



ST. VINCENT PALLOTTI COLLEGE OF ENGINEERING & TECHNOLOGY, NAGPUR

(An autonomous institution affiliated to Rashtrasant Tukadoji Maharaj Nagpur University)

B. Tech. Scheme of Examination & Syllabus 2025-26

ROBOTICS AND ARTIFICIAL INTELLIGENCE

THIRD SEMESTER

Sr No	Course Category	Course Code	Course Title	Hours per Week			Credits	Maximum Marks				Min Passing marks	Duration No. of Hrs for ESE
				L	T	P		Mid-Sem Examination	Continual Assessment	End Sem Examination	Total		
1.	PCC	25RA301T	Analog and Digital Electronics	3	-	-	3	20	20	60	100	45	3
2.	PCC	25RA301P	Analog and Digital Electronics Lab	-	-	2	1	-	25	25	50	25	-
3.	PCC	25RA302T	Actuators for Robotics	2	-	-	2	10	10	30	50	23	1.5
4.	PCC	25RA303T	Robot Mechanisms	3	-	-	3	20	20	60	100	45	3
5.	PCC	25RA303P	Robot Mechanisms Lab	-	-	2	1	-	25	25	50	25	-
6.	PCC	25RA304P	Robot Programming Lab	-	-	2	1	-	25	25	50	25	-
7.	PCC	25RA305T	Robot Safety and Maintenance	2	-	-	2	10	10	30	50	23	1.5
8.	VEC	25RA306T	Environmental Science	2	-	-	2	10	10	30	50	23	1.5
9.	HSSM	25RA307T	Fundamentals of Economics and Management	2	-	-	2	10	10	30	50	23	1.5
10.	SEC	25RA341P	Career Development – I	-	-	2	1	-	50	-	50	25	-
11.	MDM	25RA331M	MDM-I (Refer MDM basket)	2	-	-	2	10	10	30	50	23	1.5
Total				16		8	20	90	215	345	650	-	-

Note: MDM – I course will be conducted through MOOC (NPTEL). The course will be notified one month prior to commencement of semester.

MDM - I	
25RA331M	Fundamentals of Robotics

		July 2026	NEP 3.0	Applicable for 2026-27
Chairman - BoS	Dean – Academics	Date of Release	Version	



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ROBOTICS AND ARTIFICIAL INTELLIGENCE

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Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation			
						MSE	CA	ESE	Total
25RA301T	Analog and Digital Electronics	3	-	-	3	20	20	60	100

Course Objectives	Course Outcomes
1. To understand basic analog electronic devices and circuits. 2. To learn the applications of operational amplifiers and linear ICs. 3. To introduce digital logic circuits used in electronic systems. 4. To acquaint students with basic digital gates and develop logical circuits using Boolean logic.	The student will be able to: 1. Explain the working of diodes, BJTs, MOSFETs, and operational amplifier circuits. 2. Describe the operation of 555 timers, ADCs, and DACs. 3. Explain the fundamental concepts and use basic logic gates and logic reduction techniques. 4. Analyze, design, and implement combinational and logic circuits. 5. Analyze, design, and implement sequential circuits and their applications.

UNIT- I: Analog Electronics	[9 Hrs.]
PN junction's diode applications – Clipper, clamper, Rectifier (Basics Fundamentals). BJT applications – Switch, Amplifier. MOSFET-Basic working and characteristics. Operational Amplifiers: ideal characteristics and applications, Inverting, non-inverting, summing, integrator, Differentiator, Schmitt Trigger	
UNIT-II : Analog Timing and Data Conversion Circuits	[8 Hrs.]
555 Timer: astable and monostable modes, Comparators and Schmitt trigger, Analog-to-Digital Converters (ADC): principle, resolution Digital-to-Analog Converters (DAC): basic concepts	
UNIT-III: Number System and Logic Simplification	[10 Hrs.]
Analog V/s Digital systems, Number Systems, Digital Codes – Binary, Octal, decimal, Hex, , BCD, Gray, Ex -3, Conversion, Boolean Algebra, Logic Gates, standard representations for logic functions, k map representation of logic functions (SOP & POS forms), minimization of logical functions for min-terms and max-terms (up to 4 variables), don't care conditions	
UNIT- IV: Combinational Circuits	[9 Hrs.]
. Adders, Subtractor, Parity generators/checkers, Multiplexers and their use in combinational logic designs, multiplexer trees, Demultiplexers, Encoders & Decoders, BCD - to 7 segment decoder	
UNIT-V: Sequential Circuits and its Application	[9 Hrs.]
Bit Memory Cell, Clocked SR, JK, MS J-K flip flop, D and T flip-flops. Registers, shift registers, Counters	

Text Books

S.N	Title	Authors	Edition	Publisher
1.	Electronic Devices and Circuit Theory	Boylestad, R. L. and Nashelsky, L.	2011	Pearson Education.
2.	Analog and Digital Electronic Circuits: Fundamentals, Analysis and Applications,	Prasad, R.,	2021	Springer.
3.	Op-Amps & Linear Integrated Circuits,	Gaikwad, R.,	4 th edition	Pearson Education.

