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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| --- | --- | --- | --- |
| **Course Code** | **19RO2002** | **Duration** | **3hrs** |
| **Course Title** | **AUTONOMOUS VEHICLES** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (10 X 1 = 10 MARKS)** | | | | | |
| 1. | Define the term Automotive Electronics. | | CO1 | U | 1 |
| 2. | Expand the abbreviation ECU. | | CO1 | R | 1 |
| 3. | Name two radar types used for automotive sensing. | | CO2 | R | 1 |
| 4. | State the meaning of sensor fusion. | | CO2 | R | 1 |
| 5. | Specify the purpose of a Kalman filter in sensor systems. | | CO3 | U | 1 |
| 6. | Define the term DSRC. | | CO3 | R | 1 |
| 7. | Expand the abbreviation V2V communication. | | CO4 | U | 1 |
| 8. | Mention the main function of a PID controller. | | CO4 | R | 1 |
| 9. | Define the term localization in driverless cars. | | CO5 | U | 1 |
| 10. | List a major technical challenge in achieving full automation. | | CO6 | U | 1 |
| **PART – B (6 X 3 = 18 MARKS)** | | | | | |
| 11. | Compare infotainment systems with chassis control systems. | | CO1 | R | 3 |
| 12. | Write the role of night vision systems in autonomous vehicles. | | CO2 | U | 3 |
| 13. | Compare radar-based and ultrasonic sensing with respect to range and accuracy. | | CO3 | R | 3 |
| 14. | Define computer vision in the context of vehicles. | | CO4 | U | 3 |
| 15. | State an application of V2I technology. | | CO5 | R | 3 |
| 16. | State the meaning of path planning. | | CO6 | U | 3 |
| **PART – C (6 X 12 = 72 MARKS)**  **(Answer any five Questions from Q. No. 17 to 23, Q. No. 24 is Compulsory)** | | | | | |
| 17. |  | Explain the major components of an autonomous vehicle using a neat and well-labeled diagram, and describe the role of each component in the overall system. | CO1 | U | 12 |
|  |  |  |  |  |  |
| 18. | a. | Compare front-wheel drive (FWD) and rear-wheel drive (RWD) powertrains, highlighting their differences in vehicle dynamics and performance. | CO2 | U | 6 |
|  | b. | Explain the different types of car chassis with a neat and labeled diagram, and discuss the advantages of each type for suitable applications. | CO2 | R | 6 |
|  |  |  |  |  |  |
| 19. |  | Explain the key features of infotainment systems in modern vehicles and discuss how these features improve the overall driving experience. | CO3 | U | 12 |
|  |  |  |  |  |  |
| 20. |  | Explain the six levels of driving automation as defined by SAE. | CO4 | R | 12 |
|  |  |  |  |  |  |
| 21. |  | Describe the recent advancements in connected car technology using DSRC and analyze their impact on enhancing vehicle communication and safety. | CO5 | U | 12 |
|  |  |  |  |  |  |
| 22. |  | Explain the concept of Information-Centric Networking (ICN) in connected car technology and evaluate its role in enhancing data management and communication between vehicles and infrastructure. | CO5 | A | 12 |
|  |  |  |  |  |  |
| 23. |  | Compare the operation of PID and Model Predictive Controllers. | CO6 | R | 12 |
| **COMPULSORY QUESTION** | | | | | |
| 24. |  | Examine the major technical, security, and legal challenges encountered by autonomous vehicles, and assess how these factors influence the progress and adoption of the technology. | CO6 | An | 12 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

|  |  |
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|  | **COURSE OUTCOMES** |
| **CO1** | Describe the evolution of Automotive Electronics and the operation of ECUs. |
| **CO2** | Compare the different type of sensing mechanisms involved in Autonomous Vehicles. |
| **CO3** | Discuss about the use of computer vision and learning algorithms in vehicles. |
| **CO4** | Summarize the aspects of connectivity fundamentals existing in a driverless car. |
| **CO5** | Identify the different levels of automation involved in an Autonomous Vehicle. |
| **CO6** | Outline the various controllers employed in vehicle actuation. |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| --- | --- | --- | --- |
| **Course Code** | **19RO2003** | **Duration** | **3hrs** |
| **Course Title** | **AUTOMOTIVE EMBEDDED SYSTEMS** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (10 X 1 = 10 MARKS)** | | | | | |
| 1. | List two sensors used in engine management system. | | CO1 | R | 1 |
| 2. | Expand the abbreviation for ECU. | | CO1 | R | 1 |
| 3. | Mention the purpose of Data Routing Engine (DRE) in AURIX TC4xx. | | CO2 | R | 1 |
| 4. | Identify the microcontroller architecture used in AURIX TC4xx | | CO2 | R | 1 |
| 5. | Find the maximum number of devices that can be connected in a MOST network | | CO3 | R | 1 |
| 6. | Mention the maximum signaling rate for CAN bus. | | CO3 | U | 1 |
| 7. | Identify the maximum length of the data field in a KWP2000 message | | CO4 | R | 1 |
| 8. | List the categories in the protocol data frame in UDS. | | CO4 | U | 1 |
| 9. | Name the three main layers of the AUTOSAR architecture. | | CO5 | R | 1 |
| 10. | Expand ASPICE. | | CO6 | U | 1 |
| **PART – B (6 X 3 = 18 MARKS)** | | | | | |
| 11. | List the challenges faced in the development of autonomous driving systems. | | CO1 | R | 3 |
| 12. | Mention the applications of DSADC in automotive systems. | | CO2 | A | 3 |
| 13. | Differentiate between KWP2000 and UDS protocols. | | CO3 | U | 3 |
| 14. | Write short notes on OBD-II. | | CO4 | R | 3 |
| 15. | List the objectives of AUTOSAR consortium | | CO5 | U | 3 |
| 16. | State the key principles of ISO 26262. | | CO6 | U | 3 |
| **PART – C (6 X 12 = 72 MARKS)**  **(Answer any five Questions from Q. No. 17 to 23, Q. No. 24 is Compulsory)** | | | | | |
| 17. | a. | Elaborate the role of ADAS in enhancing driver safety highlighting its  Contribution towards the development of autonomous driving. | CO1 | A | 8 |
|  | b. | Discuss the features of infotainment systems in modern automotive systems. | CO1 | A | 4 |
|  |  |  |  |  |  |
| 18. |  | With a neat block diagram, explain the architecture of the AURIX microcontroller and its key functional units. | CO2 | A | 12 |
|  |  |  |  |  |  |
| 19. | a. | Explain CAN protocol with frame format and application in vehicles. | CO3 | A | 6 |
|  | b. | Discuss the working of FlexRay protocol and its importance in  automotive systems. | CO3 | A | 6 |
|  |  |  |  |  |  |
| 20. |  | Elaborate on the concept of secure diagnostics in UDS highlighting its message transmission between the source and target addresses, and the role of gateways in remote diagnostics. | CO4 | U | 12 |
|  |  |  |  |  |  |
| 21. |  | Elaborate on the AUTOSAR methodology and workflow, highlighting the steps from system design to ECU integration. | CO5 | U | 12 |
|  |  |  |  |  |  |
| 22. | a. | Discuss the evolution of electronics in an automobile industry. | CO1 | U | 6 |
|  | b. | Explain the different types of task scheduling used in RTOS | CO2 | A | 6 |
|  |  |  |  |  |  |
| 23. |  | Explain the working principle and characteristics of FlexRay, emphasizing its time-triggered communication method. | CO3 | A | 12 |
| **COMPULSORY QUESTION** | | | | | |
| 24. | a. | Design a cybersecurity plan for an in-vehicle communication network using SAE J3061 principles. | CO6 | A | 6 |
|  | b. | Discuss the common failures in automotive systems and methods to overcome the failure | CO6 | A | 6 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

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|  | **COURSE OUTCOMES** |
| **CO1** | Describe the function of basic components used in modern automotive systems. |
| **CO2** | Discuss about the applications of microcontrollers in ECU design. |
| **CO3** | Summarize the various In-Vehicle Communication Protocols and their features. |
| **CO4** | Outline the diagnostic protocols and their functions. |
| **CO5** | Illustrate the practical applications of Automotive Open Systems Architecture (AUTOSAR) |
| **CO6** | Discuss about the Quality and Safety Standards to be adopted in Automotive Systems. |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| **Course Code** | **19RO2005** | **Duration** | **3hrs** |
| **Course Title** | **INDUSTRIAL ROBOTICS AND MATERIAL HANDLING SYSTEMS** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (10 X 1 = 10 MARKS)** | | | | | |
| 1. | Identify any two major types of industrial robots based on configuration. | | CO1 | R | 1 |
| 2. | List any two benefits of using robots for CNC machine tool loading | | CO1 | U | 1 |
| 3. | Define the concept of simultaneous localization and mapping (SLAM) used in robotics. | | CO2 | R | 1 |
| 4. | State the purpose of object recognition in a vision system. | | CO2 | U | 1 |
| 5. | Explain the economic factors that justify the use of industrial robots in modern manufacturing. | | CO3 | R | 1 |
| 6. | Mention one advantage of robotic painting. | | CO3 | U | 1 |
| 7. | Define the term “degree of freedom” (DOF) in robotic design. | | CO4 | R | 1 |
| 8. | Specify one application of vacuum grippers. | | CO4 | U | 1 |
| 9. | Define accuracy in robots. | | CO5 | R | 1 |
| 10. | Explain the concept of a unit load in material handling systems. | | CO6 | U | 1 |
| **PART – B (6 X 3 = 18 MARKS)** | | | | | |
| 11. | State the importance of load-handling capacity of industrial robot. | | CO1 | U | 3 |
| 12. | Distinguish between automated visual inspection and manual inspection in terms of their effectiveness. | | CO2 | An | 3 |
| 13. | Evaluate the effectiveness of robots in ensuring operational safety in environments involving toxic or high-risk processes. | | CO3 | E | 3 |
| 14. | Illustrate with examples the advantages and disadvantages of using magnetic grippers in industrial robots. | | CO4 | A | 3 |
| 15. | Explain the key economic factors that affect the implementation of robotization in manufacturing. | | CO5 | A | 3 |
| 16. | List the functions of barcode and RFID systems in industrial automation. | | CO6 | R | 3 |
| **PART – C (6 X 12 = 72 MARKS)**  **(Answer any five Questions from Q. No. 17 to 23, Q. No. 24 is Compulsory)** | | | | | |
| 17. | a. | Compare manual machine loading with robotic machine loading in terms of productivity and safety. | CO1 | An | 8 |
|  | b. | Explain the factors affecting the load-handling capacity of an industrial robot. | CO1 | A | 4 |
|  |  |  |  |  |  |
| 18. | a. | Describe how a robot-centered cell is designed and explain its operational advantages. | CO1 | A | 12 |
|  |  |  |  |  |  |
| 19. | a. | Evaluate the importance of each component in a general-purpose machine vision system using a labeled block diagram. | CO2 | U | 12 |
|  |  |  |  |  |  |
| 20. | a. | Illustrate with a neat sketch the robotic setup used in a spray-painting system, and mention its advantages and disadvantages. | CO3 | A | 12 |
|  |  |  |  |  |  |
| 21. | a. | Illustrate the steps involved in designing a mechanical gripper for delicate components. | CO4 | A | 8 |
|  | b. | Evaluate the effectiveness of sensors in improving the performance of robotic grippers for industrial applications. | CO4 | E | 4 |
|  |  |  |  |  |  |
| 22. | a. | Discuss the various factors influencing the choice of a robot for industrial applications | CO4 | U | 6 |
|  | b. | Design a basic framework for evaluating the economic feasibility of implementing robots in a small-scale industry. | CO5 | A | 6 |
|  |  |  |  |  |  |
| 23. | a. | Discuss the role of productivity, maintenance, and energy consumption in assessing the economics of robotization. | CO5 | A | 12 |
| **COMPULSORY QUESTION** | | | | | |
| 24. | a. | Illustrate the different configurations of Automated Guided Vehicle systems and describe their industrial applications with examples. | CO6 | A | 12 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

|  |  |
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|  | **COURSE OUTCOMES** |
| **CO1** | Differentiate the various types of Industrial Robots and their architecture. |
| **CO2** | Apply the concepts of image processing for robotic inspection systems. |
| **CO3** | Analyze the applications of robots in various industrial application. |
| **CO4** | Design and fabricate simple grippers for pick and place application. |
| **CO5** | Identify the right Robot for a given industrial application. |
| **CO6** | Select the right material handling system for a given application. |

