NESA NATIONAL EXAMINATION AND SCHOOL INSPECTION AUTHORITY

SPE - Intelligent Robotics and Embedded Systems

T2-147

Wednesday, 16 July 2025
8:30 AM to 11:30 AM

Names:.....

Index number:.....

TSS NATIONAL EXAMINATIONS, LEVEL 5, 2024-2025

QUESTIONS and ANSWERS BOOKLET

TRADE (s) : SOFTWARE PROGRAMMING AND EMBEDDED SYSTEMS (SPE)

SUBJECT: INTELLIGENT ROBOTICS AND EMBEDDED SYSTEMS

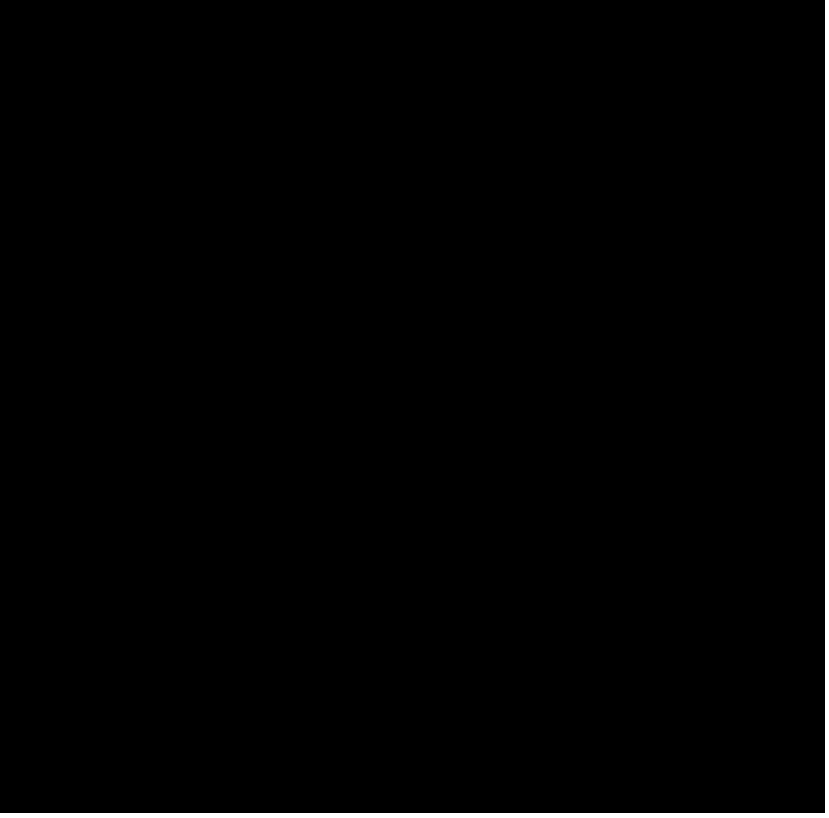
DURATION: 3 Hours

Read carefully the instructions on page 3

TOTAL MARKS...../100

FOR EXAMINER'S USE ONLY

QUESTIONS	1	2	3	4	5	6	7	8	9	10	Total
Marks											
QUESTIONS	11	12	13	14	15	16	17	18	19	20	Total
Marks											
QUESTIONS	21	22	23	24	25	26	27	28	29	30	Total
Marks											



T2-147_Intelligent Robotics and Embedded Systems

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INSTRUCTIONS TO CANDIDATES:

1. This Exam paper is composed of **three sections (A, B and C).** Follow the instructions given below and answer the indicated questions for a total of **100 marks.**

   Section **A:** Fourteen (14) questions which are **Compulsory** **55 marks**

   Section **B:** Among the five (5) questions, attempt any three (3) **30 marks**

   Section **C:** Among the two (2) questions, attempt anyone (1) **15 marks**

2. Fill in your actual **names** and **Index number** on the provided space (Cover).
3. Do not remove or tear any page or part of this Questions and Answers Booklet.
4. Answer in the language in which the Examination is set.
5. In section **A**, answer questions in the provided space. In case of multiple-choice questions, just **circle** the letter corresponding to the correct option.
6. In section **B** and **C**, answer questions in the provided space after section C questions.
7. **Allowed materials:**
   - Blue or Black pen.
   - Geometrical Instruments
   - Silent non-programmable calculators

SECTION A: Attempt all questions **(55 marks)**

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01. Alex, a junior robotics engineer at Smart Solutions Ltd, has been assigned to help design the hardware for an embedded system that will monitor temperature and humidity in a smart greenhouse. His first task is to select the appropriate passive electronic components and understand basic circuit principles. **(3 marks)**