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	Microelectronic Circuits,	Sedra, A. S. and Smith, K. C	6 th edition	Oxford University Press.
2.	Modern Digital Electronics,	Jain, R. P	2003	McGraw Hill Education

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B. Tech. Scheme of Examination & Syllabus 2025-26**ROBOTICS AND ARTIFICIAL INTELLIGENCE****FIRST SEMESTER**

Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation		
						CA	ESE	Total
25RA301P	Analog and Digital Electronics Lab	-	-	2	1	25	25	50

Course Objectives	Course Outcomes
<ol style="list-style-type: none">To understand and verify basic analog electronic circuits.To study operational amplifier configurations and timer circuits.To design and implement waveform generation and Schmitt trigger circuits.To implement and verify basic digital logic and combinational circuits.To analyze the working of sequential circuits such as flip-flops and counters.	<p>After completion of the course, students will be able to:</p> <ol style="list-style-type: none">Verify the operation of clipper, clamper, and op-amp circuits.Design and test 555 timer and Schmitt trigger circuits.Implement and verify truth tables of logic gates.Design and analyze adders, multiplexers, encoders, and decoders.Analyze and verify the operation of flip-flops and up/down counters.

Minimum eight experiments to be performed from the list

S.No	List of Experiments
1	To verify the clipper and Clamper Circuit
2	To Verify Inverting and Non inverting Op-amp
3	Design Astable /Monostable multivibrator using IC 555
4	Design and implement Schmitt Trigger circuit
5	To verify the truth table of different Logic Gates.
6	To implementation of Half adder and Full Adder and to verify their truth table.
7	To Implement full adder using 4:1 MUX and verify truth table of 1:4 DEMUX
8	To study and verify truth table of Encoder and Decoder.
9	To study and verify the truth table of different types of Flip-flops
10	To study the functioning of Up/Down counter,

Text Books

S.N	Title	Authors	Edition	Publisher
1.	Electronic Devices and Circuit Theory	Boylestad, R. L. and Nashelsky, L.	2011	Pearson Education.
2.	Analog and Digital Electronic Circuits: Fundamentals, Analysis and Applications,	Prasad, R.,	2021	Springer.
3.	Op-Amps & Linear Integrated Circuits,	Gaikwad, R.,	4 th edition	Pearson Education.

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	Microelectronic Circuits,	Sedra, A. S. and Smith, K. C	6 th edition	Oxford University Press.
2.	Modern Digital Electronics,	Jain, R. P	2003	McGraw Hill Education

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ROBOTICS & ARTIFICIAL INTELLIGENCE ENGINEERING****THIRD SEMESTER**

Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation			
						MSE	CA	ESE	Total
25RA302T	Actuators for Robotics	2	-	-	2	10	10	30	50

Course Objectives	Course Outcomes
1 To gain a clear understanding of the principles and working of actuators used in robotics 2 To support effective selection of suitable actuators for robots based on their application	1. Explain and analyze the anatomy of robotic systems, including links, joints, end effectors, and degrees of freedom. 2. Describe and evaluate the principles, characteristics, and applications of electric, pneumatic, and hydraulic actuators used in robotics. 3. Select appropriate conventional and advanced actuators for robotic systems based on application requirements and design considerations

Unit I **[10Hrs]****Electric actuators:**

Direct current motor, Permanent magnet stepper motor, Servo Control DC motors, Linear and latching linear actuators, Rotary actuators, Piezoelectric actuators, Actuator parameters and characteristics, Stepper motors, Specifications and characteristics of Stepper Motors Servo Motors, relays and solenoids as actuators. Application of electric actuators.

Unit II **[10Hrs]**

Hydraulic actuators: Hydraulic power actuation devices: Hydraulic Actuators, design considerations and selection, selection of linear actuating cylinders, Hydraulic Motors. Application of hydraulic actuators.

Unit III **[10Hrs]****Pneumatic actuators:**

Pneumatic power actuation devices: Pneumatic actuators, design considerations and selection, pneumatic cylinders, pneumatic drive system, Linear & rotary actuators. Advanced actuators – Piezoelectric actuators, elastomer actuators, soft actuators, shape memory alloy based actuators, under actuated robotic hand. Application of pneumatic actuators.