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| **Assessment Pattern as per Bloom’s Level** | | | | | | | |
| **CO / BL** | **R** | **U** | **A** | **An** | **E** | **C** | **Total** |
| **CO1** | 1 | 21 | 0 | 3 | 0 | 0 | 25 |
| **CO2** | 1 | 13 | 3 | 4 | 0 | 0 | 21 |
| **CO3** | 0 | 2 | 12 | 0 | 3 | 0 | 17 |
| **CO4** | 1 | 0 | 0 | 16 | 6 | 6 | 29 |
| **CO5** | 1 | 6 | 6 | 3 | 0 | 0 | 16 |
| **CO6** | 1 | 0 | 12 | 0 | 3 | 0 | 16 |
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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| **Course Code** | **19RO2009** | **Duration** | **3hrs** |
| **Course Title** | **MEDICAL ROBOTICS** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (10 X 1 = 10 MARKS)** | | | | | |
| 1. | Identify one key benefit of motion replication in surgical robots. | | CO1 | U | 1 |
| 2. | Explain how navigation supports precision in robotic surgery | | CO1 | R | 1 |
| 3. | Distinguish between optical and electromagnetic tracking systems. | | CO2 | R | 1 |
| 4. | Explain the need for accurate localization in medical robotic systems. | | CO2 | R | 1 |
| 5. | State one challenge of using robotic systems in neurosurgery. | | CO3 | U | 1 |
| 6. | List the main purposes of control modes in medical robotic systems. | | CO3 | R | 1 |
| 7. | Recall the main objective of rehabilitation robots in healthcare. | | CO4 | U | 1 |
| 8. | Relate one example of a robotic system used for limb rehabilitation. | | CO4 | R | 1 |
| 9. | Define assistive robots in the context of medical care | | CO5 | U | 1 |
| 10. | State the importance of gesture characterization in medical robot design | | CO6 | U | 1 |
| **PART – B (6 X 3 = 18 MARKS)** | | | | | |
| 11. | Differentiate between surgical robots and rehabilitation robots with examples. | | CO1 | An | 3 |
| 12. | Describe the working principle of mechanical linkage tracking. | | CO2 | U | 3 |
| 13. | Compare supervisory control and teleoperation modes in robotic surgery with examples. | | CO3 | An | 3 |
| 14. | Explain the concept of a steerable needle and its application in minimally invasive surgery | | CO4 | U | 3 |
| 15. | Differentiate between mobility-assistive robots and manipulation-assistive robots with examples. | | CO5 | An | 3 |
| 16. | Explain the term gesture characterization and its relevance in designing medical robots. | | CO6 | U | 3 |
| **PART – C (6 X 12 = 72 MARKS)**  **(Answer any five Questions from Q. No. 17 to 23, Q. No. 24 is Compulsory)** | | | | | |
| 17. | a. | Illustrate how motion replication improves surgical accuracy and reduces human errors. | CO1 | Ap | 6 |
|  | b. | Discuss the advantages of using a robotic-assisted system over conventional manual surgery in this scenario | CO1 | Ap | 6 |
|  |  |  |  |  |  |
| 18. |  | A robotic catheter navigation system utilizes electromagnetic tracking to guide instruments through the cardiovascular system. Explain how electromagnetic tracking assists in catheter navigation. | CO2 | Ap | 12 |
|  |  |  |  |  |  |
| 19. |  | Compare the challenges of robotic control in cardiac surgery versus orthopedic surgery using insights from case studies. Also discuss potential limitations or risks associated with using robotic systems in complex cardiac surgeries. | CO3 | An | 12 |
|  |  |  |  |  |  |
| 20. |  | A paraplegic patient is undergoing walking rehabilitation using a brain–machine interface (BMI) connected to a robotic exoskeleton. The system translates brain signals into robotic limb movements and provides real-time feedback to improve motor learning. Explain how the BMI interprets brain signals to control the exoskeleton and discuss potential challenges in implementing BMI-controlled exoskeletons, including calibration and safety. | CO4 | An | 12 |
|  |  |  |  |  |  |
| 21. |  | An elderly care center introduces a mobility-assistive robot to help residents with limited mobility perform daily tasks, such as walking, reaching objects, and transferring between chairs and beds. Suggest ways to integrate mobility-assistive robots and explain the different types to improve overall patient care | CO5 | An | 12 |
|  |  |  |  |  |  |
| 22. |  | Analyze the role of in-bore MRI tracking in enhancing the accuracy and safety of pedicle screw placement during robotic spine surgery. Discuss how it complements video matching for real-time navigation. | CO2 | An | 12 |
|  |  |  |  |  |  |
| 23. |  | Demonstrate the different control modes used in robotic surgeries using examples from real surgical case studies. | CO3 | Ap | 12 |
| **COMPULSORY QUESTION** | | | | | |
| 24. |  | Analyze gesture characterization principles to explain how a medical robot can interpret human hand movements accurately. | CO6 | An | 12 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

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|  | **COURSE OUTCOMES** |
| **CO1** | Describe the types of medical robots and the concepts of navigation and motion replication. |
| **CO2** | Discuss about the sensors used for localization and tracking |
| **CO3** | Summarize the applications of surgical robotics |
| **CO4** | Outline the concepts in Rehabilitation of limbs and brain machine interface |
| **CO5** | Classify the types of assistive robots. |
| **CO6** | Analyze the design characteristics, methodology and technological choices for medical robots |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| --- | --- | --- | --- |
| **Course Code** | **19RO2010** | **Duration** | **3hrs** |
| **Course Title** | **MACHINE LEARNING FOR ROBOTICS** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (10 X 1 = 10 MARKS)** | | | | | |
| 1. | Define a well-posed learning problem in machine learning. | | CO1 | R | 1 |
| 2. | List the different types of data in machine learning. | | CO1 | R | 1 |
| 3. | Identify whether KNN is a parametric or non-parametric algorithm. | | CO2 | R | 1 |
| 4. | State the decision boundary for logistic regression. | | CO2 | R | 1 |
| 5. | Write the expression for Bayes’ Theorem. | | CO3 | R | 1 |
| 6. | Identify one use case of Naive Bayes in real-world applications. | | CO3 | R | 1 |
| 7. | List the types of clustering techniques. | | CO4 | R | 1 |
| 8. | Recognize the fundamental aim of PCA in data analysis. | | CO4 | R | 1 |
| 9. | List how MLP differs from a single-layer perceptron. | | CO5 | R | 1 |
| 10. | Name one robotic application that uses supervised learning. | | CO6 | R | 1 |
| **PART – B (6 X 3 = 18 MARKS)** | | | | | |
| 11. | Distinguish between linear regression and logistic regression. | | CO1 | U | 3 |
| 12. | Explain how information gain is used to select the best attribute in a decision tree. | | CO2 | U | 3 |
| 13. | Explain the role of kernel functions used in support vector machine. | | CO3 | U | 3 |
| 14. | Compare DIANA (Divisive Analysis) and AGNES (Agglomerative Nesting) in hierarchical clustering, emphasizing their approaches to forming clusters. | | CO4 | U | 3 |
| 15. | Summarize the activation functions used in the artifical neural network technique. | | CO5 | U | 3 |
| 16. | Compare and contrast biological neural networks and artificial neural network. | | CO6 | U | 3 |
| **PART – C (6 X 12 = 72 MARKS)**  **(Answer any five Questions from Q. No. 17 to 23, Q. No. 24 is Compulsory)** | | | | | |
| 17. | a. | Describe the different types of machine learning (supervised, unsupervised, reinforcement learning) and provide one real-world example of each. | CO1 | U | 6 |
|  | b. | A diagnostic test is conducted on 100 patients to detect a particular disease. Out of these, 60 patients actually have the disease, and 40 do not. The test results show that 50 patients with the disease are correctly identified, while 10 patients with the disease are missed. Among the patients without the disease, 5 are incorrectly identified as positive, and 35 are correctly identified as negative.   |  | Predicted Positive | Predicted Negative | | --- | --- | --- | | Actual Positive | 50 | 10 | | Actual Negative | 5 | 35 |   Using this data, calculate accuracy, sensitivity (recall), specificity, positive predictive value (PPV), negative predictive value (NPV), and F1 Score. Briefly explain what each metric indicates about the test’s performance. | CO1 | U | 6 |
|  |  |  |  |  |  |
| 18. |  | Given the dataset of loan applicants, construct a decision tree to predict loan approval. Analyze the dataset to select the root attribute for splitting. Apply the information gain formula to calculate the gain for each attribute: Credit History, Income, Debt, and Collateral.   | **Day** | **Credit History** | **Income** | **Debt** | **Collateral** | **Approve Loan** | | --- | --- | --- | --- | --- | --- | | 1 | Good | High | Low | Yes | Yes | | 2 | Good | Medium | High | No | No | | 3 | Average | Medium | Medium | Yes | Yes | | 4 | Poor | Low | High | No | No | | 5 | Poor | Medium | Medium | Yes | Yes | | 6 | Average | Low | High | Yes | No | | 7 | Good | Low | Low | Yes | Yes | | 8 | Poor | High | Medium | No | No | | 9 | Average | Medium | Low | Yes | Yes | | 10 | Good | Medium | Medium | Yes | Yes | | 11 | Poor | Medium | Low | No | No | | 12 | Average | High | Medium | Yes | Yes | | 13 | Good | Medium | Low | No | Yes | | 14 | Poor | Low | Medium | Yes | No | | CO2 | A | 12 |
|  |  | |  |  |  |
| 19. | a. | Explain the concept of maximum margin classification in support vector machine (SVM). | CO3 | U | 6 |
|  | b. | Derive the hard margin support vector machine (SVM) optimization problem and interpret the role of support vectors. | CO3 | U | 6 |
|  |  |  |  |  |  |
| 20. |  | Apply the K-means clustering algorithm using Euclidean distance to group the following 8 data points into 3 clusters:  **B1 = (3,12), B2 = (4,6), B3 = (9,5), B4 = (6,9), B5 = (8,6), B6 = (7,3),**  **B7 = (2,1), B8 = (5,11).**  Use the initial cluster centers as B1, B4, and B7. Perform 2 iterations (epochs) of the K-means algorithm and provide:  a. The data points assigned to each cluster after the first and second iterations. b. The new cluster centers after both iterations and a brief evaluation of how well they represent the assigned points | CO4 | A | 12 |
|  |  |  |  |  |  |
| 21. |  | Compare and explain the Hebbian Learning Rule and the Perceptron Learning Rule used in Artificial Neural Networks. Incorporate relevant mathematical equations and illustrate each rule with a suitable example. | CO5 | An | 12 |
|  |  |  |  |  |  |
| 22. |  | Given the dataset consisting of two correlated features: **X₁ and X₂.** Perform Principal Component Analysis (PCA) on the given dataset using the following steps: Compute the covariance matrix of the centered data. Determine the eigenvalues and eigenvectors of the covariance matrix. Identify the first principal component and compute the percentage of total variance it explains. Interpret the significance of the first principal component in terms of the relationship between the two features.   | **Observation** | **X₁** | **X₂** | | --- | --- | --- | | O₁ | 2 | 1 | | O₂ | 3 | 5 | | O₃ | 4 | 3 | | O₄ | 5 | 6 | | O₅ | 6 | 7 | | O₆ | 7 | 8 | | CO4 | A | 12 |
|  |  |  |  |  |  |
| 23. |  | Given a dataset contains information about whether a student passes an exam based on two attributes: **Study Hours** and **Attendance**. Use the Naïve Bayes classifier to predict whether this student is likely to Pass or Fail. Apply the Naïve Bayes algorithm to compute the posterior probabilities for both classes (*Pass* and *Fail*). 1. Calculate prior probabilities. 2. Calculate conditional probabilities for each attribute value given the class. 3. Use Bayes’ theorem to find the posterior probabilities and determine the predicted class.  A new student (S) has the following features: **Study Hours = High, Low, Medium, Attendance = Regular, Irregular.**   | **Student** | **Study Hours** | **Attendance** | **Pass/Fail** | | --- | --- | --- | --- | | S₁ | High | Regular | Pass | | S₂ | Low | Irregular | Fail | | S₃ | Medium | Regular | Pass | | S₄ | Medium | Irregular | Fail | | S₅ | High | Regular | Pass | | CO3 | A | 12 |
|  |  |  |  |  |  |
| **COMPULSORY QUESTION** | | | | | |
| 24. |  | Explain the neural network model to train the mobile robot to perform obstacle avoidance and navigation tasks | CO6 | An | 12 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

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|  | **COURSE OUTCOMES** |
| **CO1** | Discuss about the concepts of machine learning |
| **CO2** | Describe the types of trees and bias |
| **CO3** | Outline the supervised learning methods with various case studies |
| **CO4** | Compare the learning methodologies and dimensionality concepts |
| **CO5** | Summarize the applications of neural networks in robotic applications. |
| **CO6** | Illustrate the applications of machine learning using case studies. |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| --- | --- | --- | --- |
| **Course Code** | **19RO2014** | **Duration** | **3hrs** |
| **Course Title** | **ROBOTICS AND AUTOMATION IN FOOD INDUSTRY** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (10 X 1 = 10 MARKS)** | | | | | |
| 1. | Enumerate the unit operations involved in snack-food manufacturing plants. | | CO1 | R | 1 |
| 2. | Identify the hygiene requirements for robots operating in food processing areas. | | CO1 | U | 1 |
| 3. | Define sensor and transducer. | | CO2 | R | 1 |
| 4. | Indicate the role of RFID sensors in inventory management. | | CO2 | U | 1 |
| 5. | List the different types of grippers used in food robotics. | | CO3 | U | 1 |
| 6. | Classify multi-finger grippers designed to withstand normal forces when holding objects. | | CO3 | U | 1 |
| 7. | Sketch the wireless star network topology on a single-hop communication. | | CO4 | A | 1 |
| 8. | Enumerate the spatial data collection steps employed in precision agriculture technology. | | CO4 | R | 1 |
| 9. | List the advantages of PID control in food processes. | | CO5 | R | 1 |
| 10. | Identify the usage of air ejector in optical sorting machine. | | CO6 | R | 1 |
| **PART – B (6 X 3 = 18 MARKS)** | | | | | |
| 11. | Write the design specifications necessary for developing a pick-and-place robot in the food sector. | | CO1 | A | 3 |
| 12. | Enumerate the basic components of a SCADA system with a simple diagram. | | CO2 | R | 3 |
| 13. | Analyze the selection criteria for gripper mechanisms in delicate food handling. | | CO3 | An | 3 |
| 14. | Classify the RFID tags used in wireless hardware platforms. | | CO4 | U | 3 |
| 15. | Examine the role of optimization in advanced food process control. | | CO5 | A | 3 |
| 16. | Discuss the contribution of automation to improve safety in food packaging. | | CO6 | U | 3 |
| **PART – C (6 X 12 = 72 MARKS)**  **(Answer any five Questions from Q. No. 17 to 23, Q. No. 24 is Compulsory)** | | | | | |
| 17. | a. | Describe the structure of process control systems in the food industry. | CO1 | U | 6 |
|  | b. | Explain the advanced neural network-based controllers in the continuous snack-food frying process with a suitable diagram. | CO1 | U | 6 |
|  |  |  |  |  |  |
| 18. | a. | Summarize the various measurement methods used in automated food processes. | CO2 | U | 6 |
|  | b. | Explain the working of machine vision systems used in food quality inspection. | CO2 | A | 6 |
|  |  |  |  |  |  |
| 19. | a. | Discuss the physics governing different gripper mechanisms and their suitability for various food products. | CO3 | U | 8 |
|  | b. | Write the design parameters of a gripper suitable for handling fragile confectionery items. | CO3 | A | 4 |
|  |  |  |  |  |  |
| 20. |  | Explain the importance of wireless sensor networks in advancing agricultural methods and optimizing food production processes. | CO4 | A | 12 |
|  |  |  |  |  |  |
| 21. |  | With the help of a neat sketch, discuss the design of PID controllers for fed-batch processes. | CO5 | U | 12 |
|  |  |  |  |  |  |
| 22. | a. | Discuss the methods for the control of bioconversion in a fed-batch reactor. | CO5 | U | 4 |
|  | b. | Summarize the food process instrumentation with special considerations in design technology. | CO2 | U | 8 |
|  |  |  |  |  |  |
| 23. |  | Illustrate the crusting degree of a sausage using image analysis and fuzzy logic based intelligent control systems. | CO4 | A | 12 |
| **COMPULSORY QUESTION** | | | | | |
| 24. |  | Explain the automatic control of food chilling and freezing to maintain product quality and safety. | CO6 | A | 12 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

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|  | **COURSE OUTCOMES** |
| **CO1** | Specify the characteristics of robots used in food industry. |
| **CO2** | Identify the applications of sensors in food industry. |
| **CO3** | Describe about the different types of gripper mechanisms. |
| **CO4** | Describe the use of sensor networks and quality control in food sector. |
| **CO5** | Discuss about the advanced methods for control of food process. |
| **CO6** | Summarize the applications of automation and robotics in food industry |

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**END SEMESTER EXAMINATION – NOV/DEC 2025**

