedical applications.
2.	Demonstration and working of EMG and ECG machines.
3.	Measure Blood pressure by Sphygmomanometer.
4.	Design and implement ECG signal conditioning circuit.
5.	Design and implement EMG Quantification circuit.
6.	Design and implement an asynchronous pacemaker circuit.
7.	Study of Defibrillator system and its voltage waveforms.
8.	Study of working of Hemodialysis machines.
9.	Study of working of Heart-Lung machine.

10.	Implement ECG simulation on PC / Microcontroller.
11.	Study of working of pulse oximeter / Heart rate meter/Respiration rate meter.
12.	Study of X-ray imaging technique.
13.	Study of image acquisition and reconstruction used in Computed tomography systems.
14.	Comparison of various medical imaging techniques for different applications.*
15.	Study on electrical safety.

Note: Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

*Suggested Hospital visit for understanding imaging modality and its applications.

Term Work:	
1	Term work should consist of 08 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks: (Experiments: 10-marks, Journal: 10-marks, Attendance: 05-marks)

Functional Safety

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE64	Functional Safety (Theory)	03	-	-	03	-	-	03
NARPE64	Functional Safety (Lab)	-	02	-	-	01	-	01

Functional Safety (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE64	Functional Safety (Theory)	03	-	-	03	-	-	03

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARPE64	Functional Safety (Theory)	20	20	60	---	---	100

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Department of Automation and Robotics

Course Prerequisite:	
Course Objectives:	
1	To make the students aware of basic concepts of safety instrumented system, standards and risk analysis techniques
Course Outcomes: After successful completion of the course students will be able to:	
1	Define the role of Safety instrumented systems in the industry.
2	Explain process and safety control with SIS technologies
3	Describe steps involved in Safety life cycle
4	Calculate combined probability for different types of events.
5	Analyse the potential hazards in the process.
6	Determine the Safety integrity level.

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tut	Total
NARPE64	Functional Safety (Lab)	---	02	---	---	01	---	01

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				

NARPE64	Functional Safety (Lab)	---	---	---	25	25	50

Lab Prerequisite:	
Lab Objectives:	
1	To make the students aware of basic concepts of safety instrumented system, standards and risk analysis techniques
Lab Outcomes: After successful completion of the course students will be able to:	
1	Define the role of Safety instrumented systems in the industry.
2	Explain process and safety control with SIS technologies
3	Describe steps involved in Safety life cycle
4	Calculate combined probability for different types of events.
5	Analyse the potential hazards in the process.
6	Determine the Safety integrity level.

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Department of Automation and Robotics

Functional Safety (Theory)

Module	Chapter	Content	Hrs
1			**05**
	1.1	Safety Instrumented System (SIS) - need, features, components, difference between basic process control system and SIS, Risk: how to measure risk, risk tolerance, Safety integrity level, safety instrumented functions.	
	1.2	Standards and Regulation – HSE-PES, AIChE-CCPS, IEC-61508, IEC 61511 (2-16), ANSI/ISA-84.00.01-2004 (IEC 61511 Mod) & ANSI/ISA –84.01-1996.9, NFPA 85.10, API RP 556, API RP 14C, OSHA (29CFR 1910.119 – Process Safety Management of Highly Hazardous Chemicals), IEC61513, IEC 60601, ISO 26262, IEC 62443	
2		**Process Control and protection layers**	**08**
	2.1	– Active / Dynamic, Safety Control – Passive / Dormant, Demand Mode vs. Continuous Mode, Common Cause and Systematic or Functional Failures**.**	
	2.2	prevention and mitigation layers, SIS Technologies: Pneumatic Systems, Relay Systems, Solid State Systems, Microprocessors / PLC (Software based) Systems, voting logic in SIS	
3		**Safety life cycle (SLC)**	**04**
	3.1	Safety life cycle as per IEC 61508 and 61511 and its	

		significance	
	3.2	analysis phase, tolerable risk, risk identification and hazard analysis, SIF identification, realization phase, operations phase.	
4		**Rules of Probability:**	**08**
	4.1	Assigning probability to an event, types of events and event combination, combining event probabilities	
	4.2	failure rate, MTBF, MTTF and PFDavg simplifications and approximations.	
5		**Process Hazard Analysis**	**08**
	5.1	**Consequence analysis:** Characterization of potential events, dispersion, impacts, effect zone,occupancy considerations, consequence analysis too**ls.**	
	5.2	**Likelihood analysis:** statistical analysis, fault propagation modeling event tree analysis and fault tree analysis, reliability block diagram, markov analysis,	
6		**Determining the Safety Integrity Level (SIL)**	**06**