Circle the correct answer to the questions below based on this scenario.

a) Which of the following is considered a passive electronic component?

i) Microcontroller
ii) Resistor
iii) LED
iv) Relay

b) In circuit theory, which law states that the total voltage around a closed loop is equal to zero?

i) Ohm's Law
ii) Kirchhoff's Voltage Law
iii) Kirchhoff's Current Law
iv) Faraday's Law

c) Which signal type is characterized by a constant voltage or current over time?

i) AC Signal
ii) DC Signal
iii) Pulsed Signal
iv) Triangular Signal

02. An electronics technician is working on the hardware design of an embedded system. She needs to select and use appropriate active electronic components such as semiconductors, ICs, and basic digital logic devices to control and manage different subsystems efficiently. **(4 marks)**

Circle the correct answer to the questions below based on this scenario.

a) Which of the following is a three-terminal semiconductor device?

i) Diode
ii) LED
iii) Transistor
iv) Solar Cell

b) Which IC is commonly used as a monitor driver in embedded systems?

i) LM741
ii) MCP 3002
iii) NE555
iv) L293D

c) What type of signal conversion is performed by an ADC (Analog-to-Digital Converter)?

i) Digital to Analog
ii) Analog to Digital
iii) Binary to Hexadecimal
iv) Analog to Binary

d) Which of the following is NOT typically classified as a logic gate?

i) AND gate
ii) OR gate
iii) Flip-Flop
iv) NOT gate

03. TechInvent Robotics is developing a new embedded device that integrates sensors, actuators, and communication modules with a microcontroller. During the system integration phase, engineers must review their knowledge of microcontroller peripherals, communication protocols, and basic interfacing principles. **(5 marks)**

State whether the following statements are ***True(T)*** or ***False(F)*** based on the scenario.

a) A microcontroller can communicate with external sensors using UART, SPI, or I2C protocols.....

b) A temperature sensor is classified as an actuator.....

c) Pull-up resistors are sometimes used when connecting switches or input devices to microcontroller pines.....

d) Wi-Fi and Bluetooth modules are examples of communication peripherals that can be connected to a microcontroller.....

e) In a Data Flow Diagram (DFD), data flow labels are used to describe how data moves between entities and processes.....

04. You are collaborating with the firmware team at RoboNet Solutions to Implement network communication for a fleet of autonomous delivery robots. To design a robust communication system, you must understand key networking concepts and protocols. **(5 marks)**

Match each network concept in Column A with its correct description from Column B.

Column A	***Column B***	***Answer***
i) TCP	a) A network topology in which each node relays data for the network, providing redundant paths and self-healing capabilities.	a = ….
ii) UDP	b) A connection-Oriented protocol that ensures reliable, ordered delivery of data between endpoints.	b = ….
iii) WebSockcet	c) A connectionless protocol that sends messages called datagrams, with minimal overhead and no delivery guarantees.	c = ….
iv) Mesh Networking	d) An error-control mechanism that uses acknowledgments and retransmissions to ensure data integrity.	d = ….
v) ARQ	e) A protocol providing persistent, full-duplex communication channels over a single TCP connection.	e = ….

05. TechVision Inc. collects raw sensor logs from its fleet of autonomous robots. Before using this data for analysis or machine learning, the data science team must perform preprocessing steps. Based on this scenario, **(4 marks)**

Circle the correct answer for each of the following sub-questions

a) Which of the following is a typical data cleaning operation?
   i) Removing duplicate records
   ii) Principal component analysis
   iii) Train-test split
   iv) Hyper parameter tuning

b) Which technique is used to convert categorical variables into numeric features?
   i) One-hot encoding
   ii) Normalization
   iii) Imputation
   iv) Clustering

c) Which statistic describes the central tendency of a dataset?

i) Standard deviation
ii) Median
iii) Correlation coefficient
iv) p-value

d) Which plot is most appropriate for visualizing the distribution of a single continuous variable?

i) Histogram
ii) Box plot
iii) Scatter plot
iv) Line chart

06. In Robotic Systems Development LTD, You're preparing to deploy a robotic system that will communicate with sensors and actuators using the Robot Operating System (ROS). The programming team needs to follow certain steps to ensure the system's functionality and communication. Complete the following statements based on this scenario: **(3 marks)**

a) The process of breaking down a complex task into smaller, manageable tasks for easier programming is called
.....

b) To ensure the robot's software works seamlessly with hardware, including sensors and actuators, a key step is
.....

c) The communication mechanism in ROS that allows nodes to exchanges data asynchronously is known as
.....