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| **Course Code** | **19RO2015** | **Duration** | **3hrs** |
| **Course Title** | **NEURAL NETWORKS AND FUZZY SYSTEMS** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (10 X 1 = 10 MARKS)**  **(Answer all the questions)** | | | | | |
| 1. | Define activation function. | | CO1 | U | 1 |
| 2. | Cite a specific example where feedback networks have been put to use in practical applications. | | CO1 | A | 1 |
| 3. | List the types of typical neural network controllers used to identify and control a neural network dynamic system. | | CO2 | A | 1 |
| 4. | Write an application of Hebbian learning rule in neural networks. | | CO2 | A | 1 |
| 5. | Define deep learning. | | CO3 | R | 1 |
| 6. | Mention the types of widely used pooling in CNN layer. | | CO3 | A | 1 |
| 7. | Indicate the properties that are to be satisfied in tolerance relation. | | CO4 | An | 1 |
| 8. | Cite the operations of crisp relations. | | CO4 | U | 1 |
| 9. | Define deuzzification. | | CO5 | R | 1 |
| 10. | Mention the applications of Fuzzy Logic control system. | | CO6 | A | 1 |
| **PART – B (6 X 3 = 18 MARKS)**  **(Answer all the questions)** | | | | | |
| 11. | Compare ANN and BNN by listing any three differences between them. | | CO1 | An | 3 |
| 12. | Describe the architecture of a Discrete Hopfield Network with a neat diagram. | | CO2 | U | 3 |
| 13. | Explain any one application of deep architecture in computer vision. | | CO3 | A | 3 |
| 14. | Indicate the properties that are to be satisfied in tolerance relation. | | CO4 | U | 3 |
| 15. | Consider 2 fuzzy sets A and B, both defined on the universe of discourse X, given as follows :   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | X1 | X2 | X3 | X4 | X5 | | A | 0.2 | 0.3 | 0.4 | 0.7 | 0.1 | | B | 0.4 | 0.5 | 0.6 | 0.8 | 0.9 |   Express (AUB)0.6 using Zadin’s notation. | | CO5 | E | 3 |
| 16. | Sketch the basic block diagram of a fuzzy logic control system. | | CO6 | A | 3 |
| **PART – C (6 X 12 = 72 MARKS)**  **(Answer any five Questions from Q.No. 17 to 23, Q.No. 24 is Compulsory)** | | | | | |
| 17. | a. | Describe the architecture of the Mc-Culloch Pitt’s neuron model with an example. | CO1 | U | 6 |
|  | b. | Explain the main components of the Basic Artificial Neuron with a neat diagram. | CO1 | A | 6 |
|  |  |  |  |  |  |
| 18. |  | Using Hebb Rule, find weights required to perform the following classifications of given input pattern ‘+’ symbols which represent the value 1 and empty squares which indicate -1. Consider **‘I’** belongs to the members of class (target value 1) and **‘O’** does not belong to the members of class (target value = -1).    **‘I’ ‘O’** | CO2 | An | 12 |
|  |  |  |  |  |  |
| 19. | a. | Analyze the architecture of the Convolution Neural Network with a neat diagram. | CO3 | An | 6 |
|  | b. | Explain any two CNN architectures evolved and developed, leading to amazing advances in the growing deep-learning field. | CO3 | A | 6 |
|  |  |  |  |  |  |
| 20. |  | Consider two fuzzy sets,  Find the following:   1. b) c) d) e)   f) g)  k) l) | CO4 | E | 12 |
|  |  |  |  |  |  |
| 21. | a. | Find the defuzzified value of the trapezoidal functions given in the figure below using center of sums defuzzification method. | CO5 | An | 9 |
|  | b. | Determine crisp λ-cut relation when λ = 0.1, 0**+**, 0.9 for the relation,    Rλ = {1 **|** μR(x,y) ≥ λ; 0 **|** μR(x,y) < λ} | CO5 | An | 3 |
|  |  |  |  |  |  |
| 22. | a. | Consider the following set of input training vectors of NAND gate. x1=[0 0 1 1], x2=[0 1 0 1], w0=-0.3(bias), Initial Weight vectors, w1=w2=0.5, learning rate, n=0.5 and xd=1. Calculate the final weights using delta learning rule. | CO2 | E | 8 |
|  | b. | Explain the steps involved in training an hetero-associative neural network using the Hebb or Delta Learning Rule. | CO2 | A | 4 |
|  |  |  |  |  |  |
| 23. |  | Find the defuzzified value (X\*) for the below fuzzy set by centroid of area (COA) defuzzification method. | CO5 | An | 12 |
|  |  |  |  |  |  |
| **COMPULSORY QUESTION** | | | | | |
| 24. | a. | Design and develop a neural network based image compression system for self-driving cars. | CO6 | An | 6 |
|  | b. | Design and develop a CMAC (Cerebellar Model Articulation Controller) for identification and real-time control of nonlinear dynamical systems. | CO6 | An | 6 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

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|  | **COURSE OUTCOMES** |
| CO1 | Classify the types of neural networks. |
| CO2 | Discuss about the applications of neural networks. |
| CO3 | Describe the concepts of deep learning and convolutional neural networks. |
| CO4 | Compare fundamentals of classical logic and fuzzy logic concepts. |
| CO5 | Characterize the fuzzy membership functions. |
| CO6 | Summarize the applications of fuzzy logic controllers. |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| --- | --- | --- | --- |
| **Course Code** | **20RO3014** | **Duration** | **3hrs** |
| **Course Title** | **INDUSTRIAL INTERNET OF THINGS AND ITS APPLICATIONS** | **Max. Marks** | **100** |

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| --- | --- | --- | --- | --- | --- |
| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (4 X 20 = 80 MARKS)**  **(Answer all the Questions)** | | | | | |
| 1. | a. | Explain in detail about IoT enablers and connectivity layers. | CO1 | U | 15 |
|  | b. | Differentiate Industrial IoT and Consumer IoT. | CO1 | U | 5 |
|  |  | **(OR)** |  |  |  |
| 2. | a. | Explain the concept of Industrial Internet Reference Architecture (IIRA) and evaluate its layers to determine how it facilitates IIOT implementation in industries. | CO2 | A | 15 |
|  | b. | Compare and contrast a traditional network and a WSN network in the context of IIOT applications. | CO2 | A | 5 |
|  |  |  |  |  |  |
| 3. | a. | Classify the different types of sensors and highlight their specific applications in the Internet of Things (IoT). | CO3 | A | 15 |
|  | b. | Distinguish between failed node and selfish node in MQTT protocol. | CO3 | A | 5 |
|  |  | **(OR)** |  |  |  |
| 4. | a. | Elaborate the functional blocks of CoAP architecture. | CO4 | A | 15 |
|  | b. | Explain in detail about cots cloud platforms. | CO4 | A | 5 |
|  |  |  |  |  |  |
| 5. |  | Explain the concepts of privacy, security requirements, and trust in IIOT. Justify the role of identity establishment, access control, and message integrity in ensuring secure communication. | CO5 | A | 20 |
|  |  | **(OR)** |  |  |  |
| 6. | a. | Explain the network security techniques management aspects of cyber security. | CO5 | A | 15 |
|  | b. | Explain the conventional web technology and relationship with IIOT. | CO5 | A | 5 |
|  |  |  |  |  |  |
| 7. |  | Elaborate the functional blocks of IoT service oriented architecture. | CO1 | A | 20 |
|  |  | **(OR)** |  |  |  |
| 8. |  | Explain the IoT-based smart city system that uses real-time data and visualization to make city management more efficient. | CO6 | An | 20 |
| **COMPULSORY QUESTION** | | | | | |
| 9. |  | Enumerate the applications of the Internet of Things (IoT) in the manufacturing sector and detail the process of its implementation, supported by a relevant case study. | CO6 | An | 20 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

|  |  |
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|  | **COURSE OUTCOMES** |
| CO1 | Recall the overview of IoT |
| CO2 | Discuss architecture of IIoT |
| CO3 | Discuss the sensor and its interfaces |
| CO4 | Explain protocol and cloud concepts. |
| CO5 | Explain web security and its need |
| CO6 | Create simple IIoT applications |

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**END SEMESTER EXAMINATION – NOVEMBER / DECEMBER 2025**

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| **Course Code** | **20RO3017** | **Duration** | **3hrs** |
| **Course Title** | **IMAGE PROCESSING AND MACHINE VISION** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (5 X 16 = 80 MARKS)**  **(Answer any five from the following)** | | | | | |
| 1. | a. | a) Define digital image processing and explain its fundamental steps with a neat diagram. | CO1 | U | 8 |
|  | b. | b) Explain the role of image acquisition and storage in an image processing system. | CO1 | U | 8 |
|  |  |  |  |  |  |
| 2. | a. | a) Explain the structure of the human eye and its relevance to image formation. | CO2 | U | 8 |
|  | b. | b) Discuss different types of sampling and quantization methods with suitable examples. | CO2 | U | 8 |
|  |  |  |  |  |  |
| 3. | a. | a) Explain basic gray level transformations and histogram processing with appropriate sketches. | CO3 | A | 8 |
|  | b. | b) Differentiate between smoothing and sharpening spatial filters with examples. | CO3 | A | 8 |
|  |  |  |  |  |  |
| 4. | a. | a) Derive and explain the 2D Fourier Transform and its inverse in image enhancement. | CO4 | An | 8 |
|  | b. | b) Describe homomorphic filtering and its applications in image processing. | CO4 | An | 8 |
|  |  |  |  |  |  |
| 5. | a. | a) Explain the fundamentals of image compression and discuss Huffman coding with an example. | CO5 | A | 8 |
|  | b. | b) Describe block coding and variable length coding with applications. | CO5 | A | 8 |
|  |  |  |  |  |  |
| 6. | a. | a) Explain the concept of active vision systems and their components. | CO5 | An | 8 |
|  | b. | b) Describe feature extraction and edge detection techniques used in machine vision. | CO5 | An | 8 |
|  |  |  |  |  |  |
| 7. | a. | a) Discuss various competing machine vision technologies such as CCD line scan and area scan sensors. | CO5 | A | 8 |
|  | b. | b) Explain passive and active stereo imaging with suitable examples. | CO5 | A | 8 |
| **PART – B (1 X 20 = 20 MARKS) [Compulsory Question]** | | | | | |
| 8. | a. | a) Explain the structure of industrial machine vision systems and discuss their applications in inspection and robot control. | CO6 | A | 10 |
|  | b. | b) Describe the rules of thumb for illumination and optics in industrial vision systems. How is vision system calibration carried out in practice? | CO6 | An | 10 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

|  |  |
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|  | **COURSE OUTCOMES** |
| CO1 | Recall image processing concepts. |
| CO2 | Explain fundamentals of digital image processing. |
| CO3 | Discuss enhancement techniques. |
| CO4 | Explain image compression. |
| CO5 | Explain machine vision concepts. |
| CO6 | Describe industrial machine vision applications |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| **Course Code** | **22RO2001** | **Duration** | **3 hrs** |
| **Course Title** | **ELECTRICAL CIRCUIT ANALYSIS** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (10 X 1 = 10 MARKS)** | | | | | |
| 1. | Define a dual network. | | CO1 | R | 1 |
| 2. | Six lamps, each with a resistance of 25Ω are connected in parallel. Find the total resistance. | | CO1 | U | 1 |
| 3. | In a linear bilateral network, a 5 V voltage source applied between terminals X and Y causes a current of 0.5 A to flow through a 10 Ω resistor between terminals P and Q. What will be the current through X–Y if the same 5 V source is applied at P–Q instead? | | CO2 | U | 1 |
| 4. | **If** RL ≠ RTh​**, how does the power transferred to the load compare to the maximum possible power?** | | CO2 | U | 1 |
| 5. | A series RL circuit consists of a **resistance of 25Ω** and an **inductance of 0.5H. Determine the time constant (τ) of the circuit.** | | CO3 | U | 1 |
| 6. | A series RC circuit has R = 12 Ω, C = 0.5F and is connected to a DC source of 24V at t = 0, initial capacitor voltage is VC(0−) = 0 V. **Determine the initial resistor current** iR(0+)**.** | | CO3 | U | 1 |
| 7. | A sinusoidal voltage, V(t) = 120 sin(314t)V is applied across a resistor, R = 24Ω. Find the rms current flowing through the resistor. | | CO4 | U | 1 |
| 8. | A series combination of 10Ω resistance and 50mH inductance is connected to a 220V, 50Hz supply. Estimate the inductive reactance of the circuit. | | CO4 | U | 1 |
| 9. | Recall the type of coupling that occurs when there exists no physical connection between two coils. | | CO4 | R | 1 |
| 10. | Define a two port network. | | CO6 | R | 1 |
| **PART – B (6 X 3 = 18 MARKS)** | | | | | |
| 11. | Write the step-by-step procedure to find the total resistance in the below mentioned parallel circuit. | | CO1 | U | 3 |
| 12. | A Norton’s equivalent circuit has IN = 6 A and RN = 4 Ω. What will be the **maximum power** delivered to the load? | | CO2 | U | 3 |
| 13. | A series RLC circuit has R = 10 Ω, L = 2 H and C = 0.5F. A DC voltage of 12V is applied at t = 0. Find the voltage across the inductor at t = 0+. | | CO3 | U | 3 |
| 14. | **Interpret** the relationship between a sinusoidal waveform and its rotating phasor representation. | | CO4 | U | 3 |
| 15. | Discuss the working principle of an Ideal transformer under load condition with a neat diagram. | | CO4 | U | 3 |
| 16. | Illustrate a one port network with a neat diagram. | | CO6 | U | 3 |
| **PART – C (6 X 12 = 72 MARKS)**  **(Answer any five Questions from Q. No. 17 to 23, Q. No. 24 is Compulsory)** | | | | | |
| 17. | a. | Construct a series RLC **dual network**. By applying Kirchoff’s law, prove that the two networks (series and parallel) are dual in nature. | CO2 | A | 6 |
|  | b. | **Find the total resistance (**step-by-step procedure with diagram)**,** total current and branch currents in the below mentioned parallel circuit **which has resistances of 5Ω, 8Ω, 8Ω and 6Ω respectively.** | CO2 | A | 6 |
|  |  |  |  |  |  |
| 18. |  | Using the superposition theorem, find the current I through the 1 Ω resistor. | CO2 | A | 12 |
|  |  |  |  |  |  |
| 19. |  | A series RLC circuit has R = 20Ω, L = 4H and C = 0.5F. A DC voltage of 12V is applied at t = 0. The initial conditions, iL(0-) = 0 and VC(0-) = 0. Find:   1. The initial branch currents and the capacitor voltage 2. The final steady state values 3. The damping factor (α) and classify the type of damping factor 4. The transient response i(t) 5. The natural and forced responses | CO3 | A | 12 |
|  |  |  |  |  |  |
| 20. | a. | **Explain** the concept of two types of mechanical coupling with a neat circuit diagram. | CO4 | U | 8 |
|  | b. | Discuss the working principle of an Ideal transformer under no-load condition with a neat diagram. | CO4 | U | 4 |
|  |  |  |  |  |  |
| 21. |  | Derive an expression for impedance, resonant frequency, current flowing through the circuit at resonance, voltage across each element in the phasor domain of a series resonant RLC circuit with the help of a neat circuit diagram. | CO5 | A | 12 |
|  |  |  |  |  |  |
| 22. |  | Find the maximum power through the 2Ω resistor using Norton’s theorem. | CO2 | A | 12 |
| 23. |  | Using Mesh analysis, find the value of mesh currents i1, i2, i3, i0. | CO2 | A | 12 |
| **COMPULSORY QUESTION** | | | | | |
| 24. |  | Derive the expressions for:   1. transmission or ABCD parameters. 2. inverse transmission (T′ or A′B′C′D′) parameters 3. hybrid (h) parameters. 4. inverse hybrid (g) parameters. | CO6 | An | 12 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

