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ताळगांव पठार,
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GU/Acad –PG/BoS -NEP/2025/386 Date: 09.09.2025

CIRCULAR

The University has decided to implement the Curriculum and Credit Framework for the Undergraduate Programme (CCFUP) under the National Education Policy (NEP), 2020 based on All India Council for Technical Education (AICTE) and National Credit Framework (NCrF) Guidelines from the Academic Year 2024-2025 onwards.

The Syllabus of Semester III & IV Courses offered under Specialization **Robotics** of **Bachelor of Engineering in Electronics and Computer Engineering/ Bachelor of Engineering in Electronics and Computer Science** Programme is attached.

The Dean, Faculty of Engineering and Principals of affiliated Engineering Colleges are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2025.09.09 11:05:26 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,

1. The Dean, Faculty of Engineering, Goa University.
2. The Principals of affiliated Engineering Colleges.

Copy to,

1. The Director, Directorate of Technical Education, Govt. of Goa
2. The Chairperson, BoS in Electronics and Computer Engineering.
3. The Controller of Examinations, Goa University.
4. The Assistant Registrar, Prof. Examinations (Technical and Allied), Goa University.
5. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

Electronics and Computer Engineering and Electronics and Computer Science

Specialization: Robotics

Sr. No.	Semester	Course Code	Title of the Course	L	T	P	Credits
1	III	ECM-281	Introduction to Robotics and AI	3	0	0	3
		ECM-282	Introduction to Robotics and AI Lab	0	0	1	1
2	IV	ECM-283	Controls of Robotic systems	3	0	0	3
		ECM-284	Controls of Robotic systems Lab	0	0	1	1

Approved by: Standing Committee of the Academic Council on 24th & 25th July 2025

SEMESTER III

Name of the Programme : Electronics and Computer Engineering/Electronics and Computer Science (Robotics)
Course Code : ECM-281
Title of the Course : Introduction to Robotics and AI
Number of Credits : 3
Effective from AY : 2024-25

Pre-requisites for the Course:	Mathematical background, Basic Programming	
Course Objectives:	**The subject aims to provide the student with:** • An understanding of all the subsystems and components of a robot. • An understanding of different drive systems and sensors used in robots. • An understanding of foundational concepts of AI and application of search techniques for effective problem solving. • An understanding of Logic, Planning and learning techniques for effective knowledge representation and intelligent decision making.	
Content:		**No of hours**
Unit - 1	**Fundamentals of robotics:** Automation and robotics, Robot applications. **Different classifications of the robot:** By application, by a coordinate system, by actuation system, by control method and by programming method. **Robot anatomy:** links and joints, Joint notation scheme. Degree of Freedom, Degree of Manipulability, Robot resolution, accuracy and repeatability. Concept of workspace/Work envelope. **Robot End Effectors:** Classification of Grippers, Criteria for selecting Grippers, Robot Grippers: Mechanical, Magnetic, Vacuum and Adhesive and Tools.	**11**
Unit - 2	**Drive systems:** Pneumatic and hydraulic Drives. Electric: Relation between torque and voltage. AC and DC Servo motors, Stepper motors, BLDC motors. Electronic control of motors. L293D **Sensors:** Characteristics of a sensor, Classification of Sensors, Touch sensors, Position Sensors: Potentiometer, LVDT, Optical Encoders, Force/Moment sensors, Range Sensor, Proximity Sensors- Inductive sensor, capacitive sensor, Hall effect sensor, Passive Sensor: RCC. **Advance Sensor Technology:** Smart sensors, MEMS based sensors, Selection of sensors while designing robotic systems.	**11**
Unit - 3	**Introduction to AI:** What is Intelligence? Problem Solving:	**11**