Text Books

S.N	Title	Authors	Edition	Publisher
1.	Introduction to Robotics	S. K. Saha	2014, 2 nd edition	TATA McGraw Hills Education
2	Fundamentals of Robotics	Dilip Kumar Pratihar	2019	Narosa Publishing House

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	Introduction to Robotics: Mechanics and Control	John J. Craig	4th Edition 2019	Pearson
2.	Industrial Robotics: Technology, Programming and Applications	Mikell P. Groover, Nicholas Godfrey, Mitchel Weiss, Roger N. Nagel, and Ashish Dutta	2nd Edition, 2012.	McGraw-Hill Publishers

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THIRD SEMESTER

Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation			
						MSE	CA	ESE	Total
25RA303T	Robot Mechanisms	3	-	-	3	20	20	60	100

Course Objectives	Course Outcomes
<p>Objectives of this course are :</p> <ol style="list-style-type: none"> Develop fundamental understanding of kinematic structures used in robotic mechanisms by analyzing motion, velocity, and acceleration in planar and spatial mechanisms. Understand mechanical design aspects of robotic components and Interpret robot configurations and classifications. 	<ol style="list-style-type: none"> Identify different types of kinematic pairs, chains, robot joints and determine degrees of freedom using Gruebler's criterion. Analyze and classify robot configurations (SCARA, articulated, etc.), robot structure, connectivity, and workspace concepts. Apply vector algebra and matrix operations in robotics and represent position and orientation in 3D space. Derive rotation matrices and composite transformations and analyze orientation using Euler angles and rotations. Formulate homogeneous transformation matrices and solve coordinate transformation problems between frames.

Unit I	[9 Hrs]
Introduction to Robotics: Robot links, joints and movement, kinematic pair, Basics of Degree of freedom, Joint notations, kinematic chain, Geometric and kinematic diagrams,	
Unit II	[9 Hrs]
Robot Mechanisms: Robot arm configurations, types of robots, Robot 3D visualization, SCARA Robot, Robot manipulator connectivity and calculation of DoF, Robot anatomy wrist & end effector, Robot classification and specifications, Robot notations and conversions.	
Unit III	[9 Hrs]
Kinematics Description: Mathematics in Robotics- Matrices and determinants, unit vectors, vectors, vector operations-dot and cross products, differentiation of vectors Coordinate frames and position of a point in 3D space, direction cosine, Coordinate Reference Frames.	
Unit IV	[9 Hrs]
Transformation matrix: Fundamental rotation matrices, Euler's theorem fixed angle and Euler angle representation of orientation. coordinate transformations, fundamental rotation matrices, Vector Representations and Operations, Transformations, Translational and Rotational, composite rotation matrix (screw axis representation of orientation), rotation about an arbitrary vector in 3d space, Properties of Transformation Matrices, Matrix Creation and Manipulation using software.	
Unit V	[9 Hrs]
Homogeneous Transformation: Homogeneous transformation, composite homogeneous transformation, inverse transform,	

Text Books

S.N	Title	Authors	Edition	Publisher
1.	Design of Machine Elements	V. B. Bhandari	2005	McGraw Hill
2.	Theory of Machines	S.S. Ratan	3 rd Edition, 2009.	Tata McGraw Hill Education Private Limited

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	Fundamentals of Robotics: Analysis and Control	Robert J. Schilling	2022	Prentice Hall
2.	Theory of Machines and Mechanisms.	Ulicker Jr., J.J., Penock, G.R. and Shigley, J.E.	2009	Oxford University Press

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Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation		
						CA	ESE	Total
25RA503P	Robot Mechanisms Lab	-	-	2	1	25	25	50

Course Objectives	Course Outcomes
Objectives of this course are : 1. Familiar with the selection of mechanism of robot for carrying out any task. 2. Understand the relation between the different link coordinates from base to the end effectors 3. Determine the velocity and acceleration of joint motion during the robot operation.	1. Model robotic mechanisms using RoboAnalyzer. 2. Perform kinematic analysis of mechanisms. 3. Analyze velocity and acceleration using MATLAB. 4. Evaluate workspace and motion characteristics. 5. Apply static force analysis in robotic systems.