|  |  |
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|  | **COURSE OUTCOMES** |
| **CO1** | Identify the various circuit elements, and their characteristics. |
| **CO2** | Analyze the circuits using KVL, KCL, Mesh and Nodal analysis techniques and theorems. |
| **CO3** | Solve first order and second order differential equations to obtain the transient responses. |
| **CO4** | Describe fundamental concepts used in single phase, three phase AC circuits and coupled circuits. |
| **CO5** | Apply Laplace transform techniques to examine the behavior of resonant circuits and tuned coupled circuits. |
| **CO6** | Derive the parameters of two port networks**.** |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| **Course Code** | **22RO2011** | **Duration** | **3hrs** |
| **Course Title** | **ROBOTIC PROCESS AUTOMATION** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (10 X 1 = 10 MARKS)** | | | | | |
| 1. | List the properties of UiPath. | | CO1 | U | 1 |
| 2. | Identify the limitations of RPA. | | CO1 | R | 1 |
| 3. | Define sequencing in RPA workflows. | | CO2 | U | 1 |
| 4. | Identify the security risks associated with Robotic Process Automation (RPA). | | CO2 | R | 1 |
| 5. | List different types of control flows in RPA. | | CO3 | R | 1 |
| 6. | Explain the significant features of data scraping. | | CO3 | U | 1 |
| 7. | List the types of activities used in UiPath for data entry. | | CO4 | R | 1 |
| 8. | List the components of PDF automation. | | CO4 | R | 1 |
| 9. | Name the email protocol in Uipath. | | CO5 | R | 1 |
| 10. | Classify sequences and flowchart**.** | | CO6 | U | 1 |
| **PART – B (6 X 3 = 18 MARKS)** | | | | | |
| 11. | Explain the evolution of Robotic Process Automation. | | CO1 | U | 3 |
| 12. | List the applications of RPA. | | CO2 | R | 3 |
| 13. | Define sequencing in RPA workflow | | CO3 | R | 3 |
| 14. | Differentiate robotic process automation and chatbot. | | CO4 | U | 3 |
| 15. | Identify the role of anchors in PDF automation. | | CO5 | U | 3 |
| 16. | Describe the process of task recording used in UiPath Studio. | | CO6 | U | 3 |
| **PART – C (6 X 12 = 72 MARKS)**  **(Answer any five Questions from Q. No. 17 to 23, Q. No. 24 is Compulsory)** | | | | | |
| 17. | a. | Describe the advantages and limitations of RPA in business processes. | CO1 | U | 6 |
|  | b. | Explain browser automation using UiPath-Recording. | CO1 | U | 6 |
|  |  |  |  |  |  |
| 18. |  | Interpret the application of RPA in improving the productivity of an organization. | CO1 | A | 12 |
|  |  |  |  |  |  |
| 19. |  | Sketch the process flow diagram of finding odd numbers using UiPath activity | CO2 | A | 12 |
|  |  |  |  |  |  |
| 20. | a. | Explain the addition of two numbers by passing variables and arguments. | CO3 | A | 6 |
|  | b. | Explain the RPA workflow using sequence and flowchart techniques. | CO3 | A | 6 |
|  |  |  |  |  |  |
| 21. |  | Explain the importance of data manipulation in Excel using RPA. | CO4 | A | 12 |
|  |  |  |  |  |  |
| 22. |  | Explain the Data- Scraping automation using amazon.com and UiPath. | CO4 | A | 12 |
|  |  |  |  |  |  |
| 23. |  | Illustrate the method to streamline email communication using UiPath. | CO5 | An | 12 |
| **COMPULSORY QUESTION** | | | | | |
| 24. | a. | Summarize the future trends and orchestrator in UiPath. | CO6 | A | 6 |
|  | b. | Explain the impact of AI and machine learning in RPA. | CO6 | A | 6 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

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|  | **COURSE OUTCOMES** |
| **CO1** | Relate RPA, where it can be applied and how it's implemented. |
| **CO2** | Outline the different types of variables, Control Flow and data manipulation techniques. |
| **CO3** | Identify and understand Image, Text and Data Tables Automation. |
| **CO4** | Interpret how to handle the User Events and various types of Exceptions and strategies. |
| **CO5** | Illustrate the RPA interfacing aspects with E-mail Automation |
| **CO6** | Understand the Deployment of the Robot and to maintain the connection. |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| **Course Code** | **23RO2004** | **Duration** | **3hrs** |
| **Course Title** | **ELECTRON DEVICES AND CIRCUITS** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (10 X 1 = 10 MARKS)** | | | | | |
| 1. | Define the term energy band in Semiconductor. | | CO1 | U | 1 |
| 2. | Mention the types of semiconductors based on doping. | | CO1 | R | 1 |
| 3. | State what is rectifier | | CO2 | R | 1 |
| 4. | List the major components of a regulated DC power supply. | | CO2 | R | 1 |
| 5. | Define the term transistor action. | | CO3 | U | 1 |
| 6. | State the need for darlington connection | | CO3 | R | 1 |
| 7. | Specify the types of MOSFETs used in electronics. | | CO4 | U | 1 |
| 8. | List different classes of amplifier operation. | | CO4 | R | 1 |
| 9. | Define voltage gain in amplifiers. | | CO5 | U | 1 |
| 10. | Mention the applications of multivibrator circuits. | | CO6 | U | 1 |
| **PART – B (6 X 3 = 18 MARKS)** | | | | | |
| 11. | Write the process of electron–hole recombination in semiconductors. | | CO1 | R | 3 |
| 12. | Draw the full-wave rectifier circuit using a center-tapped transformer. | | CO2 | U | 3 |
| 13. | State the meaning of the operating point or Q-point. | | CO3 | U | 3 |
| 14. | List the main differences between JFET and BJT. | | CO4 | U | 3 |
| 15. | Draw the schematic diagram of n-channel JFET. | | CO5 | A | 3 |
| 16. | State the Barkhausen criterion for sustained oscillations. | | CO6 | U | 3 |
| **PART – C (6 X 12 = 72 MARKS)**  **(Answer any five Questions from Q. No. 17 to 23, Q. No. 24 is Compulsory)** | | | | | |
| 17. |  | Explain the construction and working principle of PN diode and draw its VI characteristics | CO1 | R | 12 |
|  |  |  |  |  |  |
| 18. | a. | Describe the operation of shunt regulators and series regulators with circuit diagrams and waveforms. | CO2 | U | 6 |
|  | b. | A common base transistor amplifier has an input resistance of 20 Ω and output resistance of 100 kΩ. The collector load is 1 kΩ. If a signal of 500 mV is applied  between emitter and base, find the voltage amplification. Assume α ac to be nearly one. | CO2 | An | 6 |
|  |  |  |  |  |  |
| 19. |  | Explain the input and output characteristics of a transistor in CE configuration. | CO3 | R | 12 |
|  |  |  |  |  |  |
| 20. |  | Explain in detail the working principle of direct coupled class A amplifier and derive its efficiency | CO4 | U | 12 |
|  |  |  |  |  |  |
| 21. |  | Describe the characteristics of JFET and explain its drain and transfer characteristics. | CO5 | U | 12 |
|  |  |  |  |  |  |
| 22. | A | Explain the construction and working of RC phase shift oscillator using positive feedback concept. | CO5 | A | 6 |
|  |  | Draw and explain astable multi vibrator using transistor. |  | A | 6 |
| 23. | A | A Illustrate an RC-coupled amplifier and explain how it amplifies a signal through each stage. | CO6 | A | 10 |
|  |  | Draw the frequency response curve of the above. | CO6 | A | 2 |
| **COMPULSORY QUESTION** | | | | | |
| 24. |  | Describe the construction and working of Hartley oscillators and derive the frequency of oscillation and maintenance of oscillation of it. | CO6 | An | 12 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

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|  | **COURSE OUTCOMES** |
| **CO1** | Determine the characteristics of solid-state devices like diode and transistor. |
| **CO2** | Select suitable components for electronic circuit design |
| **CO3** | Design power supply circuits, amplifiers and oscillators. |
| **CO4** | Analyze the amplitude and frequency response of amplifier circuits. |
| **CO5** | Apply field effect transistor circuits in electronic systems. |
| **CO6** | Develop electronic circuits for specific applications |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| **Course Code** | **23RO2005** | **Duration** | **3hrs** |
| **Course Title** | **ELECTRICAL MACHINES** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (10 X 1 = 10 MARKS)** | | | | | |
| 1. | What is the function of a commutator in a DC motor? | | CO1 | R | 1 |
| 2. | Infer the role of the auxiliary winding in a single phase induction motor. | | CO1 | U | 1 |
| 3. | State one application of linear motors. | | CO2 | R | 1 |
| 4. | Name one transportation system that uses linear induction motors. | | CO2 | R | 1 |
| 5. | Define step angle. | | CO3 | R | 1 |
| 6. | Sketch the nature of torque–speed characteristics of a stepper motor. | | CO3 | U | 1 |
| 7. | Mention one difference between AC and DC servo motors in construction. | | CO4 | R | 1 |
| 8. | How is position controlled in a servo motor? | | CO4 | U | 1 |
| 9. | What is the role of permanent magnets in a BLDC motor? | | CO5 | R | 1 |
| 10. | State one advantage of PMSMs over conventional synchronous motors. | | CO6 | U | 1 |
| **PART – B (6 X 3 = 18 MARKS)** | | | | | |
| 11. | Why is a DC series motor not suitable for no-load operation? Justify. | | CO1 | An | 3 |
| 12. | Distinguish between Linear Synchronous motor (LSM) and Linear Induction motor (LIM) with respect to operation and applications. | | CO2 | U | 3 |
| 13. | Derive the emf equation of a stepper motor. | | CO3 | A | 3 |
| 14. | Sketch the nature of torque–speed characteristics of a DC and AC servo motor. | | CO4 | U | 3 |
| 15. | Compare square wave and sine wave BLDC motors in terms of efficiency, torque ripple, and applications. | | CO5 | U | 3 |
| 16. | Express the relationship between electrical input power, mechanical output power, and torque in PMSMs. | | CO6 | A | 3 |
| **PART – C (6 X 12 = 72 MARKS)**  **(Answer any five Questions from Q. No. 17 to 23, Q. No. 24 is Compulsory)** | | | | | |
| 17. | a. | Draw and explain the torque–speed characteristics of DC shunt and series motors. | CO1 | U | 6 |
|  | b. | Explain in detail the construction of a three phase induction motor with a neat diagram. | CO1 | U | 6 |
|  |  |  |  |  |  |
| 18. | a. | State and examine the principle of operation of a Linear Induction motor. | CO2 | A | 6 |
|  | b. | Draw and explain the torque–speed characteristic of a linear induction motor. | CO2 | A | 6 |
|  |  |  |  |  |  |
| 19. | a. | Demonstrate the constructional features of a DC Linear Motor (DCLM). | CO2 | An | 6 |
|  | b. | Develop a detailed case study on the use of LIMs in Maglev trains with diagrams. | CO2 | An | 6 |
|  |  |  |  |  |  |
| 20. |  | Explore the main constructional parts of a stepper motor. Also elucidate the working principle of a stepper motor with neat sketch. | CO3 | U | 12 |
|  |  |  |  |  |  |
| 21. | a. | Illustrate the methods of controlling the speed of a stepper motor. | CO3 | A | 6 |
|  | b. | Infer the application of stepper motors in robotics with an example. | CO3 | A | 6 |
|  |  |  |  |  |  |
| 22. | a. | Interpret the construction of a DC servo motor with a neat diagram. | CO4 | U | 6 |
|  | b. | Derive the torque equation of a DC servo motor and express the relation between torque and armature current. | CO4 | U | 6 |
|  |  |  |  |  |  |
| 23. | a. | Elaborate the construction of a Permanent Magnet Synchronous Motor with a neat diagram and describe its main components. | CO6 | U | 8 |
|  | b. | Discuss the factors affecting torque generation in PMSMs. | CO6 | U | 4 |
| **COMPULSORY QUESTION** | | | | | |
| 24. | a. | Draw and analyze the torque–speed characteristics of a BLDC motor. | CO5 | An | 6 |
|  | b. | Formulate the EMF equation of a BLDC motor and explain each term. | CO5 | An | 6 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

