higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE (VOCATIONAL)

INTRODUCTION TO ROBOTICS
NQF LEVEL 3
(First paper)

19 November 2024

This marking guideline consists of 15 pages.

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SECTION A

QUESTION 1

1.1 B
1.2 C
1.3 C
1.4 D
1.5 B
1.6 B
1.7 C
1.8 B
1.9 A
1.10 C

(10 × 1) **[10]**

QUESTION 2

2.1 False✓
Reasons (Any ONE):✓
- Libraries provide pre-written code for common tasks, simplifying development and reducing errors.
- Even in simple projects, libraries can save time by handling low-level details and hardware interactions.

2.2 False✓
Reasons (Any ONE):✓
- An inverter converts direct current (DC) to alternating current (AC), not the other way around.
- This is commonly used in applications like solar power systems, where DC from solar panels is converted to AC for use in homes or businesses.

2.3 False✓
Reasons (Any ONE):✓
- Fused Deposition Modelling (FDM) uses a heated nozzle to extrude melted thermoplastic filament layer by layer to create a 3D object.
- Light curing resin is a process used in technologies like Stereolithography (SLA) and Digital Light Processing (DLP), not in FDM.

2.4 True✓
Reasons (Any ONE):✓
- Robots in general manufacturing are often programmed for repetitive, specific tasks such as welding or assembly, and are optimised for those functions.
- Their design usually prioritises efficiency and precision in a fixed environment, which limits their adaptability to other tasks.

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2.5 False✓
Reasons (Any ONE):✓
- Gyroscopes are sensors that measure rotational movement or orientation, providing feedback on the position of a robot or its components.
- They do not perform actions or control movement but instead provide data that can be used to adjust or maintain stability in robotic systems.

(5 × 2) **[10]**

QUESTION 3

3.1 A 3D mesh is a collection of vertices, edges, and faces that defines the shape of a 3D object in space.

3.2 Hertz is the unit of frequency that measures the number of cycles per second in a periodic waveform.

3.3 A potentiometer is a variable resistor used to adjust voltage levels in a circuit.

3.4 A global variable is a variable that is accessible throughout the entire program, across different functions or modules.

3.5 An embedded system is a specialized computing system designed to perform dedicated functions within a larger system.

(5 x 1) **[5]**

QUESTION 4

4.1 Path planning
4.2 Power
4.3 Pressure sensor
4.4 Constant
4.5 Schematic

(5 × 1) **[5]**

TOTAL SECTION A: 30

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SECTION B

QUESTION 5

5.1 5.1.1

Perception in the given circuit involves the distance sensor which detects obstacles✓, functioning as the vehicle's sensory input. Cognition refers to how the Arduino processes this data to make decisions✓, such as turning on the LED to indicate an obstacle or altering the vehicle's path. For example, if the distance sensor detects an obstacle within a certain range✓, the microcontroller can activate the LED✓ to alert the vehicle's control system or trigger an avoidance manoeuvre✓. (5)

5.1.2 3D printing should be utilised for this project due to its advantages in rapid prototyping and customisation✓. It enables the creation of complex and tailored parts quickly and cost-effectively✓. For instance, in the automotive industry, 3D printing is employed to produce custom car parts✓, prototype new components✓, and manufacture lightweight structural parts that enhance vehicle performance and reduce production costs✓. (5)

5.1.3 **Arduino Uno:** Acts as the microcontroller that processes input from the distance sensor and controls the LED based on the processed data✓.
Distance sensor: Measures the distance to obstacles and provides this data to the Arduino✓.
LED: Provides a visual indicator for power or distance✓.
Breadboard (and connecting wires): Used to build the circuit and establish connections between the Arduino, sensor, and LED✓. (4)

5.2 Prototype development and component selection

5.2.1 A standard computer is unsuitable for the prototype due to its large size✓, which makes it impractical for compact designs. It also consumes more power✓ than necessary, which is a significant drawback for battery-operated systems. Additionally, standard computers are not designed for real-time processing✓ required in embedded systems. Lastly, incorporating a standard computer would add unnecessary cost and complexity✓ compared to using specialized microcontrollers.