LIST OF EXPERIMENTS

Minimum 8 practical to be performed

Exp. No.	Title of the Experiments
1	Model a mechanism various robot joints (revolute, prismatic, spherical, cylindrical) and identify DoF using MATLAB
2	Determination of Mobility of Planar Mechanisms using Gruebler's Criterion
3	Modeling of Kinematic Chains and Mechanisms to convert kinematic chains into mechanism models.
5	Modeling and Visualization of Robot Arm Configurations to study Cartesian, Cylindrical, Polar, Articulated and SCARA robots.
6	Modeling of Robot Wrist and End-Effector Motion to visualize wrist orientations and motion.
7	Simulation of SCARA Robot Configuration to study workspace and movement of SCARA robot.
8	Simulation of orientation representation using Direction Cosines to generate orientation matrices.
9	Simulation of Screw Axis representation of Robot Motion to represent rotational motion in space and visualization of screw motion.
10	Simulation of Fundamental Rotation Matrices about X, Y, and Z axes using Euler Angle and Fixed Angle Transformation
11	Development of Homogeneous Transformation Matrix robotic links.
12	Development of Composite Homogeneous Transformation of Multi-Link Robot of serial manipulator and determination End-effector position.
13	Determine inverse coordinate transformations for verification through matrix inversion.

Text Books

S.N	Title	Authors	Edition	Publisher
1.	A Text Book of Theory of Machines	R. S. Khurmi and J. K. Gupta	14 th Revised Edition 2005	S. Chand, New Delhi
2.	Theory of Machines	S.S. Ratan	3 rd Edition, 2009.	Tata McGraw Hill Education Private Limited

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	Strength of Materials	D.S. Bedi	2022	Khanna Book Publishing
2.	Theory of Machines and Mechanisms.	Ulicker Jr., J.J., Penock, G.R. and Shigley, J.E.	2009	Tata McGraw Hill Education Private Limited

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Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation		
						CA	ESE	Total
25RA304P	Robot Programming Lab	-	-	2	1	25	25	50

Course Objectives	Course Outcomes
<ol style="list-style-type: none">Use fundamental and technical knowledge of robot Programming.Learn Robot Programming using teach Pendant for various applications.Program a Robot for Industrial applications.Provide hands-on experience with industrial automation tasks.	<ol style="list-style-type: none">Perform various robotic operations including pick and place, object detection, and palletizing.Develop skills in utilizing sensors such as photoelectric and color sensors for automation tasks.Design and implement conveyor belt systems for efficient material handling.Integrate multiple components to develop automation systems for a given problem statement.

LIST OF EXPERIMENTS

Minimum 8 practical to be performed

Exp. No.	Title of the Experiments
1	Demonstration of a Robot
2	Performance of the basic and conditional commands using robot programming language
3	Performance of gripper operation Wrist Mechanism-Interpolation-Interlock commands
4	Performance to detect objects in front of the sensors (eg. Proximity Sensor).
5	Performance to detect the colors of the objects in front of the sensors (eg. Color Sensor).
6	Robot Programming using Flex Pendant- Lead through programming including Coordinate systems of Robot.
7	Performance of pick and place operation
8	Performance to sort and palletize the objects based on combinations of sensors and grippers.
9	Performance based on commands for motion control, hand control, program control, pick and place applications.
10	Performance of Robot welding application
11	Implementation of Forward kinematics of PUMA 560 through Virtual Lab.
12	Implementation of Reverse kinematics of PUMA 560 through Virtual Lab

Text Books

S.N	Title	Authors	Edition	Publisher
1.	Industrial Robotics	Groover.M.P.	1996.	McGraw – Hill International edition
2.	Introduction to Robotics	S. K. Saha	2014	TATA McGraw Hills Education
3.	Robotics and Control	R. K. Mittal, I. J. Nagrath	2003	TATA McGraw Hill Publishing Co Ltd

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	Robotics Technology and Flexible Automation	Deb S R	1994	Tata McGraw Hill, New Delhi,
2.	Fundamentals of Robotics	Dilip Kumar Pratihari,	2019	Narosa Publishing House
3	Robot Programming	Hughes Cameron	2016	Pearson Publishers
4	Robotics: Control and Programming	J. Srinivas	2009	Narosa Publication

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Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation			
						MSE	CA	ESE	Total
25RA305T	Robot Safety and Maintenance	2	-	-	2	10	10	30	50

Course Objectives	Course Outcomes
Objectives of this course are : 1. To expose the students to the importance of the Robot Safety and its standards. 2. To enable the students to apply the various BIS and ISO safety standards for Robots and Safety management system	1. Understand the Robot Safety and its problems and Hazards and ways to combat it 2. Interpret the Robot Accidents and Safety Standards for Robotic Technology and understand the effect of Robot accidents and ways to prevent it. 3. Understand and apply the various Human factors towards the safety of the Robots

Unit I [10Hrs]**Introduction to Robot Safety:**

Introduction, Safety-Related Terms and Definitions, Organizations Concerned with Safety, Introduction, Robotic Safety Problems and Hazards, Use of Robots to Promote Safety, Weak Points in Planning and Design, Operations Causing Safety Problems, The Manufacturer's and User's Role in Robot Safety.