	6.1	Evaluating Risk, Safety Integrity Levels, SIL Determination Method: As Low as Reasonably Practicable (ALARP), Risk matrix, Risk Graph	
	6.2	Layers of Protection Analysis (LOPA):Quantitative layer of protection analysis: multiple initiating events, estimating initiating event frequencies and IPL failure probabilities.	
		Total	**39**

Textbooks:	
1	Paul Gruhn and H Jarry L. Cheddie," Safety Instrumented systems: Design, Analysis and Justification", ISA, 2nd edition, 2006
2	Dr. Eric W Scharpf, Heidi J Hartmann, Harlod W Thomas, "Practical SIL target selection: Risk analysis per the IEC 61511 safety Lifecycle", exida, 2012.
Reference Books:	
1	Ed Marszal, Eric W Scharpf, "Safety Integrity Level Selection", ISA.
2	Bela G. Liptak, Instrument Engineers' Handbook, Fourth Edition, Volume One: Process Measurement and Analysis, June 27, 2003.

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
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6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation the marks can be left blank (with discretion of faculty)	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Functional Safety (Lab)

Suggested Experiments: Students are required to complete at least 08 experiments.	
Sr. No.	**Name of the Experiment**
1	Design a Safety instrumented system
2	Study of Safety instrumented system standards
3	Study of risk identification
4	Study of prevention and mitigation layers
5	Study of safety life cycle
6	Design of fault tree analysis
7	Calculate probability to an event and combining event probabilities
8	Calculate MTTF, MTBF and PFDavg
9	Study of consequence analysis
10	Design of event tree analysis
11	Design of LOPA for any one application
12	Determine SIL by risk graph
13	Determine SIL by risk matrix

Note: Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Term Work:	
1	Term work should consist of 08 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks (Experiments: 15-marks, Term work Assessment: 10-marks)

Mobile Wheeled Robots

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE65	Mobile Wheeled Robots (Theory)	03	-	-	03	-	-	03
NARPE65	Mobile Wheeled Robots (Lab)	-	02	-	-	01	-	01

Mobile Wheeled Robots (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE65	Mobile Wheeled Robots (Theory)	03	-	-	03	-	-	**03**

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARPE65	Mobile Wheeled Robots (Theory)	20	20	60	---	---	100

Course Prerequisite:	
Course Objectives:	
1	To train on students about Wheeled Mobile robots
2	Learn the various sensors used to navigate
3	Learn the various path planning algorithms to navigate
Course Outcomes: After successful completion of the course students will be able to:	
1	Learn algorithmic approaches, mathematical models and computational and motion control methods applicable to mobile robotic systems
2	Learn basic sensor systems related to state measurements, navigation and localization.
3	Learn different motion planning and navigation schemes related to mobile robots
4	Recognize and analyze the basic mechanical and electrical systems concerning robots' locomotion and manipulation

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Department of Automation and Robotics

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tut	Total
NARPE65	Mobile Wheeled Robots (Lab)	---	02	---	---	01	---	01

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARPE65	Mobile Wheeled Robots (Lab)	---	---	---	25	25	50

Lab Prerequisite:	
Lab Objectives:	
1	To study Robot programming fundamentals and ROS platform
2	To understand the installation and applications of ROS
3	To understand the Robot navigation through Simulations
Lab Outcomes: After successful completion of the course students will be able to:	
1	Demonstrate knowledge of operating system dedicated to Robot
2	Analyze various case studies of ROS application

3	Apply spatial transformation to obtain forward and inverse kinematics through programming
4	Solve robot dynamics problems, generate joint trajectory for path planning and Programming
5	Apply working principle of various ROS debugging process
6	Identify applications of robots in industry

Mobile Wheeled Robots
(Theory)

Module	Detailed Syllabus	Hrs
1	Introduction to mobile robots and mobile manipulators. Principle of locomotion and types of locomotion. Types of mobile robots: ground robots (wheeled and legged robots), aerial robots, underwater robots and water surface robots.	6
2	Kinematics of wheeled mobile robots, degree of freedom and maneuverability, generalized wheel model, different wheel configurations, holonomic and non-holonomic robots.	7
3	Sensors for mobile robot navigation: magnetic and optical position sensor, gyroscope, accelerometer, magnetic compass, inclinometer, tactile and proximity sensors, ultrasound rangefinder, laser scanner, infrared rangefinder, visual and motion sensing systems.	7
4	Robot navigation: Localization, Error propagation model, Probabilistic map based localization, Autonomous map building, Simultaneous localization and mapping (SLAM).	7

