higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)

INTRODUCTION TO ROBOTICS

(First paper)
NQF LEVEL 3

(10041053)

19 November 2024 (X-paper)
09:00–12:00

This question paper consists of 9 pages.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)
ROBOTICS FUNDAMENTALS
NQF LEVEL 3
(First paper)
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer all the questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Use only a black or blue pen.
5. Write neatly and legibly.

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SECTION A

QUESTION 1

Various options are given as possible answers to the following questions. Choose the correct answer and write only the letter (A–D) next to the question number (1.1–1.10) in the ANSWER BOOK.

1.1 Which of the following best describes the nature of robotics as a discipline?

A Robotics is purely a mechanical engineering field.
B Robotics is an interdisciplinary field combining elements of controls, kinematics, mechatronics, and more.
C Robotics is solely focused on programming and software development.
D Robotics primarily deals with traditional manufacturing techniques without integrating other fields.

1.2 What is the primary purpose of slicing in the 3D printing software pipeline?

A To orient and position the model on the print bed.
B To generate support structures for overhanging parts.
C To divide the 3D model into horizontal layers for printing.
D To plan the movement path of the print head.

1.3 What is the purpose of a voltage regulator in a robotics power system?

A To increase the voltage to a desired level.
B To convert direct current (DC) to alternating current (AC).
C To maintain a constant voltage level despite variations in input voltage.
D To divide the input voltage into two or more outputs.

1.4 In the context of mobile robotics, which component is primarily responsible for interaction with the environment?

A Controllers
B Processors
C Actuators
D End effectors

1.5 Which file type is most used for 3D printing, and what does it contain?

A OBJ file, which contains colour information and textures.
B STL file, which contains information about the 3D geometry of the object.
C OBJ file, which contains high-resolution images of the model.
D STL file, which contains 2D vector graphics.

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1.6 What is the main difference between components connected in series versus parallel?

A Components in series have the same voltage across them, while components in parallel have the same current through them.
B Components in series share the same current, while components in parallel share the same voltage.
C Components in series have different voltages and currents, while components in parallel have the same voltages and different currents.
D Components in series have different currents, while components in parallel have different voltages.

1.7 What is a key difference between a microcontroller and a single-board computer?

A A microcontroller typically has more computational power than a single-board computer.
B A single-board computer is always used for industrial applications, whereas a microcontroller is not.
C A microcontroller is designed for dedicated tasks, while a single-board computer is more general-purpose.
D A microcontroller has built-in wireless capabilities, whereas a single-board computer does not.

1.8 Which of the following is a suitable programming language for microcontroller programming

A HTML
B Python
C SQL
D CSS

1.9 What is the purpose of serial communication in microcontroller programming?

A To send and receive data between the microcontroller and a computer or other devices.
B To provide power to the microcontroller.
C To store data permanently on the microcontroller.
D To connect multiple microcontrollers together in a network.

1.10 Which of the following criteria is least likely to be considered when selecting a microcontroller for a robotics project?

A Processing speed
B Memory size
C Manufacturer's market share
D Power consumption

(10 × 1) **[10]**

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QUESTION 2

Indicate whether the following statements are TRUE or FALSE by writing 'True' or 'False' next to the question number (2.1–2.5) in the ANSWER BOOK. Give ONE reason for each answer.

2.1 The use of libraries in microcontroller programming is unnecessary for simple projects.

2.2 An inverter is a device that converts alternating current (AC) to direct current (DC).

2.3 FDM is a type of 3D printing technology that uses light to cure resin.

2.4 Robots used in general manufacturing are typically designed for specific tasks and lack flexibility.

2.5 Gyroscopes are used as actuators in robotic systems to perform movement.

(5 × 2) **[10]**

QUESTION 3

Define the following terms:

3.1 3D mesh

3.2 Hertz

3.3 Potentiometer

3.4 Global variable

3.5 Embedded system

(5 × 1) **[5]**

QUESTION 4

Complete the following sentences by writing only the missing word or words next to the question number (4.1–4.5) in the ANSWER BOOK.

4.1 In robotics, … refers to the algorithmic process of determining a path for a robot to follow from its start point to its destination.

