higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)

ROBOTICS FUNDAMENTAL
NQF LEVEL 2
(First paper)

(10041052)

18 November 2024 (Y-paper)
13:00–16:00

This question paper consists of 8 pages and 1 formula sheet.

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REPUBLIC OF SOUTH AFRICA

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ROBOTICS FUNDAMENTAL
NQF LEVEL 2
(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. Start each section on a new page.
5. Use only a black or blue pen.
6. 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 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 is a common application of robots in daily life?

A Painting houses
B Cooking gourmet meals
C Vacuuming floors
D Teaching in classroom

1.2 How have robots most significantly impacted the manufacturing industry?

A By reducing the need for raw materials
B By increasing the speed and precision of production
C By designing new products autonomously
D By managing the entire supply chain

1.3 Which of the following is NOT a benefit of using robots in healthcare?

A Enhanced precision in surgeries
B Reduced need for human doctors
C Ability to perform remote surgeries
D Assistance in rehabilitation of patients

1.4 What is one potential disadvantage of widespread robot use in the workforce?

A Increased creativity in the workplace
B Loss of jobs for human workers
C Greater safety in hazardous environments
D Higher productivity levels

1.5 In which area of daily life are social robots becoming increasingly popular?

A Space exploration
B Home entertainment and companionship
C Military operations
D Agricultural tasks

1.6 Which programming language is commonly used to program Raspberry Pi microcontrollers?

A Python
B Java
C C++
D HTML

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1.7 Which single-board computer is most commonly used for educational and DIY electronics projects?

A Intel Core i7
B Raspberry Pi
C Nvidia GeForce RTX
D Arduino UNO

1.8 In a series circuit, how does the total resistance compare to the resistance of individual resistors?

A The total resistance is less than that of the smallest resistor
B The total resistance is the same as that of the largest resistor
C The total resistance is the sum of all individual resistances
D The total resistance is equal to the product of all resistances

1.9 In a parallel circuit, what happens to the total resistance as more resistors are added?

A The total resistance increases
B The total resistance decreases
C The total resistance remains the same
D The total resistance doubles

1.10 Which formula best describes Ohm's Law?

A $V=IR$
B $P=IV$
C $E=mc^2$
D $F=ma$

(10 × 1) **[10]**

QUESTION 2

Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (2.1–2.5) in the ANSWER BOOK.

2.1 3D printing can be used to create objects with complex geometries that are difficult to produce using traditional manufacturing methods.

2.2 All 3D printers use the same material to create objects.

2.3 In a Raspberry Pi, GPIO (general-purpose input/output) pins can be programmed to act as both input and output for various electronic components.

2.4 Electrical conductors are materials that allow electrical current to flow easily through them.

2.5 The formula to calculate electrical power in a circuit is P=IVP, where P is power, I is current, and V is voltage.

(5 × 2) **[10]**

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QUESTION 3

Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–J) next to the question number (3.1-3.10) in the ANSWER BOOK

COLUMN A		COLUMN B	
3.1	The physical pins on a microcontroller or Raspberry Pi used to connect external devices	A	floating
3.2	A setting that determines whether a GPIO pin is used for input or output	B	input pin
3.3	The process of reading the state of a GPIO pin to determine whether it is high or low	C	digital write
3.4	A common function used to set the state of a GPIO pin to either high or low	D	pin mode
3.5	A type of GPIO pin that can be connected to external devices to send or receive signals	E	digital read
3.6	A method to ensure that a GPIO pin is in a known state before it is used	F	initialisation
3.7	A condition where a GPIO pin is not connected to any external circuit, leading to unpredictable behaviour	G	output pin
3.8	A function that changes the state of a GPIO pin at a specified interval	H	pull-up resistor
3.9	A process to set up and initialize GPIO pins before their use in a program	I	pulse width modulation (PWM)
3.10	The value of a GPIO pin when it is not actively being driven high or low	J	pull-down resistor

(10 × 1) **[10]**

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 The process of creating three-dimensional objects by adding material layer by layer is called … .

4.2 The most commonly used material for fused deposition modelling (FDM) or 3D printing is … .

4.3 The 3D printing process begins with designing a digital model, usually in a format like … .

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4.4 Before printing a 3D object, the digital model must be converted into … that the printer can understand.

4.5 … is the term used to describe the empty spaces inside a 3D printed object, which can be adjusted to save material and reduce printing time.