5	Motion and path planning: collision free path planning and sensor-based obstacle avoidance.	6
6	Motion control of mobile robots: Motion controlling methods, kinematic control, dynamic control and cascaded control.	6
	Total	39

Textbooks:	
1	R Siegwart, IR Nourbakhsh, D Scaramuzza, Introduction to Autonomous Mobile Robots, MIT Press, USA, 2011
2	SG Tzafestas, Introduction to Mobile Robot Control, Elsevier, USA, 2014.
Reference Books:	
1	A Kelly, Mobile Robotics: Mathematics, Models, and Methods, Cambridge University Press, USA, 2013.
2	S Thrun, W Burgard, D Fox, Probabilistic Robotics, MIT Press, USA, 2005.
3	G Dudek, M Jenkin, Computational Principles of Mobile Robotics, Cambridge University Press, USA, 2010.

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation the marks can be left blank (with discretion of faculty)	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

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Department of Automation and Robotics

Mobile Wheeled Robots (Lab)

Suggested Lab
ROS and Embedded System programming ➢ Introduction to ROS serial ➢ Working with ROS and Arduino ➢ Working with Jetson Nano and ROS ➢ Setting ROS vision in Jetson Nano ➢ Working with ROS and Raspberry Pi ➢ Interfacing RPI camera to ROS ➢Interfacing GPIO pins of RPI using ROS ➢ Interfacing sensors to RPI and ROS ➢ Controlling motors from RPI and ROS
Building cheapest autonomous mobile robot using ROS Creating a robot model of a delivery robot Interfacing our mobile robot to ROS navigation stack Implement Mapping and Localization using SLAM and AMCL How to tune Navigation parameters Commanding robot using GUI
ROS-SLAM List of SLAM wrappers in ROS Gmapping, Cartographer Deep dive into Visual SLAM Configuring different SLAM package for your robot
ROS Path planners Deep dive into ROS based path planners Working with existing planners in ROS Configuring a planner for your robot Writing your own planner for your robot

Note: Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Term Work:	
1	Term work should consist of 10 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks (Experiments: 15-marks, Term work Assessment: 10-marks)

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Department of Automation and Robotics

Advanced Embedded Systems

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE66	Advanced Embedded Systems (Theory)	03	-	-	03	-	-	03
NARPE66	Advanced Embedded Systems (Lab)	-	02	-	-	01	-	01

Advanced Embedded Systems (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARPE66	Advanced Embedded Systems (Theory)	03	01	-	03	01	-	04

Course Code	Course Name	Examination Scheme				
		Theory		Term Work	Practical & Oral	Total
		Internal Assessment	End Sem Exam			

		Mid Term Test	Continuous Assessment				
NARPE66	Advanced Embedded Systems (Theory)	20	20	60	---	---	100

Course Prerequisite: Microcontrollers, Microprocessor, C-Programming	
Course Objectives:	
1	Study the architecture of ARM series microprocessor and its need in applications
2	Learn architecture and programming for ARM Cortex-M series Microcontroller.
3	Application of RTOS for embedded programming
Course Outcomes: After successful completion of the course students will be able to:	
1	Understand the characteristics and technologies of embedded systems.
2	Describe different program modelling concepts
3	Describe the ARM microprocessor architecture and its features.
4	Understand the functions and programming of memory peripherals on advanced ARM.
5	Study the concepts of Real time operating systems and write programs

6	Study the concepts of Task resource sharing

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tut	Total
NARPE66	Advanced Embedded Systems (Lab)	---	02	---	---	01	---	01

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid Term Test	Continuous Assessment				
NARPE66	Advanced Embedded Systems (Lab)	---	---	---	-	25	50

Lab Prerequisite:	
Lab Objectives:	
1	Familiar with the basic concepts and terminology of the target area, the embedded systems design flow.
2	Able to program ARM cortex processor using assembly , embedded c hardware abstract language
3	Use RTOS for writing multithreaded tasks
Lab Outcomes: After successful completion of the course, students will be able to:	
1	Write embedded C program and program the ARM cortex processor
2	Use Hardware Abstract language to use the ARM processor peripherals
3	Interface various sensors and actuators to the ARM cortex processors
4	Write CMSIS RTOS code for the ARM processors

Advanced Embedded Systems (Theory)