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|  | **COURSE OUTCOMES** |
| **CO1** | Discuss the basics of different types of DC and AC motor. |
| **CO2** | Explain the constructional features of different Motors. |
| **CO3** | Demonstrate the working principle of various types of Motors. |
| **CO4** | Relate the torque speed characteristics of several Motors. |
| **CO5** | Describe the various method of speed control of motors used for Automation. |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| **Course Code** | **23RO2006** | **Duration** | **3hrs** |
| **Course Title** | **AUTOMATIC CONTROL SYSTEMS** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (10 X 1 = 10 MARKS)** | | | | | |
| 1. | Identify the characteristics of negative feedback in control system. | | CO1 | U | 1 |
| 2. | Define transfer function. | | CO1 | R | 1 |
| 3. | State damping ratio. | | CO2 | R | 1 |
| 4. | Determine the type and order of the following system transfer function  . | | CO2 | U | 1 |
| 5. | Define gain margin. | | CO3 | R | 1 |
| 6. | State the advantages of Bode Plot. | | CO3 | U | 1 |
| 7. | The first column of the Routh array is 5, 3, 2, 4, -3.Calculate the number of roots in right half of s-plane. | | CO4 | A | 1 |
| 8. | List the advantages of state variable approach. | | CO5 | R | 1 |
| 9. | Define controllability. | | CO5 | R | 1 |
| 10. | Sketch the step response of a P and PI-controller. | | CO6 | U | 1 |
| **PART – B (6 X 3 = 18 MARKS)** | | | | | |
| 11. | Write the force balance equation of ideal mass element. | | CO1 | U | 3 |
| 12. | A second order system has a damping ratio of 0.6 and natural frequency of oscillation is 10 rad/sec. Determine the damped frequency of oscillation. | | CO2 | U | 3 |
| 13. | Sketch Polar plot for the transfer function | | CO3 | An | 3 |
| 14. | Explain the conditions for stability. | | CO4 | U | 3 |
| 15. | Write the general form of state variable representation. | | CO5 | A | 3 |
| 16. | List the Characteristics of PID-controller. | | CO6 | U | 3 |
| **PART – C (6 X 12 = 72 MARKS)**  **(Answer any five Questions from Q. No. 17 to 23, Q. No. 24 is Compulsory)** | | | | | |
| 17. |  | Compare open loop with closed loop control systems with suitable example. | CO1 | R | 12 |
|  |  |  |  |  |  |
| 18. |  | Determine the overall transfer function of the system for the signal flow graph shown below. | CO1 | A | 12 |
|  |  |  |  |  |  |
| 19. |  | Examine the response of second order system when the input is unit step. | CO2 | A | 12 |
|  |  |  |  |  |  |
| 20. |  | The open loop transfer function of a unity feedback control system is given by. Sketch the polar plot and determine the phase margin and gain margin. | CO3 | An | 12 |
|  |  |  |  |  |  |
| 21. |  | Sketch Bode plot for the following transfer function and obtain the gain cross over frequencies, | CO3 | An | 12 |
|  |  |  |  |  |  |
| 22. |  | Consider the matrix A. Compute  by using Homogeneous state Equations | CO5 | A | 12 |
|  |  |  |  |  |  |
| 23. |  | Summarize the steps involved in the design of PID Controller in frequency domain. | CO6 | E | 12 |
| **COMPULSORY QUESTION** | | | | | |
| 24. |  | Construct Routh array and determine the stability of the system represented by the characteristic equation. Comment on the location of the roots of characteristic equation | CO4 | An | 12 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

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|  | **COURSE OUTCOMES** |
| **CO1** | Develop mathematical models of control components and physical systems. |
| **CO2** | Analyze the time domain responses of LTI systems. |
| **CO3** | Determine the frequency domain specifications of the LTI systems. |
| **CO4** | Investigate the stability of systems based on frequency domain using different techniques. |
| **CO5** | Derive equivalent transfer function and state space model for a given system. |
| **CO6** | Design controllers for practical applications. |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| **Course Code** | **23RO2009** | **Duration** | **3hrs** |
| **Course Title** | **ROBOT KINEMATICS AND DYNAMICS** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (10 X 1 = 10 MARKS)** | | | | | |
| 1. | Determine the Cartesian Coordinates equivalent to the polar representation r = 5 and θ = 60 degree. | | CO1 | A | 1 |
| 2. | Construct the rotation matrix for a rotation of 45° about the Z-axis. | | CO1 | U | 1 |
| 3. | Write the general form of the Homogeneous Transformation Matrix | | CO2 | R | 1 |
| 4. | State the reason why the inverse of the Rotation Matrix is equal to its transpose. | | CO2 | An | 1 |
| 5. | Differentiate forward and inverse kinematics of a robot manipulator. | | CO3 | U | 1 |
| 6. | Name the four kinematic parameters used in forward kinematic analysis of a robot. | | CO3 | R | 1 |
| 7. | Write the twist equation in a robot. | | CO4 | U | 1 |
| 8. | State the reasons for degeneracy condition of a robot. | | CO4 | U | 1 |
| 9. | Specify two applications of Inverse Dynamic Analysis of a robot. | | CO5 | U | 1 |
| 10. | List the deterministic algorithms used in motion planning. | | CO6 | R | 1 |
| **PART – B (6 X 3 = 18 MARKS)** | | | | | |
| 11. | Specify the functions of five standard frames used in industrial robots. | | CO1 | U | 3 |
| 12. | Frame B {2.3.1} is rotated about ‘z’ axis by 30 degrees. Determine its resultant position. | | CO2 | An | 3 |
| 13. | Specify the step by step procedure to solve an Inverse Kinematics Problem using the Trigonometric Approach. | | CO3 | U | 3 |
| 14. | Differentiate Boundary Singularity and Interior Singularity conditions of a robot manipulator. | | CO4 | An | 3 |
| 15. | Derive the force equation of a cart spring system using Lagrange Approach. | | CO5 | A | 3 |
| 16. | Compare Joint Space and Cartesian Space trajectory description techniques used in motion planning of a robot. | | CO6 | An | 3 |
| **PART – C (6 X 12 = 72 MARKS)**  **(Answer any five Questions from Q. No. 17 to 23, Q. No. 24 is Compulsory)** | | | | | |
| 17. | a. | Compare the coordinate systems used to represent the position of a point or rigid body in space, | CO1 | An | 6 |
|  | b. | Frame F was subjected to the following transformations in order.   1. rotation about the x-axis by 90 degrees. 2. translation of 4 units along the x-axis, 2 units along y-axis and 1 unit along z-axis and 3. rotation about the z axis by 30degrees.   Determine the total transformation matrix. | CO1 | A | 6 |
|  |  |  |  |  |  |
| 18. | a. | Derive the forward and inverse kinematic equations of a 2 link RR Manipulator. | CO2 | A | 6 |
|  | b. | The kinematic diagram of an articulated robot is shown in the Fig. given below. Assign the coordinate frames of the robot as per the DH rule and hence create the DH parameter table. | CO2 | A | 6 |
|  |  |  |  |  |  |
| 19. |  | Derive the Inverse Kinematic Equation of a 2 link RR manipulator using Jacobian Technique up to 5 iterations, given L1=L2=1, initial position (x,y) = (1.4142,0), initial angle θ1 = π/4, θ2 = π/2 and initial error e-(-0.4142, 1) | CO3 | A | 12 |
|  |  |  |  |  |  |
| 20. | a. | Derive the Jacobian Equation that relates the joint velocity and end effector velocity in a 2-link manipulator. | CO4 | U | 6 |
|  | b. | Classify the types of robot singularity and highlight the implication of the singularity condition on robot performance. | CO4 | U | 6 |
|  |  |  |  |  |  |
| 21. |  | Derive the Torque Equation of a two link planar manipulator with revolute joints using Lagrange Method. | CO5 | A | 12 |
|  |  |  |  |  |  |
| 22. | a. | Compute the Cartesian coordinates for the end of the arm, given that the length of joints L1 = 15in, L2 = 12in, angles θ1= 60 degrees and θ2=45 degrees. | CO2 | A | 6 |
|  | b. | Using the standard Denavit–Hartenberg (DH) convention, list the ordered sequence of transformations that relate two successive link frames of a robot manipulator. Hence derive the general expression for the arm equation of a serial manipulator. | CO2 | A | 6 |
|  |  |  |  |  |  |
| 23. |  | Using Pseudo Jacobian Technique, determine the IK solution of a 3 DoF Cartesian Robot, given desired end effector position (1,1,1) and error (0,0,0) | CO3 | A | 12 |
| **COMPULSORY QUESTION** | | | | | |
| 24. | a. | It is desired to have the second joint of a 3-axis robot go from an initial angle  of 20 degrees to a final angle of 50 degrees in 5 seconds. Calculate the coefficients for a third-order polynomial joint-space trajectory. The robot starts  from rest but should have a final velocity of 5 degrees /sec. | CO6 | A | 6 |
|  | b. | Describe the A\* algorithm used in motion planning with suitable example. | CO6 | A | 6 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

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|  | **COURSE OUTCOMES** |
| **CO1** | Represent a point and vector in space |
| **CO2** | Derive transformation matrices for translation and rotation |
| **CO3** | Apply forward and inverse kinematic analysis of manipulators |
| **CO4** | Make use of Jacobians for differential kinematic analysis |
| **CO5** | Analyze dynamics using Lagrangian Mechanics |
| **CO6** | Perform simulation studies of robot trajectory planning |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| **Course Code** | **23RO2010** | **Duration** | **3hrs** |
| **Course Title** | **MICROCONTROLLERS FOR ROBOTICS** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (10 X 1 = 10 MARKS)** | | | | | |
| 1. | Name the flag of Program Status Word (PSW) used in arithmetic, JUMP, ROTATE and Boolean instructions. | | CO1 | U | 1 |
| 2. | Which microcontroller has a higher clock speed: 8-bit or 32-bit? | | CO1 | U | 1 |
| 3. | If the contents of register **A = 38H** and another number **45H** is added to it, what will be the result in the accumulator after executing the **DAA (Decimal Adjust Accumulator)** instruction? | | CO2 | A | 1 |
| 4. | In which addressing mode is the operand specified in the instruction itself in 8051? | | CO2 | R | 1 |
| 5. | Which serial communication protocol is generally used to interface Bluetooth with 8051? | | CO3 | R | 1 |
| 6. | How many ports does the 8051 microcontroller have for general purpose I/O? | | CO3 | R | 1 |
| 7. | How many stages are there in the ARM9 pipeline? | | CO4 | U | 1 |
| 8. | Which stage in ARM instruction execution writes the result back to the register? | | CO4 | R | 1 |
| 9. | Which instruction set does Cortex-M4 use to improve code density? | | CO5 | U | 1 |
| 10. | In interfacing a stepper motor with 8051, which parameter controls the speed of rotation? | | CO6 | U | 1 |
| **PART – B (6 X 3 = 18 MARKS)** | | | | | |
| 11. | Differentiate between Program counter (PC) and Data Pointer (DP). | | CO1 | An | 3 |
| 12. | Write a ALP in 8051 to add two 8-bit numbers. | | CO2 | A | 3 |
| 13. | Show the status of the CY, AC and P flag after the addition of 38H and 2FH in PSW of 8051 microcontrollers. . | | CO3 | An | 3 |
| 14. | Write the salient features of ARM instruction set. | | CO4 | U | 3 |
| 15. | Relate Thumb-2 instruction set with Thumb instructions. | | CO5 | U | 3 |
| 16. | Write a program to blink LEDs continuously interfaced with 8051 microcontrollers. | | CO6 | A | 3 |
| **PART – C (6 X 12 = 72 MARKS)**  **(Answer any five Questions from Q.No. 17 to 23, Q.No. 24 is Compulsory)** | | | | | |
| 17. |  | Sketch the architecture of 8051 Microcontroller and explain the functions of each block. | CO1 | U | 12 |
|  |  |  |  |  |  |
| 18. |  | With suitable examples, explain the addressing modes and instruction set of 8051 microcontroller. | CO2 | U | 12 |
|  |  |  |  |  |  |
| 19. | a. | Explain the functions of TMOD and TCON registers in 8051 Microcontroller. | CO3 | U | 6 |
|  | b. | Explain how DAC is interfaced with 8051 Microcontroller with neat sketch. | CO3 | U | 6 |
|  |  |  |  |  |  |
| 20. |  | Sketch the RISC architecture of ARM 9 and discuss its merits and demerits. | CO4 | A | 12 |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| 21. | a. | Analyze how Nested Vector Interrupt controller manages and prioritizes external interrupt from peripherals with neat diagram. | CO5 | An | 6 |
|  | b. | Discuss the applications of cortex M4 architecture. | CO5 | An | 6 |
|  |  |  |  |  |  |
| 22. | a. | Define embedded system and discuss its characteristics. | CO1 | A | 6 |
|  | b. | Illustrate the memory organization in 8051 Microcontroller with neat sketches. | CO1 | A | 6 |
|  |  |  |  |  |  |
| 23. | a. | Write an assembly language program in 8051 to perform logical operations on two 8-bit numbers. | CO2 | A | 6 |
|  | b. | Write an assembly language program in 8051 to multiply and divide two 8-bit numbers. | CO2 | A | 6 |
| **COMPULSORY QUESTION** | | | | | |
| 24. |  | Illustrate how a seven segment LED display is used to display numbers 1,2,4,8 and alphabets A, C, D, E when interfaced with 8051. Write an embedded c code to display the numbers and alphabets. | CO6 | E | 12 |
|  |  |  |  |  |  |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL**M** – MARKS ALLOTTED

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|  | **COURSE OUTCOMES** |
| **CO1** | Compare the architecture of various controllers. |
| **CO2** | Classify different types of instruction set and addressing modes. |
| **CO3** | Design real time systems using microcontrollers. |
| **CO4** | Discuss the general features of RISC architecture. |
| **CO5** | Summarize the specific features of cortex controller. |
| **CO6** | Develop interfacing program with controllers. |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| **Course Code** | **23RO2011** | **Duration** | **3hrs** |
| **Course Title** | **COMPUTER VISION** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (10 X 1 = 10 MARKS)** | | | | | |
| 1. | Identify the primary function of CMOS sensors in digital image acquisition. | | CO1 | R | 1 |
| 2. | List any two relationships between the pixels. | | CO1 | R | 1 |
| 3. | Define sharpening in spatial domain image enhancement technique. | | CO2 | R | 1 |
| 4. | Enumerate the steps involved in Canny edge detection algorithm. | | CO2 | R | 1 |
| 5. | Define chain code in boundary representation. | | CO3 | R | 1 |
| 6. | Identify the technique that is used to separate a foreground object from its background. | | CO3 | U | 1 |
| 7. | List the properties of transformation of objects with sharp edges for recognition of object. | | CO4 | R | 1 |
| 8. | Compare erosion and dilation effects on binary images. | | CO4 | U | 1 |
| 9. | Identify any one application of 3D reconstruction in medical imaging. | | CO5 | U | 1 |
| 10. | Interpret the relationship between visual SLAM and robot localization. | | CO6 | U | 1 |
| **PART – B (6 X 3 = 18 MARKS)** | | | | | |
| 11. | Review binary image, gray scale image and color image | | CO1 | U | 3 |
| 12. | Explain the process of binary image thresholding and its applications. | | CO2 | U | 3 |
| 13. | Compare the performance of line and circle detection using Hough Transform. | | CO3 | An | 3 |
| 14. | Classify different approaches to object recognition based on their methodologies. | | CO4 | U | 3 |
| 15. | Explain the process of 3D scene understanding from multiple images. | | CO5 | U | 3 |
| 16. | Summarize the key features of visual SLAM for mobile robots. | | CO6 | U | 3 |
| **PART – C (6 X 12 = 72 MARKS)**  **(Answer any five Questions from Q. No. 17 to 23, Q. No. 24 is Compulsory)** | | | | | |
| 17. | a. | Illustrate the image formation model with neat diagrams of the human eye and a pinhole camera. | CO1 | U | 8 |
|  | b. | Discuss the element of a general-purpose digital image processing system. | CO1 | U | 4 |
|  |  |  |  |  |  |
| 18. | a. | Apply histogram equalization for the gray levels of an 8 X 8 image given below and plot the histogram of the original and the processed image.   |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | | Gray levels | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | No. of pixels | 8 | 10 | 10 | 2 | 12 | 16 | 4 | 2 | | CO2 | A | 8 |
|  | b. | Summarize the process of color transformation between RGB and HSV spaces. | CO2 | U | 4 |
|  |  |  |  |  |  |
| 19. |  | Explain regional and boundary descriptors used in computer vision and their applications in object recognition. | CO3 | U | 12 |
|  |  |  |  |  |  |
| 20. | a. | Discuss the modelling of objects in an image by combining two images to recognize the object efficiently. | CO4 | U | 5 |
|  | b. | Explain the object recognition technique in high-level digital image processing system with the help of a neat diagram. | CO4 | U | 7 |
|  |  |  |  |  |  |
| 21. | a. | Analyze structure from Motion technique in autonomous vehicles. | CO5 | An | 4 |
|  | b. | Explain the role of digital image processing in transforming sensor readings for a vision system with an example. | CO5 | A | 8 |
|  |  |  |  |  |  |
| 22. | a. | Summarize various illumination techniques used in machine vision systems and their impact on image quality. | CO1 | U | 4 |
|  | b. | Discuss the edge linking and boundary detection using Hough transform. | CO3 | U | 8 |
|  |  |  |  |  |  |
| 23. |  | Explain the process of filtering an image in the frequency domain and classify the smoothing and sharpening filters in frequency domain. | CO2 | U | 12 |
|  |  |  |  |  |  |
| **COMPULSORY QUESTION** | | | | | |
| 24. | a. | Discuss the robot perception pipeline from image acquisition to decision making. | CO6 | U | 6 |
|  | b. | Describe the ROS architecture and important packages for vision-based robot development. | CO6 | U | 6 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