4.2 The rate at which energy is transferred or converted in an electrical circuit is known as …

4.3 A … measures the force exerted on a surface and converts it into an electrical signal.

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4.4 A … is a value that does not change during the execution of a program and is typically used to represent fixed data.

4.5 A … represents the components of an electrical circuit and their connections, often used for designing and troubleshooting.

(5 × 1) **[5]**

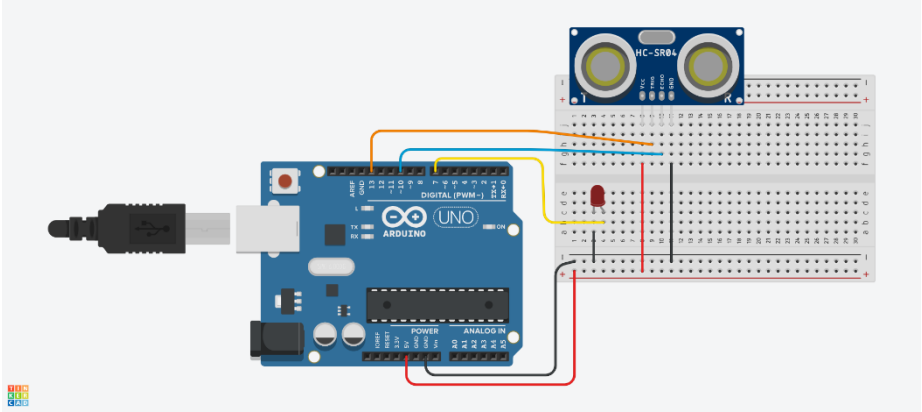
TOTAL SECTION A: 30

SECTION B

QUESTION 5

Read the scenario and study the image and answer the questions.

You are part of a team working on developing an autonomous vehicle for a major automotive company. The project involves integrating various technologies, including robotics, 3D printing, microcontrollers, sensors, and programming, to enhance the vehicle's capabilities. Your team's goal is to create a prototype that can navigate autonomously, sense obstacles, and perform specific tasks without human intervention.



5.1 Prototype planning

5.1.1 Explain the concepts of perception and cognition in the given circuit and give one example of how it would be used in the given scenario. (5)

5.1.2 Explain why 3D printing should be utilised for this project and justify your answer. Give one example of its application in the automotive industry. (5)

5.1.3 Identify each component in the circuit and describe their purpose. (4)

5.2 Prototype development and component selection

5.2.1 Why would a standard computer not be suitable for use as part of the prototype? (4)

5.2.2 Explain how an H-Bridge motor controller would be suitable for this prototype. (3)

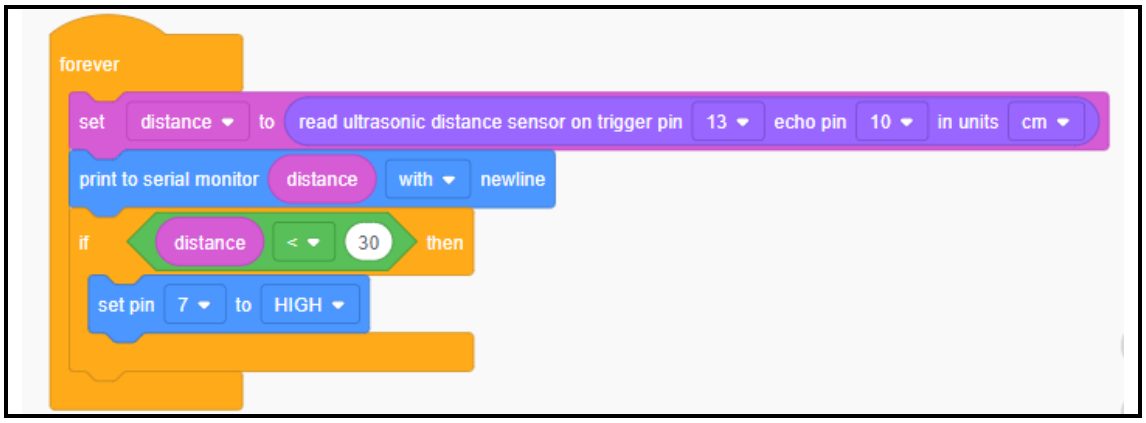
5.2.3 Identify the component that is missing in the circuit and explain what problems will arise from its absence. (3)