Sr No	Topic	Hrs
1	**Introduction to ARM Cortex** ● History of ARM processors and Series ● ARM Architecture ,Addressing Modes ● Instructions Overview Arithmetic,Logic ,Branch, and Call Instructions ● ARM Memory Map , Memory Access, and Stack ● ARM Pipeline ● Development and debugging Tools for Embedded Systems	8

2	**Cortex M4 Microcontrollers & Peripherals:STM32F401CC** ● Cortex M4-based controller architecture ● ARM Cortex M4 Core, Interconnect Matrix in ARM Cortex M4 Microcontroller ● Reset and Clock Control, Clock Recovery System, Power Control ● Memory mapping,	7
3	**Cortex M4 Microcontrollers & Peripherals:STM32F401CC** ● Cortex M4 Peripherals – RCC, GPIO, Timer, System timer, PWM ● Cortex M4 Peripherals -- ADC,RTC ● DMA Interfacing	6
4	**Advanced Cortex:** Basics of cache,Memory Hierarchy,Direct Mapped and Set Associative cache Cache policy Memory Management Unit Virtual Memory,Translation Lookaside Buffer,address translation,Memory Attributes	6
5	**RTOS basics**, Timing Constraints, classification and modelling Task Instance ,Deadlines ,Types of Real Time OS,Types of Task Scheduling and its comparisons	6
6	**Task Operations**, Structure, Synchronization, Communication and Concurrency. Defining Semaphores, Operations and Use, Defining Message Queue, States, Content, Storage, Operations and Use Resource Sharing between Tasks Priority Inversion,Priority Inheritance Protocol	6
	Total	39

Textbooks:	
1	ARM assembly Language programming and Architecture Muhammed Ali Mazidi ,Sarmad Naimi,Sepehr Naimi and Shuejn Chen by Microdigital Ed
2	Beginning STM32 Warren Gay apress Publication
3	Shibu K.V," Introduction to Embedded Systems", Mc Graw Hill, 2nd edition.
4	Frank Vahid, and Tony Givargis, "Embedded System Design: A unified Hardware/Software Introduction", Wiley Publication
5	Raj Kamal," Embedded Systems Architecture, Programming and design",Tata MCgraw-Hill Publication.
6	Dr. K.V.K.K. Prasad, "Embedded Real Time Systems: Concepts, Design & Programming",Dreamtech Publication.
Reference Books:	
1	Joseph Yiu, "The Definitive Guide to the ARM Cortex-M", Newness, ELSEVIER
2	ARM Systems Developer's Guides- – A. N. Sloss, D. Symes, C. Wright, Elsevier 2008
3	Embedded Microcomputer Systems, Real Time Interfacing – J.W. Valvano, Cole, 1999.

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.

3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc.	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation the marks can be left blank (with discretion of faculty)	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

Advanced Embedded Systems (Lab)

Suggested Experiments: Students are required to complete at least 08 experiments.	
Sr. No.	**Name of the Experiment**
1	Write program to blink LED
2	Initialise the timer to blink the LED
3	Initialize UART to communicate with PC
4	Interface I2C,SPI devices
5	Interface Display devices
6	Interface various actuators like relay,motors etc
7	Implement a project using RTOS

Note: Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Term Work:	
1	Term work should consist of 08 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks: (Experiments: 10-marks, Journal: 10-marks, Attendance: 05-marks)

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Department of Automation and Robotics

Machine Learning

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARMM61	Machine Learning (Theory)	03	-	-	03	-	-	03
NARMM61	Machine Learning (Lab)	-	02	-	-	01	-	01

Machine Learning (Theory)

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARMM61	Machine Learning (Theory)	03	-	-	03	-	-	**03**

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid Term Test	Continuous Assessment				

NARMM61	Machine Learning (Theory)	20	20	60	---	---	100

Course Prerequisite: Knowledge about Linear algebra and probability	
Course Objectives:	
1	To familiarize students with basic concepts of Machine learning.
2	To provide understanding of the concepts of regression, classification, clustering and machine learning algorithms
3	To introduce the students to various applications of Machine learning for industrial automation and robotics.
Course Outcomes: After successful completion of the course students will be able to:	
1	Introduce concepts of Machine learning
2	Explain statistical tools and development of model for ML
3	Explain and analyse the various algorithms for Supervised learning
4	Explain and analyse the various algorithms for Unsupervised learning.
5	Explain and analyse the algorithms of Artificial NN.
6	Apply ML algorithms for industrial automation and robotics.