Unit II [10Hrs]

Robot Accidents and Safety Standards for Robotic Technology: Introduction. Real-Life Examples of Robot Accidents Robot Accidents in Japan, Western Europe, and the United States Causes and Characteristics of Robot Accidents Effects of Robot Accidents and Periods Off Work Due to Robot Accidents Robot Accidents at Manufacturer and User Sites Robot Accident Analysis and Prevention.

Safety Standards for Robotic Technology: BIS and ISO safety standards for Robots, Safety management system, Hazard identification, Risk analysis and Evaluation, Audit Programme, Preventive Maintenance of Robots.

Unit III [10Hrs]

Robot Safety and its Safety devices, Human Factors in Robotics: Introduction, Robot Safety Education, Safety Considerations in Robot Testing and Start-Up, Commissioning, and Acceptance, Safety Considerations in Robot Welding Operations, Robot Safety in the Automobile Industry. Robot Standardization and Safety Standards.

Robots Versus Humans, Human Factors' Issues During the Factory Integration of Robotic Systems, Built-In Human Biases and Some Design Improvement Guidelines for Improving Robot Operator Comfort and Productivity, Benefits and Drawbacks of Robotization from the Standpoint of Human Factors.

Text Books

S.N	Title	Authors	Edition	Publisher
1.	Advanced Robotics (Design & Applications)	Sabrie Soloman	-	Khanna Book Publishing
2.	Robot Reliability and Safety	B.S. Dhillon	-	CRC Press, 2015

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	Industrial Robotics: Technology, Programming, and Applications	Mikell P. Groover	2nd Edition	McGraw-Hill Education

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Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation			
						MSE	CA	ESE	Total
25RA331MT	Fundamentals of Robotics	2	-	-	2	10	10	30	50

Course Objectives	Course Outcomes
Objectives of this course are : 1. To explain the history of robotics, its evolution, and its role in modern industry, along with an approach for implementation. 2. To provide a foundational understanding of the types of robots, the terminologies used in robotics, robot motion, robot components, and their applications. 3. To motivate students to build a strong foundation in robotics and automation to develop a career path as per the needs of the modern industry.	1. Explain the foundational concepts of robotics, including its historical context, robot anatomy, motion, drive systems, and the critical performance parameters like precision and repeatability. 2. Describe the types and functions of end effectors and sensors, and also explain robot programming methods to define and control robot motion in a three-dimensional space. 3. Identify and describe robot work cells, explain the applications of robots, and state the approach for the implementation of robotics.

Unit I	[10Hrs]
Introduction: robotics and automation, history, robot anatomy and configurations, Robot motion: DoF, Robot joint notations, Work Volume, drive systems, motion speed, load carrying capacity, types of robot control, Precision of movement, repeatability.	
Unit II	[10Hrs]
Robot end effectors: Types, Gripper mechanisms, Tools as end effectors, Physical support, consideration in gripper selection and design. Sensors for robotics: Types and uses, robot drives, actuators for robots Robot Programming: Methods, robot program as a path in space, Methods of defining positions in space.	
Unit III	[10Hrs]
Robot work cell design and control: types of layout, Multiple robots and machine interface, considerations in work cell design, work cell control, Interlocks, Error detection and recovery. Robot applications: Material transfer and machine loading-unloading, Processing operations, Assembly, Inspections, others Robot implementation: Approach for implementing robotics, Safety, training, maintenance and quality	

Text Books

S.N	Title	Authors	Edition	Publisher
1.	Industrial Robotics	Mikell Groover, Mitchel Weiss, Roger Nagel, Nicholas Odrey, Ashish Dutta	2 nd Edition	McGraw-Hill Education (India) Private Ltd.
2.	An Introduction to Robotics	KC Jain, PL Verma, Rajesh Khodre	1 st 2023	Khanna Publishers
3.	Foundations of Robotics & Automation (Theory & Practice)	A. B. Bhattacharya and Debasish Roy	1 st 2025	Khanna Publishing House

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	Robotics for the Students of B.Tech., B.E., and B.Sc. (Engg.)	Chikesh Ranjan & Kaushik Kumar	2024	S. Chand Publishing
2.	Robotics and Control	R.K. Mittal and I.J. Nagrath	2017	McGraw Hill Education India

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