(4)

5.2.2 An H-Bridge motor controller is suitable for the prototype because it allows for bidirectional control of DC motors✓, enabling movement in different directions. It also provides efficient control✓, minimising power loss. Additionally, it integrates well with microcontrollers✓, facilitating precise motor control for the prototype. (3)

5.2.3 The missing component is likely a resistor✓, which is necessary for limiting current through other components. Without the resistor, excessive current could damage sensitive components or lead to circuit failure✓. This could result in malfunction or unreliable operation of the prototype✓. (3)

5.3 **Voltage Regulator:**

- **Operation:** Maintains a constant output voltage regardless of variations in input voltage or load conditions.
- **Purpose:** Ensures that the microcontroller and sensors receive a stable voltage, protecting them from power fluctuations.
- **Relevance:** Vital for the reliable operation of the distance sensor, ensuring accurate readings and stable performance.

Voltage Divider:

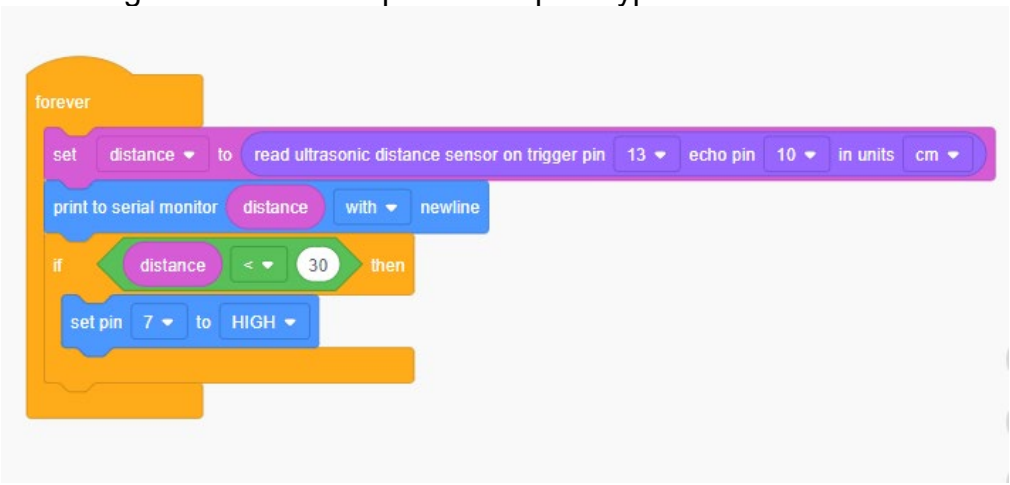
- **Operation**: Uses two resistors in series to create a lower voltage output from a higher voltage input.
- **Purpose**: Allows the microcontroller to measure different voltage levels safely, often used for analogue sensors or voltage scaling.
- **Relevance**: Can be used to scale down the voltage from the distance sensor to a level the microcontroller can read.

Charge Controller:

- **Operation**: Manages the charging of batteries, ensuring they are charged correctly and protecting them from overcharging.
- **Purpose**: Extends battery life and ensures reliable power supply to the vehicle's components.
- **Relevance**: Maintains the power supply to the distance sensor and other components, preventing power loss or damage from improper charging.

- *3 marks for describing the basic operation of each component.*
- *3 marks for outlining the purpose of each component in the context of the autonomous vehicle project.*
- *3 marks for explaining the relevance of each component to the distance sensor integration.* (9)

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



5.4.1 **Functionality overview:** The Blockly code continuously reads distance measurements, using a forever loop, from a distance sensor and prints these measurements to the serial monitor✓. If the distance is smaller than 30cm then pin 7 is set to high. ✓

(2)

5.4.2 pinMode(10, INPUT); ✓ (1)

5.4.3 **Model answer:**
Program code is written and compiled in an Integrated Development Environment (IDE)✓. The code is then uploaded to the microcontroller through a USB connection or programming interface✓. (2)
[38]

QUESTION 6

6.1 **Model answer:** (5)
Line 4: // Add Wi-Fi credentials✓
Line 10: // Define the function to handle requests to the root URL✓
Line 20: // Begin serial communication for debugging✓
Line 27: // Notify that the device has successfully connected to Wi-Fi✓
Line 36: // Continuously handle incoming client requests✓

6.2 6.2.1

- Zigbee is ideal for the smart home scenario due to its low power consumption✓, ability to support mesh networking for extensive device communication✓, and suitable range for home environments.
- Bluetooth is less suitable due to its shorter range✓ and higher power consumption✓, making it less effective for managing multiple devices in a smart home setting. (4)

6.2.2 It is a good choice because it has built-in Wi-Fi capabilities for seamless integration into a wireless sensor network✓ and supports low power consumption, which is ideal for energy-efficient systems✓.