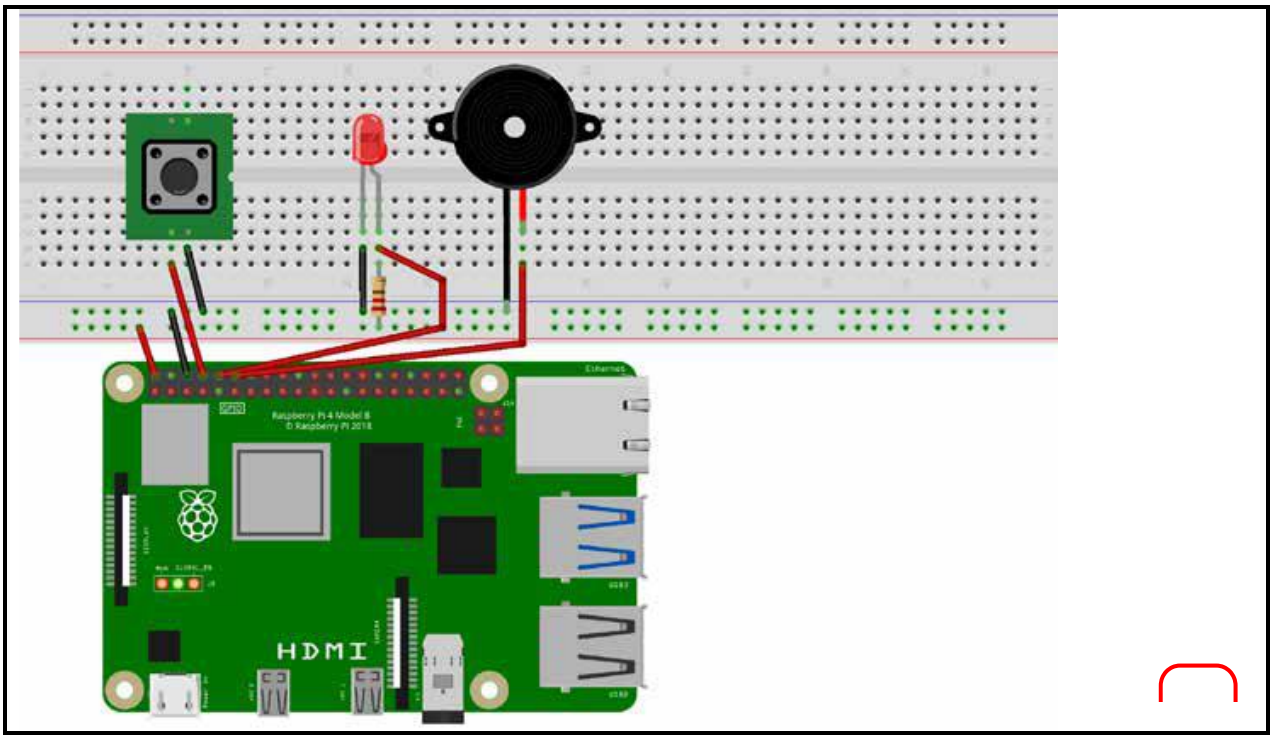
(5 × 1) **[5]**

TOTAL SECTION A: 35

SECTION B

QUESTION 5

Study the image below and answer the questions that follow.



[Source: *www.google/images.co.za*]

5.1 List all the electronic components visible in the circuit diagram. (5)

5.2 Describe what happens in this circuit when the button is pressed. (3)

5.3 Why is it important to set the correct mode (input or output) for GPIO pins in this circuit? (3)

5.4 Explain why using a resistor with the LED is crucial in this circuit. What could the consequences be if a resistor is not used? (3)

5.5 Suggest a practical application for this circuit set-up in a real-world scenario. How could this combination of a button, LED, and buzzer be used in a security or notification system? (3)

[17]

QUESTION 6

Study the code below and answer the questions that follow.

```
import RPi.GPIO as GPIO
import time

# GPIO pin configuration
BUTTON_PIN = 17
LED_PIN = 27
BUZZER_PIN = 22

# Setup GPIO
GPIO.setmode(GPIO.BCM)
GPIO.setup(BUTTON_PIN, GPIO.IN, pull_up_down=GPIO.PUD_UP)  # Button with pull-up resistor
GPIO.setup(LED_PIN, GPIO.OUT)
GPIO.setup(BUZZER_PIN, GPIO.OUT)

try:
    while True:
        # Read button state
        button_state = GPIO.input(BUTTON_PIN)

        if button_state == GPIO.LOW:  # Button is pressed
            GPIO.output(LED_PIN, GPIO.HIGH)  # Turn on LED
            GPIO.output(BUZZER_PIN, GPIO.HIGH)  # Turn on Buzzer
        else:
            GPIO.output(LED_PIN, GPIO.LOW)  # Turn off LED
            GPIO.output(BUZZER_PIN, GPIO.LOW)  # Turn off Buzzer

        time.sleep(0.1)  # Short delay to debounce button

except KeyboardInterrupt:
    # Clean up GPIO on Ctrl+C exit
    GPIO.cleanup()
```