	Defining a problem. **State Space Search:** Breadth First Search, Depth First Search, **Heuristic Search:** Generate and Test, Simple Hill Climbing, Steepest-Ascent Hill climbing, Best First Search, A* algorithm. **Optimal Search:** Iterative Deepening A*, Recursive Best First Search.	
Unit - 4	**Knowledge Representation:** Representation and Mapping, Approaches to knowledge representation. **Predicate Logic:** Representing simple facts and logic, Representing instance and ISA relationship, Computable functions and predicates. **Logic and Inferences:** Formal Logic, Propositional Logic, Resolution method in Propositional Logic, and First Order Logic, Forward & Backward Chaining. **Planning:** STRIPS, Forward and Backward State Space Planning, Goal Stack Planning, Plan Space Planning. **Game Playing:** Mini-Max Search Procedure, Alpha-Beta Pruning.	**12**
Pedagogy:	Interactive, reflective, and inquiry-based methods, with a strong emphasis on critical thinking and problem-solving skills	
References/ Readings:	**TEXTBOOKS:** 1. S. K. Saha; Introduction to Robotics, 2nd Ed.; McGraw Hill. ISBN: 9780070141109 2. M. P. Groover, M. Weiss, R. N. Nagel, N. G. Odrey; Industrial Robotics: Technology, Programming and Applications; McGraw Hill. ISBN: 9780070221543 3. Saeed B. Niku; Introduction to Robotics: Analysis, Control, Applications, 2nd Ed.; Wiley Publications. ISBN: 9780471743797 4. Elaine Rich, Kevin Knight; Artificial Intelligence; TMH. ISBN: 9780074624755 5. Stuart Russell, Peter Norvig; Artificial Intelligence: A Modern Approach; Pearson. ISBN: 9780134610993	
	REFERENCE BOOKS: 1. John J. Craig; Introduction to Robotics, Mechanics & Control; Pearson Education Inc. ISBN: 9780133157037 2. Mittal, R. & Nagrath, I. J.; Robotics and Control; McGraw Hill, ISBN: 9780074602128 3. Nils J. Nilsson; Artificial Intelligence: A New Synthesis; Harcourt Asia. ISBN: 9781558604674 4. Patrick Winston; Artificial Intelligence; Pearson Education, ISBN: 9780321545892 5. Ivan Bratko; Prolog Programming for Artificial Intelligence; Pearson Education, ISBN: 9780321417460	

Course Outcomes:	**Upon completion of the course, students will be able to** CO 1. Explain the basic principles of robotics, including robot classifications, anatomy, and end effectors, and explain their applications in various industries. CO 2. Apply different actuation systems and sensors to design and control robotic systems using platforms like Arduino and Raspberry Pi. CO 3. Analyze and evaluate search algorithms such as BFS, DFS, and A* to solve real-world AI problems and optimize robotic decision-making. CO 4. Create intelligent systems by implementing AI planning techniques, such as STRIPS and Minimax, to enable robots to perform complex tasks autonomously.

Name of the Programme : **Electronics and Computer Engineering/Electronics and Computer Science (Robotics)**
Course Code : **ECM-282**
Title of the Course : **Introduction to Robotics and AI Lab**
Number of Credits : **01**
Effective from AY : **2024-25**

Prerequisites for the Course:	Mathematical background, Basic Programming	
Course Objectives:	The subject aims to provide students with the ability to: • Understand the architecture and design principles of real-time embedded systems used in IoT applications. • Apply programming skills to interface sensors and actuators using Arduino and Raspberry Pi. • Analyze and evaluate data from IoT devices for edge computing and decision-making. • Develop embedded AI solutions using appropriate search and optimization algorithms for real-time applications	
Content:	**List of programs/ Experiments** ***(Following experiments should be conducted. A certified journal reporting the experiments conducted should be submitted at the end of the term)***	**No of Hours**
	1. Electronic Control of a DC Servo motor 2. Electronic Control of a Stepper motor 3. Electronic control of BLDC motor 4. Interfacing of proximity and range sensors to Arduino/R-Pi 5. Interfacing of Accelerometers and Gyroscopes sensors to Arduino/R-Pi 6. Interfacing of force sensors to Arduino/R-Pi 7. Program to implement breadth first search algorithm. 8. Program to implement depth first search algorithm. 9. Program to implement Best First Search algorithm. 10. Program to implement alpha beta pruning. 11. Program for implementation Hill climbing problem. 12. Program to implement A* search algorithm. 13. Program to solve water jug problem. 14. Program to simulate tic – tac – toe game using min-max algorithm.	**30**
Pedagogy:	Integration of instructional learning, constructive thinking, inquiry-based, collaborative, experiential, and problem-solving approaches.	
	TEXTBOOKS:	