|  |  |
| --- | --- |
|  | **COURSE OUTCOMES** |
| **CO1** | Distinguish the basic components of specific visual system. |
| **CO2** | Summarize the effect of low-level vision algorithms. |
| **CO3** | Illustrate the use of high-level vision algorithms for specific purpose. |
| **CO4** | Analyse the techniques used for object identification. |
| **CO5** | Apply Robot Operating System and Open CV packages for Robotic vision. |
| **CO6** | Demonstrate various applications using vision and tracking algorithms. |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **25RO201** | **Duration** | **3hrs** |
| **Course Title** | **LINEAR ALGEBRA AND DIFFERENTIAL EQUATIONS FOR ROBOTICS ENGINEERING** | **Max. Marks** | **100** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Q. No.** | **Questions** | **LUO** | **RBT Level** | **Related CO** |
| **PART – A (10 X 2 = 20 MARKS)** | | | | |
| 1. | A humanoid robot leg is modeled by:  .  Identify whether the system is near-singular which may cause control instability by calculating the determinant of the coefficient matrix. | 1a | R | 1 |
| 2. | Two linear actuators share a load in a robotic gripper. The load-sharing system is modeled by:  Identifythe values and by using elimination or substitution method. | 1b | R | 1 |
| 3. | A robot is walking with a very simplistic “spring–mass” model for its torso. The control provides a restoring torque but has no damping to save energy. The continuous-time dynamics are  ,  Classify the stability of the walking gait by finding the eigenvalues of . | 2a | U | 2 |
| 4. | List the any two properties of Eigen vectors. | 2b | U | 2 |
| 5. | A self-driving car is following a straight, pre-computed path. At time , the GPS signal drops out for 2 seconds. The last known (just before dropout) state is:   * Velocity: . * Measured constant longitudinal acceleration during the dropout: (from the accelerometer).   Express the velocity function v(t). | 3a | R | 3 |
| 6. | A small drone of mass is hovering vertically. Its motion along the vertical axis is affected by air resistance (modeled as viscous damping) and a spring-like restoring force (e.g., tether or soft landing spring). There is no external force applied. The motion of the drone is modeled by the second-order ODE:  with .  Identify the displacement x(t) as a function of time. | 3b | R | 3 |
| 7. | A delivery drone of mass rolls on a horizontal rail (so motion is 1-D along ). A constant forward propulsive thrust is applied for seconds to push the drone along the rail. There is a constant resistive force (friction/drag) always opposing the motion. The drone starts from rest at . The thrust is applied for 𝑡=4s. Using Lagrange’s equation for the generalized coordinate find the acceleration and the velocity . | 4b | U | 4 |
| 8. | Consider the steady (time-harmonic snapshot) acoustic field in a long underwater channel that satisfies the second-order homogeneous PDE  Find for . | 4c | U | 4 |
| 9. | A manufacturing robot uses a curved-jaw gripper to pick up steel ball bearings. The motor applies a torque (N·m) to the gripper jaw; the jaw contacts the spherical bearing at radius (m). Because of contact geometry and friction, the normal gripping force required to hold the ball is modeled by  with material constant ().  Given: , . Identify the gripping force at this operating point. | 5a | A | 5 |
| 10. | A drone flying indoors (GPS-denied) uses a downward camera to estimate its vertical motion through optical flow. The measured flow (in flow units) depends on the vertical velocity (m/s) and the ground texture scale :  Here, is positive upward (negative downward), and a higher means more visual detail on the ground, producing stronger optical flow.  Verify that is a homogeneous function and **find** its degree. | 5b | A | 5 |
| **PART – B (5 X 6 = 30 MARKS)** | | | | |
| 11. | A self-driving car’s front camera is slightly tilted and mis-calibrated, so lane corners appear distorted in the image. The transformation matrix of the camera’s image warp is . A road marker in the image is seen at pixel coordinate Compute the actual road-plane coordinate of this marker using the inverse of a matrix. | 1d | A | 1 |
| 12. | In a robotic arm, the end-effector dynamics are modeled with an upper-triangular stiffness matrix because forces in one axis influence subsequent axes (but not vice versa). The simplified stiffness model is  Calculate the principal stiffness modes of the robotic arm by finding the eigenvalues and eigenvectors of the matrix. | 2b | An | 2 |
| 13. | A drone of mass moves vertically. Its motion is affected by airresistance (damping) and a tethered spring-like force. Additionally, the drone’s motors provide a vertical thrust that increases exponentially with time: . The governing equation is:  with  and initial conditions  Estimate the velocity of the drone. | 3d | A | 3 |
| 14. | A small drone of mass moves along the horizontal -axis. A constant propulsive thrust acts forward and there is a constant resistive force (rolling/aerodynamic loss approximated constant) acting opposite to motion. The drone starts from rest: . The thrust is applied for .  Using Lagrange’s equation for the generalized coordinate : (1) *Determine* the acceleration and velocity  (2) *Compute* the work done by the thrust from to s (total mechanical energy input). (3) *Compute* the work lost to the resistive force. | 4b | An | 4 |
| 15. | A 2-link planar robot arm in an assembly cell must move its gripper with a small linear velocity to feed parts. Both links are 1 m long. At the current posture the controller measures joint angles  so the second link is rotated 90° relative to the first. The desired end-effector linear velocity is  Calculate the joint angular velocities and that produce this end-effector velocity. | 5c | A | 5 |
| **PART – C (5 X 10 = 50 MARKS)** | | | | |
| 16 | A 3-joint robotic manipulator is required to achieve a target position. The joint displacements x, y, and z satisfy the following system of equations:  Determinethe values of x, y, and z using the Gauss–Jordan elimination method. | 1e | A | 1 |
| **(OR)** | | | | |
| 17 | A self-driving car’s lane detection algorithm adjusts based on the following system of equations derived from three image sensor readings:  Computethe values of x, y, and z using Cramer’s Rule. | 1b | An | 1 |
|  | | | | |
| 18 | A mobile robot’s small-angle linearized state evolves as The planner needs a 5-step prediction to check trajectory errors. Given  ,  Predict using diagonalization. | 2d | A | 2 |
| **(OR)** | | | | |
| 19 | A 3-axis actuator mapping is linearized as . For immediate torque tracking we need at high frequency. Given  Calculate and then using Cayley–Hamilton. | 2c | An | 2 |
|  |  |  |  |  |
| 20 | A robotic surgical system is designed to hold its tool tip steady at a target position. The system's stabilization is modeled by a spring-like force. However, the surgeon's hand tremors introduce a disturbance.  The displacement of the tool tip, from its target is governed by the following initial value problem for :  Does the robot successfully compensate for the tremor and maintain a stable position? Justify your answer using the method of variation of parameters. | 3c | An | 3 |
| **(OR)** | | | | |
| 21 | A welding robotic arm has torque distribution N·m) along its radial coordinate . Its steady equilibrium torque satisfies the Cauchy–Euler ODE  for . The initial conditions at are  *Estimate* for . | 3d | An | 3 |
|  |  |  |  |  |
| 22 | A robotic arm operating in a flexible manufacturing system experiences vibrational displacement along its structure. The displacement satisfies the partial differential equation  with initial conditions  *Find* for , and interpret the physical meaning of the solution in terms of vibrational displacement propagation along the robotic arm under the influence of exponential external excitation. | 4d | An | 4 |
| **(OR)** | | | | |
| 23 | A robotic arm segment in a manufacturing system experiences dynamic displacement due to periodic external forces. The displacement satisfies the partial differential equation  with initial conditions  *Find* for , and interpret the physical meaning of the solution in terms of vibrational displacement propagation in the robotic arm under harmonic excitation. | 4d | An | 4 |
|  |  |  |  |  |
| **Compulsory Question:** | | | | |
| 24 | A small drone with mass m=1 kg needs to move upward energy-efficiently. It starts at rest, moves up 5 meters, and ends at rest. The total movement time is 3 seconds. Estimate the optimal thrust profileusing Lagrange's method to minimize energy consumption. | 5d | An | 5 |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| --- | --- | --- | --- |
| **Course Code** | **25RO202** | **Duration** | **3hrs** |
| **Course Title** | **APPLIED PHYSICS FOR ROBOTICS ENGINEERING** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | **LUO** | **RBT Level** | **Related CO** |
| **PART – A (10 X 2 = 20 MARKS)** | | | | |
| 1. | State Newton’s First Law and give one example of its application in robotic arms. | 1a | R | 1 |
| 2. | Identify the significance of work-energy theorem in industrial automation. | 1b | U | 1 |
| 3. | List any two factors that affect heat conduction in robotic components. | 2a | U | 2 |
| 4. | Name a thermal interface material and its function in robot design. | 2b | U | 2 |
| 5. | Mention one sensing application of the Doppler effect in robotics. | 3a | R | 3 |
| 6. | Define resonance and mention one of its effects in robotic structures. | 3b | R | 3 |
| 7. | Name two types of lasers used in precision measurements for robotics. | 4a | U | 4 |
| 8. | Give an example of how fiber optics is used for navigation in robots. | 4b | U | 4 |
| 9. | Define Meta stable state in stimulated emission. | 5a | U | 5 |
| 10. | Illustrate the thermoelectric generator with a circuit. | 5b | U | 5 |
| **PART – B (5 X 6 = 30 MARKS)** | | | | |
| 11. | Calculatethe minimum net force required to accelerate the robot from rest to 1.5 m/s in 3 seconds of an autonomous delivery robot is designed to transport packages across a smooth warehouse floor. The robot weighs 80 kg (including payload) and is equipped with four motorized wheels. Initially at rest, the robot must accelerate to a cruising speed of 1.5 m/s, travel to a destination 25 meters away, and then come to a complete stop precisely at a docking station. | 1a | E | 1 |
| 12. | Deduce the work done for the following cases.  Case1: F& S are parallel.  Case2: F & S are perpendicular. | 1b | E | 2 |
| 13. | Justifythe statement with a suitable thermodynamical law.  When a hot object and a cold object are brought into contact, heat flows from hot to cold until they reach thermal equilibrium. | 2a | An | 3 |
| 14. | Justify the requirement of a metastable state to get stimulated emission of radiation for lasing action in LiDAR. | 4b | An | 4 |
| 15. | Differentiate the thermoelectric nanogenerator and piezoelectric nano generators used for self-powered robots | 5c | An | 5 |
| **PART – C (5 X 10 = 50 MARKS)** | | | | |
| 16 | Evaluatethe change in velocity during the time interval t=3s and t=6s and the average acceleration during this interval for drone having the velocity described by the equation V= ct + Dt2 where C=0.1 m/s2 and D=0.02m/S3 | 1c | E | 1 |
| **(OR)** | | | | |
| 17 | Evaluate the take-off velocity and the minimum length of runway of a Jumbo Jet starts with an acceleration of 3m/s2 and makes a run for 35 s before take-off. | 1e | E | 1 |
|  |  |  |  |  |
| 18 | Justify the requirement of cryogenic robots for space exploration and the thermodynamics associated with that. | 2b | A | 2 |
| **(OR)** | | | | |
| 19 | Evaluate an energy balance for the boiler system, quantify losses, and propose improvements to raise the boiler efficiency from 78% to higher for the given data.   * Fuel: Natural gas, calorific value = 50,000 kJ/kg, * Fuel flow = 80 kg/hr, Steam produced = 1,200 kg/hr * Steam conditions: 10 bar, 180°C (saturated), * Feedwater enters at 30°C, * Flue gas exhaust temperature = 220°C, * Ambient air = 25°C.   Boiler metal mass = large → assume steady state (ΔU ≈ 0). | 2c | An | 2 |
|  |  |  |  |  |
| 20 | Assess the use of Doppler shift measurements in mobile robots for real-time velocity estimation and collision avoidance | 3d | E | 3 |
| **(OR)** | | | | |
| 21 | Evaluate the frequency of ultrasonic waves generated through piezoelectric oscillator. | 3f | E | 3 |
|  |  |  |  |  |
| 22 | Develop a test to determine the accuracy of a LiDAR-based SLAM system in a simulated warehouse. | 4c | An | 4 |
| **(OR)** | | | | |
| 23 | Evaluate the Numerical aperture and the acceptance angle for a multimode fiber | 4e | E | 4 |
| **Compulsory Question:** | | | | |
| 24 | Justify that the quantum confinement at 1D, 2D and 3D size reduction leads to improved efficiency of electronic device with suitable schematic. | 5d | An | 5 |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| **Course Code** | **25RO203** | **Duration** | **3hrs** |
| **Course Title** | **ADDITIVE MANUFACTURING** | **Max. Marks** | **100** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Q. No.** | **Questions** | **LUO** | **RBT Level** | **Related CO** |
| **PART – A (10 X 2 = 20 MARKS)** | | | | |
| 1 | List the types of industrial casting processes. | 1a | R | 1 |
| 2 | Define ‘extrusion’ and state its applications. | 1b | R | 1 |
| 3 | List the metal forming methods used in aerospace industry. | 1c | U | 1 |
| 4 | Define ‘computer-aided design’. | 2a | U | 2 |
| 5 | State the purpose of ‘geometric modelling’ in rapid prototyping. | 2b | U | 2 |
| 6 | Define ‘reverse engineering’ | 3a | R | 3 |
| 7 | List the types of additive manufacturing technologies. | 4a | R | 4 |
| 8 | Differentiate ‘SLA processes’ from ‘FDM processes’. | 4b | U | 4 |
| 9 | State the role of Selective Laser Sintering in AM. | 5a | R | 5 |
| 10 | Define “porosity” in the context of AM parts. | 5b | U | 5 |
| **PART – B (5 X 6 = 30 MARKS)** | | | | |
| 11 | Explain the process parameters applied to form a cast component to desired dimensions. | 1d | A | 1 |
| 12 | Infer the influence of CAE simulation in product design optimization. | 2a | An | 2 |
| 13 | Assess the advantages of reverse engineering in product development. | 3a | A | 3 |
| 14 | Distinguish ‘traditional prototyping’ from ‘rapid prototyping’. | 4a | An | 4 |
| 15 | Compare LOM with SLS | 5a | An | 5 |
| **PART – C (5 X 10 = 50 MARKS)** | | | | |
| 16 | Explain the causes of dimensional variation in a casting process and the methods used to control it. | 1f | U | 1 |
| **(OR)** | | | | |
| 17 | Evaluate the selection criteria of metal forming methods for precision parts in robotics. | 1e | E | 1 |
|  |  |  |  |  |
| 18 | Assess the significance of geometric modeling in enhancing manufacturing processes. | 2e | An | 2 |
| **(OR)** | | | | |
| 19 | Explain the ways in which topology optimization unlocks design opportunities in digital manufacturing. | 2c | An | 2 |
|  |  |  |  |  |
| 20 | Evaluate the effectiveness of reverse engineering in product improvement and innovation. | 3a | E | 3 |
| **(OR)** | | | | |
| 21 | Examine the role of smart manufacturing tools in reducing production lead times. | 3f | An | 3 |
|  |  |  |  |  |
| 22 | Explain the functioning of FDM process model and the part orientation used in printing the components. | 4a | A | 4 |
| **(OR)** | | | | |
| 23 | Evaluate the impact of infill density and build orientation on printed part strength. | 4b | E | 4 |
| **Compulsory Question:** | | | | |
| 24 | Evaluate the importance of powder structure in Selective Laser Sintering. | 5d | E | 5 |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| --- | --- | --- | --- |
| **Course Code** | **25RO204** | **Duration** | **3hrs** |
| **Course Title** | **PYTHON PROGRAMMING FOR ROBOTICS** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | **LUO** | **RBT Level** | **Related CO** |
| **PART – A (10 X 2 = 20 MARKS)** | | | | |
| 1. | Identify the escape sequence used for a new line. | 1b | R | 1 |
| 2. | List any two data types in Python. | 1a | U | 1 |
| 3. | Name the function that reads one line from a text file. | 2c | R | 2 |
| 4. | Define encryption and decryption. | 2b | R | 2 |
| 5. | **Name** the method that removes unwanted spaces from both ends of a string. | 3c | R | 3 |
| 6. | List the functions used to remove elements from a list. | 3b | U | 3 |
| 7. | **Identify** the keyword used to inherit properties from another class. | 4a | R | 4 |
| 8. | **Name** the GUI library commonly used in Python. | 4e | R | 4 |
| 9. | **Identify** the file extension used for Micro Python programs. | 5a | R | 5 |
| 10. | **List** the hardware boards supported by Micro Python. | 5b | U | 5 |
| **PART – B (5 X 6 = 30 MARKS)** | | | | |
| 11. | Determine the largest of three numbers using nested if statements. | 1e | A | 1 |
| 12. | **Develop** a Python script to read a text file and write only unique lines to another file. | 2c | An | 2 |
| 13. | A teacher maintains a list of students’ marks in python for a class test. Each student’s mark is stored in a list named  marks = [78, 92, 65, 89, 55, 73, 99]. Grades are assigned as follows:  A → 90 and above  B → 80–89  C → 70–79  D → 60–69  F → below 60  Calculate the average mark of the class and display each student’s grade based on the given criteria using python scripts. | 3b | A | 3 |
| 14. | **Develop** a simple calculator GUI using buttons, labels, and text boxes. | 4e | An | 4 |
| 15. | An autonomous robot is equipped with an **HC-SR04 ultrasonic sensor** connected to a **Micro Python development board (ESP32).** The sensor sends ultrasonic waves to detect nearby objects and measures the **echo time** to calculate the distance. The **speed of sound** in air is taken as **343 m/s.**  **Determine** the distance of the object from the sensor by writing a Micro Python program that:   * Triggers the ultrasonic pulse, * Captures the echo time using GPIO pins, and * Calculates and displays the distance in **centimeters** on the serial monitor. | 5b | A | 5 |
| **PART – C (5 X 10 = 50 MARKS)** | | | | |
| 16 | A company maintains details of its employees such as **name, years of experience,** and **basic salary.** The HR department decides to provide bonuses based on experience as follows:   * Experience **> 10 years → 20% bonus** * Experience **5–10 years → 10% bonus** * Experience **< 5 years → 5% bonus**   The **total salary** is the sum of the **basic salary** and the **bonus.**  **Develop a Python script** that reads employee details using **nested loops** and **conditional statements**, calculate the **bonus** and **total salary** for each employee, and displays the results in a **tabular format.** | 1f | An | 1 |
| **(OR)** | | | | |
| 17 | A store manager needs to calculate the total bill for multiple customers. Each customer buys a set of items, and prices are entered one by one until the manager enters “0” to stop. Compute the total bill amount for each customer using a while loop and display the grand total at the end. | 1e | A | 1 |
|  | | | | |
| 18 | A security company wants to protect confidential messages exchanged between two devices. They decide to implement a simple encryption and decryption system using Python, where each character in the message is converted to a new character based on its **ASCII value with a shift value of 3. Solve** the problem by writing a Python program that:   * Accepts a message from the user, * Converts each character into its encrypted form using ASCII value manipulation, * Decrypts the message back to its original form, and * Displays both the encrypted and decrypted text on the screen. | 2b | An | 2 |
| **(OR)** | | | | |
| 19 | **Develop** a Python program that copies data from one file to another while removing duplicate lines. | 2c | An | 2 |
|  | | | | |
| 20 | A data analytics team collects a list of integer values representing **daily sales transactions** made by a retail store. The manager wants to analyze only the **even-numbered sales values,** which indicate transactions made through a special discount program.  **Determine** the sum of all even numbers stored in the list using **both** of the following approaches:   1. A **traditional loop** (using **for** and **if** statements). 2. A **list comprehension** technique for compact code. | 3b | A | 3 |
| **(OR)** | | | | |
| 21 | An e-commerce company stores product details in tuples as (product name, price, quantity). The manager wants to identify high-value products using python scripts.  **Sample Data:**  products = [  ("Laptop", 55000, 3),  ("Mouse", 500, 10),  ("Keyboard", 1500, 7),  ("Monitor", 12000, 5)  ]  Infer the data and display all products whose total value (price × quantity) exceeds ₹10. | 3e | An | 3 |
|  | | | | |
| 22 | **Interpret** the characteristics of GUI widgets by designing a window with buttons, labels, and entry boxes using Tkinter. | 4e | U | 4 |
| **(OR)** | | | | |
| 23 | **Develop** a Python program with classes and objects to simulate a mini library system that allows book issue and return operations. | 4c | An | 4 |
| **Compulsory Question:** | | | | |
| 24 | Develop a **Micro Python program** that monitors **temperature and humidity** in a laboratory using a **DHT11 sensor** and an **OLED display**. The system should continuously read sensor values and display them on the OLED screen. If the **temperature exceeds 30°C,** show a **“High Temperature Alert”** message. | 5e | An | 5 |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| --- | --- | --- | --- |
| **Course Code** | **25RO501** | **Duration** | **3hrs** |
| **Course Title** | **ROBOTIC SYSTEM DESIGN AND CONTROL** | **Max. Marks** | **100** |