07. ITRobotics is designing an embedded system for a sensor-based automated irrigation system. To ensure the system functions efficiently, the team must utilize passive electronic components for signal processing and power regulation.Read each item carefully and circle the option that best explains or describe the concept. **(5 marks)**

a) What best describes a passive electronic component?

i) A component that requires an external power source to function.
ii) A component that generates energy for the system
iii) A component that does not generate energy, but may dissipate or store energy
iv) A component used for logic processing in embedded systems.

b) Which of the following is a characteristic of a DC signal?

i) It alternates between positive and negative cycles
ii) It remains constant over time
iii) It has a frequency that varies based on input
iv) It only exists as a sinusoidal wave form

c) What is the role of resistors in an embedded system?

i) To store energy for future use
ii) To control the flow of electrical current
iii) To amplify signals in the system
iv) To convert mechanical energy to electrical energy

d) Capacitors are used for which application in embedded systems?

i) To filter and smooth out AC signals
ii) To amplify power signals
iii) To convert analog signals to digital
iv) To regulate temperature in sensors

e) Which type of transducer is best for measuring temperature changes in an embedded system?

i) Actuators
ii) Capacitors
iii) Sensors
iv) Resistors

08. Imagine you have joined an engineering company, "SignalSys Innovation", that specializes in designing embedded power control systems for robotics. As part of the hardware development team, you need to understand the correct operational flow of setting up a regulated DC power supply for an embedded system. **(2 marks)**

Rewrite the following stages of regulated DC power supply design in the correct order, starting from the first stage to the last.

Stages:

a) Rectification
b) Step-down transformation
c) Regulation
d) Smoothing

1 .....

2 .....

3 .....

4 .....

09. At TechBots Inc, a company that develops smart embedded systems for industrial automation, you have been assigned to assist in designing a peripheral integration plan. Your task involves understanding hardware communication, system diagrams, and initialization practices for embedded projects. **(4 marks)**

complete each statement below using appropriate term or phrase that demonstrates your understanding based on scenario.

a) In microcontroller communication, a ..... interface is typically used for high-speed serial communication between a master and one or more slave deveices.

b) .....diagrams represent the flow of data between processes, data stores, and external entities in a system.

c) To ensure sensors and actuators function properly, you must correctly configure the ..... pins on the microcontroller.

d) In embedded systems, ... resistors are often used on input lines to define the default state when no active signal is present.

10. At Embedded Tech LTD, a startup developing intelligent embedded devices, you have joined the Data Preparation and Analysis team. Your current task involves classifying key concepts related to data preprocessing and transformation processes before they can be used in machine learning models. Match each data preprocessing concept in column A by selecting the most appropriate explanation from column B. **(5 marks)**

Column A	**Column B**	**Answer**
a) Data Cleaning	i) Combining data from multiple sources into a unified dataset	a) = ...
b) Feature Engineering	ii) Graphically representing information to identify patterns and trends	b) = ...
c) Descriptive Statistics	iii) Summarizing data characteristics using measures like mean and median	c) = ...
d) Data Integration	iv) Removing noise and correcting inconsistencies in data	d) = ...
e) Data Visualization	v) Creating new input features to improve model performance	e) = ...

11. BrightTech Innovations is developing an embedded monitoring system. You have been assigned to help apply correct practices in the selection and use of active electronic components during the system's hardware development phase. Circle the best option that demonstrates the correct application of active component knowledge to each of sub-questions below. **(4 marks)**

a) When selecting a two-terminal semiconductor to allow current to flow only in one direction, which device would be appropriate?

i) Photodiode
ii) Solar Cell
iii) General Purpose Silicon Diode
iv) Field Effect Transistor (FET)

b) In designing a regulated DC power supply, which component is primarily responsible for stabilizing the output voltage?

i) Step-down transformer
ii) Voltage regulator
iii) Smoothing capacitor
iv) Rectifier diode

c) To amplify a small input voltage signal into a larger output signal while maintaining linearity, which operational amplifier configuration should you apply?

i) Comparator
ii) Voltage follower
iii) Inverting Op Amp
iv) Crystal Oscillator

d) If you need a memory element that stores one bit of data and changes state on a clock edge, which component should you use?

i) Flip-Flop
ii) Register
iii) Latch
iv) Bit manipulator

12. A robotics startup, RoboLogix, is building a secure API system using Python and FastAPI to communicate between its cloud dashboard and embedded robotic devices. As part of the API integration, the development team must follow proper practices for token handling, security headers, and cross-origin requests. Apply your understanding of Python-based integration practices to evaluate each statement below. Indicate whether each statement is ***True(T)*** *or* ***False(F)***. **(4 marks)**

a) To implement token-based authentication, you should include the token inside the URL of every API request……

b) When handling CORS issues, one way to solve them is by configuring the backend server to allow specific origins……

c) Secure user authentication can be maintained in mobile apps by storing tokens in asyncstorage or securestorage……

d) The Content-Type header in an HTTP request is used to define the access permissions of the user……