References/ Readings:	1. S. K. Saha; Introduction to Robotics, 2nd Ed.; McGraw Hill, ISBN: 9780070141109 2. M. P. Groover, M. Weiss, R. N. Nagel, N. G. Odrey; Industrial Robotics: Technology, Programming and Applications; McGraw Hill, ISBN: 9780070221543 3. Saeed B. Niku; Introduction to Robotics: Analysis, Control, Applications, 2nd Ed.; Wiley Publications, ISBN: 9780471743797 4. Elaine Rich, Kevin Knight; Artificial Intelligence; TMH, ISBN: 9780074624755 5. Stuart Russell, Peter Norvig; Artificial Intelligence: A Modern Approach; Pearson, ISBN: 9780134610993
	REFERENCE BOOKS: 1. John J. Craig; Introduction to Robotics, Mechanics & Control; Pearson Education Inc. ISBN: 9780133157037 2. Mittal, R. & Nagrath, I. J.; Robotics and Control; McGraw Hill, ISBN: 9780074602128 3. Nils J. Nilsson; Artificial Intelligence: A New Synthesis; Harcourt Asia, ISBN: 9781558604674 4. Patrick Winston; Artificial Intelligence; Pearson Education, ISBN: 9780321545892 5. Ivan Bratko; Prolog Programming for Artificial Intelligence; Pearson Education, ISBN: 9780321417460
Course Outcomes:	**Upon completion of the course, students will be able to** CO 1. Implement DC servo, stepper, and BLDC motors using electronic circuits and microcontrollers. CO 2. Implement and analyze BFS, DFS, and Best First Search for solving pathfinding problems. CO 3. Implement and simulate AI algorithms such as A*, Hill Climbing, Alpha-Beta Pruning, Min-Max, and problem-solving strategies like the Water Jug Problem using programming tools. CO 4. Develop sensor-based applications by interfacing proximity, range, accelerometer, and gyroscope sensors with Arduino or Raspberry Pi.

SEMESTER IV

Name of the Programme : Electronics and Computer Engineering/Electronics and Computer Science (Robotics)
Course Code : ECM-283
Title of the Course : Controls of Robotic systems
Number of Credits : 3
Effective from AY : 2024-25

Pre-requisites for the Course:	Nil	
Course Objectives:	**The course aims to provide the students with:** • An ability to solve problems related to kinematics of a robot. • An ability to solve problems related to dynamics of a robot. • An understanding of Trajectory planning and motion planning. • An ability to design and program simple robotic platforms	
Content:		**No of hours**
Unit - 1	**Coordinate frames, mapping and transforms**: description of objects in space, transformation of vectors, Inverting a Homogenous Transform, Fundamental rotation matrices. **Direct Kinematic model:** Kinematic model for Robotic Manipulator (2 DOF and 3 DOF). DH notations. Manipulator Transformation Matrix. **Inverse Kinematics:** Solvability of inverse kinematic models, solution techniques, closed form solution.	**10**
Unit - 2	**Differential Kinematics:** Linear and Angular motion of rigid bodies, Velocity propagation along links, Manipulator Jacobian, Jacobian singularities. **Manipulator Dynamics:** Determination of Robotic Joint Torques, Langrage Euler formulation, Newton Euler formulation, Example with 2 link Manipulator.	**12**
Unit - 3	**Trajectory planning:** Definitions and planning tasks, joint space techniques, Cartesian space techniques, joint space v/s Cartesian space. **Control of Manipulators:** Open and closed loop control, Linear control schemes, PD and PID control schemes, Force control of manipulators, Force control strategies.	**11**
Unit - 4	**Analysis of wheeled robots and Biped robots:** Introduction, Staircase Ascending (SSP), Power Consumption, Dynamic Balances. **Motion planning:** Gross/Free Space Motion Planning **Find path problems using:** Visibility Graph, Voronoi diagram, Cell Decomposition, Tangent-Graph Technique. **Dynamic Motion Planning Problems:** Path Velocity, Decomposition, Accessibility Graph, Relative velocity scheme,	**12**

	Incremental planning, Artificial Potential field approach, reactive control scheme.	
Pedagogy:	Interactive, reflective, and inquiry-based methods, with a strong emphasis on critical thinking and problem-solving skills	
References/ Readings:	**TEXT BOOKS:** 1. S. K. Saha; Introduction to Robotics, 2nd Edition, McGraw Hill Education, ISBN: 9789332902800 2. M. P. Groover, M. Weiss, R. N. Nagel, N. G. Odrey; Industrial Robotics: Technology, Programming, and Applications, McGraw Hill Education, ISBN: 9781259006210 3. Saeed B. Niku; Introduction to Robotics: Analysis, Control, Applications, 2nd Edition, Wiley Publications, ISBN: 9781119527626 4. Roland Siegwart, Illah R. Nourbakhsh; Introduction to Autonomous Mobile Robots, 2nd Ed.; MIT Press, ISBN: 9780262015356	
	REFERENCE BOOKS: 1. John J. Craig; Introduction to Robotics: Mechanics & Control, Pearson Education Inc., ISBN: 9788131718360 2. Peter Corke; Robotics, Vision and Control, Springer, ISBN: 9783319544120 3. K. S. Fu, R. C. Gonzalez, C. S. G. Lee; Robotics: Control, Sensing, Vision, and Intelligence, McGraw Hill Book Co., ISBN: 9780071002370 4. Mittal, R. & Nagrath, I. J.; Robotics and Control, McGraw Hill Education, ISBN: 9780070482937	
Course Outcomes:	**Upon completion of the course, students will be able to:** CO 1. Explain the use of transformation matrices and coordinate frames in modeling robotic manipulators. CO 2. Compute forward and inverse kinematics for multi-DOF robot arms using DH parameters and matrix transformations. CO 3. Analyze robotic manipulator dynamics using Jacobians and Euler-Lagrange/Newton-Euler formulations to determine joint torques. CO 4. Design and simulate motion planning solutions for mobile robots using techniques like visibility graphs, Voronoi diagrams, and artificial potential fields.	