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| --- | --- | --- | --- | --- | --- |
| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (5 X 16 = 80 MARKS)**  **(Answer any five from the following)** | | | | | |
| 1. | a. | Categorize robotic manipulators based on their physical configurations and work volume highlighting **how each configuration is suited for specific industrial tasks** such as welding, assembly, packaging or precision inspection. | CO1 | A | 8 |
|  | b. | Compare hydraulic, pneumatic and electric actuators and discuss their suitability for **heavy-load lifting robots, lightweight collaborative arms, and high-speed assembly robots.** | CO1 | An | 8 |
|  |  |  |  |  |  |
| 2. | a. | A point P (2,3,5) mounted on a tool rotates 30° about x axis and then translates (2,3,4). Determine its position in the base frame and justify why such coordinate transformations are critical in **robotic palletizing and autonomous tool-change systems.** | CO2 | A | 8 |
|  | b. | A 2-link arm with link lengths L1 = 10 in, L2 = 12 in is at θ1 = 90°, θ2 = 30°. Compute the Cartesian coordinates of its end-effector. | CO2 | A | 8 |
|  |  |  |  |  |  |
| 3. | a. | Derive the **Jacobian** relating joint velocities and end-effector velocities for a 2-link planar arm. | CO3 | A | 8 |
|  | b. | Compare BoundaryandInterior singularities and discuss their impact on end-effector dexterity. | CO3 | An | 8 |
|  |  |  |  |  |  |
| 4. |  | Using Lagrange’s formulation, derive the dynamic equations for a 2-DOF robot and relate to torque computation in **force-controlled robotic applications** | CO4 | A | 16 |
|  |  |  |  |  |  |
| 5. | a. | Evaluate the performance of **P, PD, and PID controllers** in joint-space control of a robotic manipulator operating with varying payload masses. | CO5 | E | 8 |
|  | b. | Differentiate task-space control and joint-space control for an industrial welding robot required to follow a complex weld seam | CO5 | An | 8 |
|  |  |  |  |  |  |
| 6. |  | Derive the DH parameter table and hence derive the Arm Equation of a 2 axis articulated robotic arm shown in fig. | CO2 | A | 16 |
|  |  |  |  |  |  |
| 7. | a. | Derive the Newtonian force–acceleration relation for a cart–spring system and explain how similar concepts apply to **robot joint vibration isolation systems**. | CO4 | A | 16 |
|  | b. | Indicate the role of Resolved Motion Rate Control in ensuring smooth, coordinated motion in **surgical robotic arms.** |  |  |  |
| **PART – B (1 X 20 = 20 MARKS) [Compulsory Question]** | | | | | |
| 8. | a. | Compare joint-space and normalized joint-space representations and explain their application in **humanoid robot limb coordination.** | CO6 | An | 5 |
|  | b. | A joint moves 20° to 80° in 5 s, stops and then moves from 80° to 25° in 5 s Determine cubic trajectory coefficients for both intervals. | CO6 | A | 15 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

|  |  |
| --- | --- |
|  | **COURSE OUTCOMES** |
| CO1 | Evaluate the performance of robotic structures and components in terms of their integration within automation systems. |
| CO2 | Interpret forward and inverse kinematic models of robot configurations in both joint and Cartesian spaces. |
| CO3 | Evaluate robotic motion characteristics using Jacobians for conditions leading to singularities. |
| CO4 | Evaluate the performance of dynamic models for robotic manipulators. |
| CO5 | Design joint-space and task-space control schemes using PID and model-based methods. |
| CO6 | Implement motion planning algorithms for robotic tasks using modern simulation tools |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| **Course Code** | **25RO502** | **Duration** | **3hrs** |
| **Course Title** | **INDUSTRIAL AUTOMATION** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (5 X 16 = 80 MARKS)**  **(Answer any five from the following)** | | | | | |
| 1. | a. | Discuss the different levels of automation and explain their applications in modern manufacturing industries | CO1 | U | 8 |
|  | b. | Explain the key technologies that enable Industry 4.0, and describe their applications in industrial automation with suitable examples | CO1 | U | 8 |
|  |  |  |  |  |  |
| 2. | a. | Explain different programming methods used to program the PLC with suitable example. | CO2 | A | 8 |
|  | b. | Write the step-by-step procedure to interface PLC with PC. | CO2 | A | 8 |
|  |  |  |  |  |  |
| 3. | a. | Explain the types of Timers used in PLC programming with suitable example | CO3 | U | 8 |
|  | b. | Write the need for Human-Machine Interfaces (HMIs) in manufacturing industries and explain their types. | CO3 | U | 8 |
|  |  |  |  |  |  |
| 4. | a. | Three way Traffic Light Control using PLC  There is a traffic signal with three directions, as shown in the figure. Each direction has three lamp outputs — Green, Red, and Yellow. Write a suitable PLC program to control the lamps for all three directions. | CO3 | An | 8 |
|  | b. | Develop a PLC program to perform the following function: A tank is equipped with a level sensor. Based on the measured level, calculate the volume of the tank using an appropriate math function  𝑉𝑜𝑙𝑢𝑚𝑒=𝜋×𝑟𝑎𝑑𝑖𝑢𝑠2×𝐿𝑒𝑣𝑒𝑙 | CO3 | An | 8 |
|  |  |  |  |  |  |
| 5. | a. | Explain the features, advantages, and typical applications of Profibus protocol. | CO4 | U | 8 |
|  | b. | Explain the features, advantages, and typical applications of MODBUS protocol. | CO4 | U | 8 |
|  |  |  |  |  |  |
| 6. | a. | Explain the step-by-step procedure to interface PLC and SCADA systems | CO5 | U | 8 |
|  | b. | Describe the different generations of SCADA architecture with suitable diagrams, highlighting the advantages and limitations of each | CO5 | U | 8 |
|  |  |  |  |  |  |
| 7. | a. | Explain the role of PC based Controller in SCADA system | CO5 | U | 8 |
|  | b. | Explain the architecture of Local Control Unit with relevant diagram | CO6 | U | 8 |
| **PART – B (1 X 20 = 20 MARKS) [Compulsory Question]** | | | | | |
| 8. |  | Explain the use of low level and high-level operator interface in Distributed Control System. | CO6 | U | 20 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