13. A robotics engineering student, Aline, is preparing to deploy her robot prototype in a university showcase. As part of the final preparation, she needs to complete system integration tasks like mounting hardware, validating communication between software and sensors, and ensuring user guidance documentation is ready. Utilize your understanding of robotic system integration to evaluate each statement below. Indicate whether it is ***True(T)*** *or* ***False(F)***. **(3 marks)**

a) Integration testing helps confirm that different hardware and software modules work independently of one another……

b) It is acceptable to skip hardware compatibility checks if the software has already passed all unit tests……

c) Assembling robotic systems should involve using appropriate tools and observing safety procedures……

14. NeuroBotics LTD, is developing an AI-powered robotic assistant that uses computer vision to interact with its environment. The team is preparing simulation environments with interactive 3D models to test movement, object recognition, and facial detection capabilities. Basing on understanding of 3D model design and AI integration circle the most appropriate option for each practical situation. **(4 marks)**

a) A designer is customizing the interface of a 3D modeling software to improve workflow efficiency. What is the designer most likely adjusting?

i) File types
ii) Modeling angle
iii) Interface layout and toolbars
iv) Texturing resolution

b) To ensure that a 3D-printed is strong and durable, what design aspect should be considered during modeling?

i) Aesthetics only
ii) Wall thickness and material
iii) Background color
iv) Metadata fields

c) Which of the following actions best demonstrates the application of metadata in managing a 3D model library?

i) Saving models with random names
ii) Tagging models with relevant project names and categories
iii) Creating new materials for modeling
iv) Exporting models without structure

d) When preparing to model an avatar for animation, what is the first technical step to take after drafting the concept?

i) Apply lighting effects
ii) Perform rigging
iii) Create mesh structure
iv) Export as a 2D file

Section B: Attempt any three (3) questions (30 marks)

15. You are given the following dataset containing information about various cars and related descriptions. Apply your understanding to answer the questions below: **(10 marks)**

Manufacturer	year	Body Type	Transmission	Fuel type	Seats	Status	Owner age
Toyota	2020	Sedan	Automatic	Gasoline	5	Used	35
Honda	2019	SUV	Manual	Gasoline	7	New	40
Ford	2021	Truck	Automatic	Diesel	2	Used	50
Tesla	2022	Sedan	Automatic	Electric	5	New	30
Chevrolet	2018	SUV	Automatic	Gasoline	7	Used	28
BMW	2001	Coupe	Automatic	Gasoline	4	New	45
Mercedes	2020	Sedan	Automatic	Diesel	5	Used	48
Hyundai	2019	Truck	Manual	Gasoline	2	Used	22
…	…	…	…	…	…	…	…
Subaru	2022	SUV	Automatic	Gasoline	7	New	34
Nissan	2000	Sedan	Automatic	Gasoline	5	Used	70
Hyundai	2022	Sedan	Automatic	Electric	5	Used	22
Kia	2020	SUV	Automatic	Gasoline	7	New	29
Volkswagen	2021	Coupe	Manual	Hybrid	4	New	31
Mazda	2022	Convertible	Automatic	Gasoline	3	Used	27
Tesla	1999	Convertible	Automatic	Diesel	3	New	44
Tesla	2022	Sedan	Automatic	Diesel	5	New	44

Assume this dataset is loaded into a DataFrame named df:

a) Write code snippet to add a new column called car_age to the DataFrame, which dynamically calculates the age of each car based on the current year. (*current year keeps changing*)

b) Write a code snippet to calculate the standard deviation of owner age for cars that were manufactured after the year 2000.

c) List the number of cars by fuel type and sort the result in descending order

d) Find the average number of seat for each body type

e) Filter and display all cars that have more than 5 seats, are automatic transmission and less than 10 years' old

16. Let us assume we have the following actual and predicted values for a classification model. (P represents *Positive outcome* where N represents *Negative outcome*) **(10 marks)**

Actual class	P	P	P	N	N	P	N	P	N	P
Predicted class	P	P	N	P	N	P	N	N	N	P

a) To evaluate the model:

i) Calculate the Accuracy.
ii) Calculate the Precision.
iii) Calculate the Recall.
iv) Calculate the F1 Score.

b) Explain the significance of setting *random_state=42* in the following code snippet

```
# Train-test split
X_train, X_test, Y_train, Y_test=train_ test_ split(x,y, test_size=0.2,random_state=42)
```