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Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tut	Total
NARMM61	Machine Learning (Lab)	---	02	---	---	01	---	01

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid Term Test	Continuous Assessment				
NARMML61	Machine Learning (Lab)	---	---	---	25	25	50

Lab Prerequisite:	
Lab Objectives:	
1	To familiarize students with basic concepts of Machine learning.
2	To provide understanding of the concepts of regression, classification, clustering and machine learning algorithms.

3	To introduce the students to various applications of Machine learning for industrial automation and robotics
Lab Outcomes: After successful completion of the course, students will be able to:	
1	Develop programs to perform statistical analysis of data sets.
2	Implement algorithms based on Supervised learning.
3	Implement algorithms based on Unsupervised learning.
4	Execute classification algorithms on a given data set.
5	Develop programs based on Artificial NN.
6	Apply ML algorithms for industrial automation and robotics.

Machine Learning (Theory)

Module	Chapter	Content	Hrs
1		**Introduction to Machine Learning:**	**04**
	1.1	Introduction to Machine learning and Deep learning.	
	1.2	Types of machine learning – Supervised, Unsupervised and Reinforcement learning	
2		**Design of Machine Learning System:**	**08**

	2.1	**Collection of data:** Data statistics – mean, variance, covariance, standard deviation, random variable, probability distribution function.	
	2.2	**Data preparation:** data cleaning, data scaling, training of data, testing of data and its validation.	
	2.3	**Evaluation Metrics:** Confusion matrix, precision, recall, F-score.	
3		**Supervised Learning:**	**10**
	3.1	**Regression:** Linear Regression, Multiple linear regression, Polynomial regression	
	3.2	**Regularization techniques:** Basics of LASSO and Ridge regression.	
	3.3	**Classification:** Logistic Regression, Decision trees, Naïve Bayes, SVM for linearly separable data, Kernel SVM for non linearly separable data.	
4		**Unsupervised Learning:**	**06**
	4.1	**Clustering:** K-means and Hierarchical Clustering	
	4.2	Dimensionality reduction: Linear Discriminant Analysis (LDA), Principal Component Analysis (PCA)	
5		**Artificial Neural Networks:**	**07**

	5.1	The Neurons and the Brain, Neural Networks and Representation, Perceptron, Multilayer perceptron (MLP).	
	5.2	Back propagation, Gradient descent, NN Pruning.	
6		**Application of ML algorithms in Industrial Automation and Robotics:**	**04**
	6.1	Data screening, feature engineering, model design, limitations of ML algorithms applied for Factory automation, process control.	
	6.2	Data screening, feature engineering, model design and limitations of ML algorithms applied for autonomous cars, automated robotic arm	
		Total	**39**

Textbooks:

1	Harrington, Peter. Machine learning in action. Simon and Schuster, 2012.
2	Zheng, Alice, and Amanda Casari. Feature engineering for machine learning: principles and techniques for data scientists. "O'Reilly Media, Inc.", 2018.
3	Jiang, Hui. Machine Learning Fundamentals: A Concise Introduction. Cambridge University Press, 2021.

4	Huyen, C. "Designing Machine Learning Systems: An Iterative Process for Production-Ready Applications", O'Reilly Media, 2022.
5	Gupta, Itisha, and Garima Nagpal. Artificial Intelligence and Expert Systems. Stylus Publishing, LLC, 2020.
Reference Books:	
1	Pandey, Yogendra Narayan, et al. Machine Learning in the Oil and Gas Industry. Press, Texas, 2020.
2	Bangert, Patrick, ed. Machine learning and data science in the oil and gas industry: Best practices, tools, and case studies. Gulf Professional Publishing, 2021.
3	Das, Santosh Kumar, et al., eds. Machine learning algorithms for industrial applications. Cham: Springer, 2021.

Internal Assessment:

1) Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks.
2) Mid Term test is to be conducted when approx. 50% syllabus is completed.
3) Duration of the midterm test shall be one hour.

Continuous Assessment:

Continuous Assessment is of **20 marks**. The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr. No	Rubrics	Marks
1	Certificate course for 4 weeks or more: NPTEL/ Coursera/	10 marks

	Udemy/any MOOC	
2	Wins in the event/competition/hackathon	10 marks
3	Content beyond syllabus presentation	10 marks
4	Creating Proof of concept	10 marks
5	Mini Project / Extra Experiments/ Virtual Lab	10 marks
6	GATE Based Assignment test/Tutorials etc.	10 marks
7	Participation in event/workshop/talk / competition followed by small report and certificate of participation relevant to the subject (in other institutes)	05 marks
8.	Multiple Choice Questions (Quiz)	05 marks
9.	Peer Review and participation the marks can be left blank (with discretion of faculty)	05 Marks

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five need to be solved.