6.1 In which programming language is the code written? (2)

6.2 Explain the purpose of the **GPIO.setmode(GPIO.BCM)** command in the code. What does this configuration achieve? (3)

6.3 What does the **GPIO.setup(BUTTON_PIN, GPIO.IN, pull_up_down=GPIO.PUD_UP)** command do? Why is it important to configure the button with a pull-up resistor? (3)

6.4 Describe the effect of the command, **GPIO.output(BUZZER_PIN, GPIO.HIGH),** on the buzzer connected to **BUZZER_PIN**. What happens when this command is executed? (3)

6.5 The code uses a **try** block with a **while True** loop. What is the purpose of this loop, and how does it affect the button, LED, and buzzer? (3)

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6.6 What is the significance of the **time.sleep(0.1)** function in the code? How does changing the duration of the sleep affect the behaviour of the LEDs? (3)

6.7 Why is the **GPIO.cleanup()** command used in the **except KeyboardInterrupt** block? What would happen if this command were not included? (3)
[20]

QUESTION 7

7.1 State Ohm's law in words. (2)

7.2 According to conventional current, in which direction does current flow in an electric circuit? (2)

7.3 Describe how a multi meter is used to measure voltage. Assume that the probes have been inserted and that the multi meter has been switched on. (7)

7.4 A current of 3 amps (A) flows through a resistor of 4 ohms (Ω) in a circuit. What is the voltage across the resistor? (4)

7.5 A voltage supply of 15 volts (V) and a current of 2 amps (A) flows through a circuit. What is the power consumed in the circuit? (4)

7.6 A current of 3 amps (A) flows through a resistor of 5 ohms (Ω). What is the power dissipated by the resistor? (4)
[23]

QUESTION 8

Study the scenario below and answer the question that follows.

A company has developed a new autonomous cleaning robot designed for use in hospitals. The robot is equipped with various sensors to navigate and avoid obstacles, including patients, staff, and equipment. One day, while the robot was cleaning a corridor, it detected a spill of a hazardous chemical. As the robot moved to clean the spill, a patient in a wheelchair entered the corridor. The robot's algorithm prioritised cleaning the hazardous spill to prevent potential harm to others, but in doing so, it accidentally bumped into the patient's wheelchair, causing minor injury.

The first law of robotics states the following: "A robot may not injure a human being or, through inaction, allow a human being to come to harm."

Discuss how the robot's actions in this scenario align or conflict with the first law of robotics. Suggest an alternative action the robot could have taken to adhere more closely to the first law. **[5]**

TOTAL SECTION B: 65
GRAND TOTAL: 100

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FORMULA SHEET

Speed:	$v = \frac{d}{t}$	$\vec{v} = \frac{d}{t}$	Acceleration:	$a = \frac{\Delta v}{\Delta t}$
Force:	$F = m\ x\ a$	Weight:	$W = m\ x\ g$	
Work:	$w = F\ x\ s$	Torque:	$\tau = F\ x\ r$	
Density:	$\rho = \frac{m}{V}$	Pressure:	$P = \frac{F}{A}$	
EMF[V]:	$\varepsilon = V + Ir$	Ohm's Law:	$V = I\ x\ R$	
Power:	$P = V\ x\ I$	$P = I^2 x\ R$	$P = \frac{V^2}{R}$	$P = \frac{W}{t}$
Energy:	$E = P\ x\ t$			
Solid angle [sr]:	$\Omega = \frac{A}{r^2}$	$A = \pi\ x\ r^2$	$A = \frac{\pi D^2}{4}$	
Other:	$R = \frac{\rho \ell}{A}$			
	$R_t = R_o\ (1 + \alpha_0 T)$	$t = \frac{1}{f}$	$\beta = \frac{\Phi}{A}$	
	$mmf = NI$	$H = \frac{mmf}{\ell}$	$H = \frac{NI}{\ell}$	
	$F = \beta I \ell$	$\frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$	$S = V_1 I_1 = V_2 I_2$	
	Series circuit	***Parallel circuit***		
	$R_T = R_1 + R_2 + R_3$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$	$R_T = \frac{R_1 x\ R_2}{R_1 + R_2}$	
	$I_T = I_1 = I_2 = I_3$	$I_T = I_1 + I_2 + I_3$	$I_T = \frac{V_T}{R_T}\ R$	
	$V_T = V_1 + V_2 + V_3$	$V_T = V_1 = V_2 = V_3$	$V_T = I_T R_T$	
Joule's Law:	$H = I^2 Rt$	(heat dissipation [J])		

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