17. A robotics team is building a warehouse robot using the Robot Operating System (ROS) with Python. The robot needs to monitor temperature using a sensor and publish the data, while another node logs the readings for analysis. You are tasked with analyzing and improving the structure and communication between nodes. **(10 marks)**

a) Analyze the following ROS Python publisher node, identify two areas where improvements can be made for better code structure or functionality, and explain why.

```
#!/usr/bin/env python3
import rospy
from std_msgs.msg import Float32
rospy.init_node('temp_publisher')
pub = rospy.Publisher('/temp', Float32, queue_size=10)
while not rospy.is_shutdown():
temp=25.0 #example sensor reading
pub.publish(temp)
```

b) The subscriber node currently just prints messages, rewrite it to log each temperature reading to a file while maintaining ROS subscriber structure.

c) Analyze the ROS communication paradigm used in this system. Why is pub/sub more suitable than a service call in this sensor monitoring scenario?

d) ROS systems often require tuning. What two ROS parameters could you introduce in the temperature publisher node to make it configurable? Briefly explain their benefit.

18. You've been assigned to assess the reliability and robustness of Python scripts used in a robotics control system. Your role is to implement functionality and critically evaluate programming practices that improve code quality, reusability, and fault tolerance. **(10 marks)**

a) Write a Python function that takes a list of temperature readings and returns only those above 60^0 C. Then, justify why using a modular function here improves code maintainability and testing in embedded applications.

b) A robot logs its status to a file called robot_log.txt. Write a program that reads all numeric values from the file and calculates the average. Critically assess how using file handling enhances system feedback and decision-making.

c) Demonstrate a Python script that safely attempts to open and read a configuration file. Include try-except error handling for file-related issues. Then evaluate how exception handling contributes to the safety and resilience of mission-critical robotics applications

19. As a senior robotics integrator at TechBots Ltd, you are overseeing the final phase of integrating hardware and software components in a warehouse automation robot. Your responsibilities include validating interoperability, identifying integration ricks, and justifying your design decisions. **(10marks)**

a) After assembling and wiring the hardware modules (motors, sensors, and controller), your team must validate that the setup meets the design criteria. Describe two critical hardware-level tests you would conduct and justify their importance.

b) During software testing, your robot arm occasionally fails to respond when a specific button is pressed in the control app. Explain how you would systematically evaluate and identify whether the issue is software, hardware, or communication related.

c) The management has asked you to justify why documenting integration and test results is necessary for large-scale robotics deployment. Provide at least two key justifications backed by examples or real-world reasoning

Section C: Attempt only one (1) question **(15 marks)**

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20. At NeoSense Technologies, a company specializing in smart agriculture systems, the engineering team is developing a solution to monitor soil moisture and temperature in greenhouses. Your role as a network systems developer is to create a robust and scalable IoT communication module that will transmit real-time temperature data from edge devices to a central cloud dashboard. This system must ensure secure transmission, handle intermittent connectivity, and support growth to hundreds of devices **(15 marks)**

a) Design a basic TCP socket communication setup in Python to send simulated temperature data ("Temp: 25.5C") from the client to the server. Provide both the client and server code.

b) Create a simple RESTful API endpoint (in Python using FastAPI or Flask) that will receive temperature data in JSON format and store it into a variable or display it in the terminal.

c) Propose two key security measures that should be applied when transmitting temperature data over the network. Briefly justify each.

d) Design a retry mechanism using pseudocode or code snippet to handle temporary network disconnections while sending sensor data.

e) Imagine that the system must scale up to handle data from 500 smart devices. Describe two strategies or architectural decisions you would implement to ensure the communication remains efficient and reliable.

21. AgriBot is developing a smart robot that can autonomously monitor crop health by analyzing plant images and predicting potential diseases. As part of the AI development team, your task is to design and implement the full AI pipeline, from data preparation to deployment, using Python and relevant libraries. **(15 marks)**

a) Design a basic workflow for building an AI-powered image classifier using Python. List the key stages involved and describe each briefly.

b) Write a Python code snippet that loads and preprocesses image data using TensorFlow or PyTorch. Include resizing, normalization, and batching.

c) Create a sample neural network architecture in Python using any framework of your choice (Keras, PyTorch) that is suitable for binary classification of plant health (Healthy vs Infected).

d) Explain two techniques you would use to reduce overfitting in your AI model. Support your explanation with examples or methods you would implement.

e) Draft a brief deployment plan for integrating the trained AI model into the AgriBot robot system Mention the tools, steps, and any key considerations

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