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|  | **COURSE OUTCOMES** |
| CO1 | Evaluate various automation technologies used in manufacturing and process industries. |
| CO2 | Develop automation programs using structured programming techniques for industrial control systems. |
| CO3 | Design Human-Machine Interfaces (HMIs) tailored to industrial automation requirements for monitoring and control. |
| CO4 | Assess the suitability of different industrial communication protocols for process automation applications. |
| CO5 | Implement Supervisory Control and Data Acquisition (SCADA) systems for complex industrial processes. |
| CO6 | Formulate distributed control strategies using DCS architecture for process industry automation. |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| --- | --- | --- | --- |
| **Course Code** | **25RO503** | **Duration** | **3 hrs** |
| **Course Title** | **INDUSTRIAL INTERNET OF THINGS AND ITS APPLICATIONS** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (5 X 16 = 80 MARKS)**  **(Answer any five from the following)** | | | | | |
| 1. |  | **Define** Industrial Internet of Things (IIoT). I**ndicate** the role of the functional blocks in IIoT architecture with a neat block diagram. **Describe** the function of its major components in the industrial applications. Also, Describe the concept of Hype Cycle with a neat diagram. | CO1 | U | 16 |
|  |  |  |  |  |  |
| 2. |  | **Explain the function of the major components of the Internet of Things (IoT).** Illustrate and describe the **different architectures of IoT** with the help of **neat block diagrams,** highlighting the **functions of each layer** and their significance in enabling IoT-based robotic and industrial applications. | CO2 | U | 16 |
|  |  |  |  |  |  |
| 3. |  | Compare and contrast the hardwiring of sensors using different communication protocols such as MODBUS, HART and Ethernet, based on their key characteristics. | CO3 | An | 16 |
|  |  |  |  |  |  |
| 4. |  | **Explain the need for communication protocols in the Industrial Internet of Things (IIoT).** Discuss in detail the **different IIoT communication protocols** used for data exchange between devices, highlighting their **working principles and key features with suitable examples.** | CO4 | A | 16 |
|  |  |  |  |  |  |
| 5. |  | Analyze the critical vulnerabilities in IoT systems with respect to data confidentiality, device authentication, and communication security. Apply suitable mitigation techniques and illustrate their effectiveness with examples from industrial or robotic IoT applications. | CO5 | An | 16 |
|  |  |  |  |  |  |
| 6. |  | Examine the emerging trends in the Industrial Internet of Things (IIoT) in areas such as intelligent automation, digital twins and data analytics. Apply this knowledge to evaluate the major advantages and challenges associated with integrating IIoT technologies in industrial and robotic applications. | CO1 | A | 16 |
|  |  |  |  |  |  |
| 7. |  | **Explain the working of a transducer system with a neat block diagram.** Classify the various types of transducers based on their **principle of transduction,** giving suitable examples. Further, **explain the architecture of sensors** and describe the **special requirements of sensors used in the Industrial Internet of Things (IIoT).** Finally, **discuss the role of sensors in IIoT applications.** | CO3 | A | 16 |
|  | | | | | |
| **PART – B (1 X 20 = 20 MARKS) [Compulsory Question]** | | | | | |
| 8. | a. | Examine the role of analytics in the Internet of Things (IoT) and evaluate how analytical techniques contribute to enhancing system efficiency, decision-making, and overall performance in intelligent industrial or robotic networks. | CO6 | A | 10 |
|  | b. | Analyze various data visualization techniques employed in IoT analytics and illustrate how effective visualization supports data interpretation, anomaly detection and real-time system monitoring. | CO6 | An | 10 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

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|  | **COURSE OUTCOMES** |
| CO1 | Evaluate the performance of IoT systems and their core architectural layers and functions. |
| CO2 | Evaluate IIoT architectures in terms of performance and scalability. |
| CO3 | Assess sensor technologies and interface mechanisms for industrial applications. |
| CO4 | Evaluate protocol stacks and cloud integration strategies for IIoT systems. |
| CO5 | Assess the role of web security in IIoT and evaluate strategies to enhance cybersecurity. |
| CO6 | Create a basic IIoT application with cloud connectivity and sensor integration. |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| --- | --- | --- | --- |
| **Course Code** | **25RO601** | **Duration** | **3hrs** |
| **Course Title** | **AUTONOMOUS MOBILE ROBOTS USING ROS** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (5 X 16 = 80 MARKS)**  **(Answer any five from the following)** | | | | | |
| 1. | a. | Apply the concepts of robotic locomotion to illustrate how different locomotion types enable mobility in various mobile robot designs. | CO1 | A | 8 |
|  | b. | Write the different types of mobile robots used in modern applications such as logistics, inspection, rescue, and surveillance. | CO1 | R | 8 |
|  |  |  |  |  |  |
| 2. | a. | Describe the degree of maneuverability in different types of mobile robots with examples. | CO2 | A | 8 |
|  | b. | Explain the significance of Kinematic Model in representing the robot position with appropriate equations. | CO2 | U | 8 |
|  |  |  |  |  |  |
| 3. |  | Analyze and compare the kinematic behavior of differential drive, skid-steering, and omnidirectional mobile robots in terms of velocity, pose estimation, and maneuverability. | CO3 | An | 16 |
|  |  |  |  |  |  |
| 4. | a. | Explain the working principle of optical encoder and mention how the resolution can be improved in the encoder. | CO4 | R | 8 |
|  | b. | Design an actuation mechanism of mobile robot that operate at speed of 25 rps if a stepper motor with step angle of 2.5 degree is used for actuation. Determine the stepping frequency of stepper motor. | CO4 | U | 8 |
|  |  |  |  |  |  |
| 5. | a. | Compare sector and topological mapping techniques with relevant examples. | CO4 | A | 8 |
|  | b. | Analyze the effect of temperature variation on a Wheatstone bridge when using sensors like thermistors or pressure sensors and discuss how temperature compensation can be implemented. | CO5 | An | 8 |
|  |  |  |  |  |  |
| 6. |  | Explain how visibility graphs & Voronoi diagrams are applied in roadmap approaches for path planning, and analyse their significance in optimizing pathfinding. | CO4 | U | 16 |
|  |  |  |  |  |  |
| 7. | a. | Describe the role of the cost function g(n) in A\* algorithm and explain how it influences the node selection process | CO5 | R | 8 |
|  | b. | Summarize the challenges involved in mobile robot localization for specific applications. | CO5 | U | 8 |
| **PART – B (1 X 20 = 20 MARKS) [Compulsory Question]** | | | | | |
| 8. | a. | Explain the purpose of a ROS launch file in managing multiple nodes and parameters. | CO6 | U | 10 |
|  | b. | Using RViz, describe how you would debug a situation where a robot’s laser scan is not visible even though the robot is moving in Gazebo. | CO6 | R | 10 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

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|  | **COURSE OUTCOMES** |
| CO1 | Evaluate robot locomotion and mobility models for wheeled and differential drive robots. |
| CO2 | Build sensor models and implement localization algorithms. |
| CO3 | Develop ROS-based navigation stacks with global and local path planners. |
| CO4 | Implement SLAM techniques (GMapping, Cartographer) using ROS frameworks. |
| CO5 | Simulate mobile robot tasks and missions using Gazebo and RViz. |
| CO6 | Create integrated autonomous robot applications with perception, control, and navigation layers. |

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**END SEMESTER EXAMINATION – NOV / DEC 2025**

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| --- | --- | --- | --- |
| **Course Code** | **25RO602** | **Duration** | **3hrs** |
| **Course Title** | **ADVANCED MACHINE LEARNING** | **Max. Marks** | **100** |

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| **Q. No.** | **Questions** | | **CO** | **BL** | **M** |
| **PART – A (5 X 16 = 80 MARKS)**  **(Answer any five from the following)** | | | | | |
| 1. | a. | Given the dataset consisting of two correlated features: **X₁ and X₂.** Perform Principal Component Analysis (PCA) on the given dataset using the following steps: Compute the covariance matrix of the centered data. Determine the eigenvalues and eigenvectors of the covariance matrix. Identify the first principal component and compute the percentage of total variance it explains. Interpret the significance of the first principal component in terms of the relationship between the two features.   | **Observation** | **X₁** | **X₂** | | --- | --- | --- | | O₁ | 2 | 1 | | O₂ | 3 | 5 | | O₃ | 4 | 3 | | O₄ | 5 | 6 | | O₅ | 6 | 7 | | O₆ | 7 | 8 | | CO1 | A | 10 |
|  | b. | Describe the different types of machine learning (supervised, unsupervised, reinforcement learning) and provide one real-world example of each. | CO1 | U | 6 |
|  |  |  |  |  |  |
| 2. | a. | The performance of an athlete depends on the number of hours spent in training. Given the data for training time (in hours) and performance score (out of 1000), find the relationship between training time and performance using **linear regression**. Also, predict the performance score for an athlete who trained for **42 hours**.   | **S.No.** | **Training**  **Time (hours)** | **Performance**  **Score** | | --- | --- | --- | | 1 | 20 | 410 | | 2 | 35 | 690 | | 3 | 25 | 520 | | 4 | 40 | 800 | | 5 | 30 | 600 | | 6 | 15 | 350 | | CO2 | A | 8 |
|  | b. | Derive the cost (loss) function used in logistic regression from the maximum likelihood estimation (MLE) principle. Explain why the mean squared error (MSE) is not suitable for logistic regression. | CO2 | An | 8 |
|  |  |  |  |  |  |
| 3. |  | Given the training data for predicting whether tennis can be played, apply the decision tree method to determine the root attribute. Also, calculate the information gain for the attributes: Outlook {Sunny, Overcast, Rain}, Temperature {Hot, Mild, Cool}, Humidity {High, Normal}, and Wind {Weak, Strong}.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Day | Outlook | Temperature | Humidity | Wind | Play Tennis | | 1 | Sunny | Hot | High | Weak | No | | 2 | Sunny | Hot | High | Strong | No | | 3 | Overcast | Hot | High | Weak | Yes | | 4 | Rain | Mild | High | Weak | Yes | | 5 | Rain | Cool | Normal | Weak | Yes | | 6 | Rain | Cool | Normal | Strong | No | | 7 | Overcast | Cool | Normal | Strong | Yes | | 8 | Sunny | Mild | High | Weak | No | | 9 | Sunny | Cool | Normal | Weak | Yes | | 10 | Rain | Mild | Normal | Weak | Yes | | 11 | Sunny | Mild | Normal | Strong | Yes | | 12 | Overcast | Mild | High | Strong | Yes | | 13 | Overcast | Hot | Normal | Weak | Yes | | 14 | Rain | Mild | High | Strong | No | | CO3 | A | 16 |
|  |  |  |  |  |  |
| 4. |  | Apply the K-means clustering algorithm using Euclidean distance to categorize the following 8 data points into 3 clusters:  **A1 = (4,11), A2 = (2,5), A3 = (8,6), A4 = (6,8),**  **A5 = (3,12), A6 = (6,11), A7 = (11,2), A8 = (7,9).**  Given the initial cluster centers as A1, A4 and A7, execute the K-means clustering algorithm for 2 epochs. At the conclusion of these epochs, provide the following:  a. Determine the new clusters, detailing the specific data points assigned to each cluster after the first and second epochs.  b. Calculate the new centers of each cluster after both epochs, and evaluate how well these centers represent the assigned data points. | CO4 | A | 16 |
|  |  |  |  |  |  |
| 5. | a. | Explain the concept of Association Rule Mining (ARM) and its applications in Market Basket Analysis and Recommendation Engines. Given the following transactions from a supermarket:   | **Transaction ID** | **Items Purchased** | | --- | --- | | T1 | Bread, Milk, Butter | | T2 | Bread, Egg, Butter | | T3 | Milk, Bread | | T4 | Bread, Milk, Egg | | T5 | Milk, Butter |   (a)Identify two possible association rules. (b) Discuss how such rules can be applied to improve product placement and recommendation strategies. | CO5 | U | 8 |
|  | b. | Apply the Apriori algorithm to the transaction dataset given below to identify the frequent item sets and generate the association rules. Assume minimum support = 40% and minimum confidence = 60%.   | **Transaction ID** | **Items Purchased** | | --- | --- | | T1 | Milk, Bread, Butter | | T2 | Bread, Butter | | T3 | Milk, Bread | | T4 | Bread, Butter, Eggs | | T5 | Milk, Bread, Butter |   Show each stage of candidate and frequent itemset generation (C1, L1, C2, L2, etc.), compute support and confidence values, and derive the final strong association rules. | CO5 | A | 8 |
|  |  |  |  |  |  |
|  |  | Explain the concept of Maximum Margin Classification in Support Vector Machines (SVM). Derive the Hard Margin SVM Optimization Problem with appropriate mathematical formulation, and analyze the role and significance of Support Vectors in defining the optimal decision boundary. | CO3 | A | 12 |
|  | b. | Explain the kernel trick in SVM. Provide examples of common kernels and explain how they help in non-linear classification. | CO3 | U | 4 |
|  |  |  |  |  |  |
| 7. | a. | The multivariate Iris flower data collection contains the morphological differences of Iris flowers from three closely related species, namely **Setoflora**, **Florica**, and **Versiflor**. Each flower sample consists of four features: **sepal length**, **sepal width**, **petal length**, and **petal width**. The dataset given below contains measurements of eight flower samples belonging to these three species. Using this dataset, apply the **K-Nearest Neighbor (KNN)** classification algorithm with **K = 3** to categorize the species of a new flower having **sepal length = 5.2 cm**, **sepal width = 3.4 cm**, **petal length = 1.5 cm**, and **petal width = 0.1 cm**. Compute the Euclidean distance between the new flower and all training samples, identify the three nearest neighbors, and determine the most probable species to which the flower belongs. Finally, justify your classification result.   | **Sepal Length (cm)** | **Sepal Width (cm)** | **Petal Length (cm)** | **Petal Width (cm)** | **Species** | | --- | --- | --- | --- | --- | | 5.1 | 3.5 | 1.4 | 0.2 | Setoflora | | 4.9 | 3.0 | 1.4 | 0.2 | Setoflora | | 6.5 | 3.0 | 5.2 | 2.0 | Florica | | 5.9 | 3.2 | 4.8 | 1.8 | Versiflor | | 5.0 | 3.6 | 1.4 | 0.2 | Setoflora | | 6.7 | 3.1 | 4.4 | 1.4 | Versiflor | | 6.3 | 2.9 | 5.6 | 1.8 | Florica | | 6.4 | 3.4 | 3.3 | 0.4 | Versiflor | | CO3 | A | 10 |
|  | b. | Compare the bagging and the boosting method | CO4 | U | 6 |
| **PART – B (1 X 20 = 20 MARKS) [Compulsory Question]** | | | | | |
| 8. | a. | Illustrate the working of a Convolutional Neural Network (CNN) with an example of convolution, pooling, and classification stages. | CO6 | An | 10 |
|  | b. | Compare single-layer and multilayer perceptron’s. Explain why multilayer perceptron’s are more powerful in modeling complex data. | CO6 | U | 10 |

**CO** – COURSE OUTCOME **BL** – BLOOM’S LEVEL **M** – MARKS ALLOTTED

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|  | **COURSE OUTCOMES** |
| CO1 | Use machine learning principles for data driven decision making |
| CO2 | Develop optimized machine learning models to address domain specific industrial challenges |
| CO3 | Evaluate the effectiveness of the clustering algorithm for high dimensional industrial problems |
| CO4 | Assess machine learning paradigms for solving automative and predictive analytics problems |
| CO5 | Interpret association rule mining results to drive actionable insights in market basket analysis |
| CO6 | Evaluate deep learning models such as CNNs, RNNs in real world applications |