5.3 Briefly explain the:

1. Basic operation
2. Purpose
3. Relevance (to the distance sensor integration) of the following components in the context of your autonomous vehicle project:
    - Voltage regulator
    - Voltage divider
    - Charge controller

(3 × 3) (9)

5.4 The following code is used as part of the prototype:



5.4.1 Describe what this Blockly code does. (2)

5.4.2 Write the Arduino code for setting up the relevant pin for the sensor connected to pin 13. (1)

5.4.3 Explain how program code is exported/uploaded to this microcontroller. (2)

[38]

QUESTION 6

Read the scenario below and answer the questions.

A Smart Home system automates climate control, lighting, and security using IoT devices and a central hub. Temperature and humidity sensors connected to a microcontroller manage energy efficiency, while smart lighting and security features are controlled via a smartphone app, necessitating expertise in wireless communication and microcontroller programming.

6.1 The following code sets up a web server on an Arduino-compatible microcontroller with Wi-Fi capabilities. The code is currently missing comments. Add appropriate comments to lines 4, 10, 20, 27 and 36.

Use the format:
Line 4: // Your comment here

```
1.  #include <WiFi.h>
2.  #include <WebServer.h>
3.
4.  //
5.  const char* ssid = "Your_SSID";
6.  const char* password = "Your_PASSWORD";
7.
8.  WebServer server(80);
9.
10. //
11. void handleRoot() {
12.   String message = "Mobile Robot Data: ";
13.   String data = "Your_Robot_Data";
14.   message += data;
15.   server.send(200, "text/html", message);
16. }
17.
18. void setup() {
19.   Serial.begin(115200);
20.   //
21.   WiFi.begin(ssid, password);
22.   while (WiFi.status() != WL_CONNECTED) {
23.     delay(1000);
24.     Serial.println("Connecting to WiFi...");
25.   }
26.
27.   //
28.   Serial.println("Connected to WiFi");
29.   Serial.println(WiFi.localIP());
30.
31.   server.on("/", HTTP_GET, handleRoot);
32.
33.   server.begin();
34. }
35.
36. //
37. void loop() {
38.   server.handleClient();
39. }
```

(5)

6.2 6.2.1 From the following list of wireless technologies, choose one most suitable and one least suitable for the SMART home scenario. Justify your choices by considering factors such as range, power consumption, and device communication requirements.

- Wi-Fi
- Bluetooth
- Zigbee
- Z-Wave (4)

6.2.2 The ESP32 microcontroller is good for monitoring temperature and humidity in a smart home scenario. Explain why it is a good choice. (2)

6.2.3 Explain what is a microcontroller with wireless capabilities and indicate its role in the SMART home wireless sensor network. (2)

6.3 Circuitry and safety

6.3.1 In a SMART home installation, correct wiring is crucial for safety and functionality.

Indicate how incorrect polarity can affect the operation of devices and the overall safety of the home electrical system. Give one safety risk associated with reversed polarity and describe one preventative measure that can be taken during installation. (3)

6.3.2 In a SMART home, you need to power various devices including sensors, lights, and smart appliances. If you use two 12V batteries connected in series and each battery has a capacity of 5 amp-hours, calculate the total voltage and amp-hours available for the SMART home system. Explain the outcome of your calculation. (4)

6.4 Application of designs

6.4.1 Indicate how 3D printing is used in the development of a custom housing for a SMART home device. (2)

6.4.2 How are 3D printing materials, like PLA and ABS, selected based on the specific requirements of the device? (2)

6.4.3 Name five significant events in IoT history and describe how each directly affects the solutions for a SMART home implementation. (5)

6.4.3 In the context of developing a SMART home prototype, explain how you would modify and debug code to enhance the efficiency of data handling between sensors and actuators. (3)

[32]

TOTAL SECTION B: 70
GRAND TOTAL: 100

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