(2)

6.2.3 **Model answer**:
It is a microcontroller that includes built-in modules for wireless communication, like Wi-Fi or Bluetooth✓. Its role is to gather data from sensors and transmit it wirelessly to a central hub✓, enabling remote monitoring and control of smart home systems. (2)

6.3.1 Incorrect polarity in a SMART home installation can cause devices to malfunction✓, such as LEDs failing to light or motors running backwards. It also poses safety risks✓, like electrical shorts or fires. Preventative measures include checking wiring against diagrams, using colour-coded wires, and testing connections with a multimeter before powering up✓. (3)

6.3.2

- Calculating the total voltage as 12V + 12V = 24V✓.
- Calculating the total amp-hours as 5 amp-hours. ✓
- When two 12V batteries are connected in series, the total voltage is the sum of the individual battery voltages ✓, while the capacity in amp-hours (Ah) remains the same. ✓ (4)

6.4 6.4.1 3D printing allows for quick creation of custom housings for smart home devices by enabling rapid prototyping✓ and precise design customization✓, reducing costs✓ and allowing material flexibility✓.
1/2 mark each for rapid prototyping, precise design customization, reducing costs, and allowing material flexibility (2)

6.4.2 PLA is selected for its ease of use✓, biodegradability ✓, making it ideal for low-stress parts. ABS is chosen for its strength✓, and heat resistance✓, suitable for more robust or high-temperature applications.

1/2 mark each (2)

6.4.3 **Events and applications examples** (Students may have any 5):

- **Development of Machine-to-Machine (M2M) Communication (Early 2000s)** ✓: Enabled automated communication between home devices in SMART homes. ✓
- **Introduction of MQTT Protocol (1999)**: ✓ Provided a lightweight communication protocol for IoT devices in Smart Homes✓
- **Launch of IPv6 (1998)**: ✓ Expanded the number of available IP addresses in SMART homes.
- **Deployment of LoRaWAN Networks (2015)**: ✓ Enabled long-range, low-power communication, like remote monitoring of large properties or outdoor smart garden sensors. ✓
- **Advancement of Edge Computing (2010s**✓Allowed data processing closer to the source, crucial for real-time SMART home applications like voice-controlled virtual assistants, home security systems, and automation of appliances. ✓
- **Release of Arduino (2005)**: ✓ Simplified prototyping and development of IoT devices, making it easier to create SMART home solutions like custom smart lighting systems, automated irrigation, or home security alarms. ✓
- **Introduction of Sigfox (2010)**: ✓ Provided a low-power, wide-area network for IoT devices, enhancing connectivity for SMART home applications ✓
- **Development of Smart Grid Technology (2000s)**: ✓ Enabled efficient energy management and distribution in SMART homes

- **Launch of 5G Networks (2019)**: ✓ Offered high-speed, low-latency connectivity, supporting advanced SMART home applications ✓
- **Emergence of Blockchain for IoT (2017)**: ✓ Improved security for SMART home devices like smart locks, security systems, and automated appliances. ✓

- *Students must have any 5 events*
- *½ mark for naming the event*
- *½ mark for describing the event and its relevance to the SMART home scenario* (5)

6.4.3 To enhance data handling efficiency in a SMART home prototype, I would modify the code to optimise data structures and reduce sensor polling rates, using interrupts to respond to changes promptly✓. This approach improves communication efficiency and reduces processing load✓. Ensuring the code is lightweight and responsive is crucial to meet the system's performance✓. (3)

[32]

TOTAL SECTION B: 70
GRAND TOTAL: 100

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