Name of the Programme : **Electronics and Computer Engineering/Electronics and Computer Science (Robotics)**
Course Code : **ECM-284**
Title of the Course : **Controls of Robotic systems Lab**
Number of Credits : **01**
Effective from AY : **2024-25**

Prerequisites for the Course:	Mathematical background, Basic Programming	
Course Objectives:	The subject aims to provide students with the ability to: • Understand the fundamental principles of robot kinematics, including forward and inverse kinematic modeling. • Apply path and trajectory planning techniques to control the motion of a robotic arm in different workspaces • Analyze and implement motion control strategies for robotic arms using structured programming techniques. • Design and develop intelligent robotic applications involving obstacle avoidance and real-time sensor integration.	
Content:	**List of programs/ Experiments** ***(Following experiments should be conducted. A certified journal reporting the experiments conducted should be submitted at the end of the term)***	**No of Hours**
	1. Forward Kinematics of a Robot arm (Hardware/Simulation Software) 2. Inverse Kinematics of a Robot arm(Hardware/Simulation Software) 3. Programming a robot arm for straight line paths (Hardware/Simulation Software) 4. Programming a robot arm for Circular Paths (Hardware/Simulation Software) 5. Programming a robot arm for Curved Paths (Hardware/Simulation Software) 6. Programming a robot arm for pick and place operation (Hardware/Simulation Software) 7. Programming a robot arm for Loops (Hardware/Simulation Software) 8. Programming a robot arm for branches and subroutines (Hardware/Simulation Software) 9. Programming a robot arm for external events (Hardware/Simulation Software) 10. Trajectory Planning for Robot Arm (Joint Space and Task Space) (Hardware/Simulation Software) a. Implement joint space and Cartesian space trajectory generation.	**30**

	b. Use linear or cubic interpolation for smooth motion. 11. Obstacle Avoidance Using Robot Arm (Hardware/ Simulation Software) a. Use IR or ultrasonic sensors to detect obstacles. b. Dynamically update path using kinematics and avoid collisions. 12. Velocity and Acceleration Analysis of a Robot Arm (Hardware/ Simulation Software) a. Derive joint velocities and accelerations using Jacobian matrix. b. Simulate or measure for different motions (e.g., pick and place).	
Pedagogy:	Integration of instructional learning, constructive thinking, inquiry-based, collaborative, experiential, and problem-solving approaches.	
References/ Readings:	**Textbooks** 1. S. K. Saha; Introduction to Robotics, 2nd Edition, McGraw Hill Education, ISBN: 9789332902800 2. M. P. Groover, M. Weiss, R. N. Nagel, N. G. Odrey; Industrial Robotics: Technology, Programming, and Applications, McGraw Hill Education, ISBN: 9781259006210 3. Saeed B. Niku; Introduction to Robotics: Analysis, Control, Applications, 2nd Edition, Wiley Publications, ISBN: 9781119527626 **Reference Books** 4. John J. Craig; Introduction to Robotics: Mechanics & Control, Pearson Education Inc., ISBN: 9788131718360 5. Peter Corke; Robotics, Vision and Control, Springer, ISBN: 9783319544120 6. K. S. Fu, R. C. Gonzalez, C. S. G. Lee; Robotics: Control, Sensing, Vision, and Intelligence, McGraw Hill Book Co., ISBN: 9780071002370 7. Mittal, R. & Nagrath, I. J.; Robotics and Control, McGraw Hill Education, ISBN: 9780070482937	
Course Outcomes:	**Upon completion of the course, students will be able to:** CO 1. Explain the concepts of robot arm kinematics and motion control, including workspace, DOF, and trajectory types. CO 2. Implement forward and inverse kinematics, as well as basic path planning algorithms, using simulation or hardware tools. CO 3. Analyze robotic arm behavior through velocity and acceleration modeling using Jacobian-based calculations. CO 4. Develop autonomous robot arm programs for tasks such as pick-and-place, obstacle avoidance, and event handling using appropriate sensors and control logic.	