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Department of Automation and Robotics

Machine Learning (Lab)

Suggested Experiments: Students are required to complete at least 08 experiments.	
Sr. No.	**Name of the Experiment**
1.	Write a python program to determine mean, variance and standard deviation of a given data set.
2.	Write a python program to implement linear regression with one variable for a given data set.
3.	Write a python program to implement linear regression with two variables for a given data set.
4.	Implement regularized regression techniques such as LASSO or Ridge for given dataset
5.	Write python programs to implement logistic regression for any given dataset.
6.	Write python programs to implement K-means clustering algorithm for image compression
7.	Write python programs to implement Hierarchical clustering for any application
8.	Implement SVM for any classification application
9.	Implement decision tree or random forest algorithm for data classification
10.	Implement ANN for hand-written digit recognition
11.	Write a program for application of ML algorithm for automation application
12.	Case study/ mini-project on applying ML algorithms for any robotic application

Note: Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Term Work:	
1	Term work should consist of 08 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks: (Experiments: 10-marks, Journal: 10-marks, Attendance: 05-marks)

3-D Printing with CAD/CAM

Course Code	Course Name	Teaching Scheme (Teaching Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/PR	Tut	Total
NARVSL61	3-D Printing with CAD/CAM (Lab)	-	04	-	-	02	-	02

Course Code	Course Name	Examination Scheme					
		Theory			Term Work	Practical & Oral	Total
		Internal Assessment		End Sem Exam			
		Mid-Term Test	Continuous Assessment				
NARVSL61	3-D Printing with CAD/CAM (Lab)	-	-	-	25	25	50

Course Prerequisite: Engineering Drawing, Basics of CNC machines	
Course Objectives:	
1	To impart the 3D modeling skills for development of 3D models of basic engineering components.
2	To introduce Product data exchange among CAD systems
3	To familiarize with production drawings with important features like Bill of Materials etc.
4	To familiarize with subtractive manufacturing process in particular CNC systems
5	To acquaint with basic part programing process for specific operations
6	To familiarize with the additive manufacturing process, particularly in 3D printing.
Course Outcomes: After successful completion of the course students will be able to:	
1	Illustrate basic understanding of types of CAD model creation, visualize and prepare 2D modeling of a given object using modeling software
2	Build a solid model of a given object using 3D modeling software.
3	Generate assembly models of given objects using assembly tools of a modeling software and can perform product data exchange among CAD systems.
4	Develop and execute part programing for any given specific operation and can build any given object using various CNC operations.

5	Demonstrate CAM Tool path and prepare NC- G code.
6	Build any given real life object using the 3D printing process.

3-D Printing with CAD/CAM (Skill Lab)

Suggested Experiments: Students are required to complete at least **eight** from the suggested list below.

Sr. No.	Name of the Experiment
1	3D modeling of basic Engineering components like nuts & bolts, screws, springs, etc.
2	3D modeling of a mechanical joint like Cotter joint, Knuckle joint, etc.
3	3D modeling of a mechanical coupling like Universal Coupling, etc.
4	3D modeling of a robotic component like end effector, robotic gripper, etc.
5	Generation of any assembly model (minimum three child parts) along with Production drawing
6	Disassembling any physical model having not less than three parts, sketch (to true dimensions) the minimum views required for each component and convert these sketches into a 3-D model.
7	Part programming of CNC Turning trainer (Involving processes like Step turning, facing, Taper turning, threading, etc.)
8	Part programming of CNC Milling trainer (Involving processes like contouring, drilling, facing, pocketing etc.)

9	Part fabrication on CNC turning/ milling trainer.
10	Tool-path generation by translation of part geometry from computer aided design (CAD) to computer aided manufacturing (CAM) systems.
11	Case Study: Report on a visit conducted to any industry explaining the design features, pre-processing in CAM software and its capabilities.
12	Development of a physical 3D robotic structure using any one of the rapid prototyping processes.
13	Check the constraints of any two RP systems for features like layer thickness,orientation of geometry, support generation, post processing etc.
14	Case Study: Usability of rapid tooling integrated with any manufacturing process, with their advantages and limitations in any one of emerging areas.

Note: Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Term Work:	
1	Term work should consist of 8 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks (Experiments: 10 marks, Journal Assessment: 10 marks, Attendance: 5 marks)

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