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NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2024

ELECTRICAL TECHNOLOGY: DIGITAL ELECTRONICS

MARKS: 200

TIME: 3 hours

This question paper consists of 14 pages, including a 1-page formula sheet and an answer sheet.



INSTRUCTIONS AND INFORMATION

1. This question paper consists of SIX questions.
2. Sketches and diagrams must be large, neat and fully labelled.
3. Show ALL calculations and round off answers to TWO decimal places.
4. Number the answers correctly according to the numbering system used in this question paper.
5. You may use a non-programmable calculator.
6. Show the units for ALL answers of calculations.
7. A formula sheet is provided at the end of this question paper.
8. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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 numbers (1.1 to 1.15) in the ANSWER BOOK, for example 1.16 D.

- 1.1 The purpose of the Occupational Health and Safety Act is to ...
- A provide for the health and safety of persons at work.
 - B provide for the health and safety of persons at home.
 - C prevent wear and tear on machinery.
 - D prevent workers from using machinery. (1)
- 1.2 What is the function of a bistable multivibrator?
- A To switch on a circuit.
 - B To generate a controlled clock pulse.
 - C To form a debounce circuit.
 - D To set and reset the output of a multivibrator circuit. (1)
- 1.3 Pin 3 of a 555 Integrated Circuit (IC) is called:
- A Vcc.
 - B ground.
 - C output.
 - D input. (1)
- 1.4 The output waveform of a Schmitt trigger circuit will always be a ... wave.
- A sine
 - B triangular
 - C radio
 - D square (1)
- 1.5 The bistable multivibrator has the following characteristics:
- A Free running with ONE input
 - B Free running with TWO inputs
 - C TWO stable states with TWO inputs
 - D NO stable states with ONE input (1)
- 1.6 The maximum current a 555 IC can either sink or source is:
- A 2 A
 - B 200 A
 - C 2 mA
 - D 20 mA (1)

- 1.7 The function of an encoder is to ...
- A convert an analogue signal to a digital signal.
 - B convert a digital signal to an analogue signal.
 - C convert a binary code into a recognisable decimal form.
 - D convert a decimal code into a recognisable binary form. (1)
- 1.8 With reference to microcontrollers, the term RAM means:
- A Read All Memory
 - B Random Allocation Memory
 - C Read and Memorise Memory
 - D Random Access Memory (1)
- 1.9 With reference to microcontrollers, a ... is an example of an input.
- A sensor
 - B motor
 - C monitor
 - D LED display (1)
- 1.10 What will happen to the value of a light dependant resistor (LDR) if the light shining on it increases?
- A It will remain the same.
 - B It will first increase and then decrease.
 - C It will increase.
 - D It will decrease. (1)
- 1.11 Pulse triggered flip-flop circuits are also referred to as:
- A Master/Slave
 - B Follow my lead
 - C Simultaneous trigger
 - D Continuous trigger (1)
- 1.12 A fast temporary memory that allows information to be stored and retrieved by the system as it operates, is called the ...
- A ROM.
 - B RAM.
 - C CPU.
 - D I/O unit. (1)
- 1.13 The ... is where the timing signal is delayed by a fraction of time through each flip-flop.
- A ripple counter
 - B down counter
 - C frequency divider
 - D propagation delay (1)

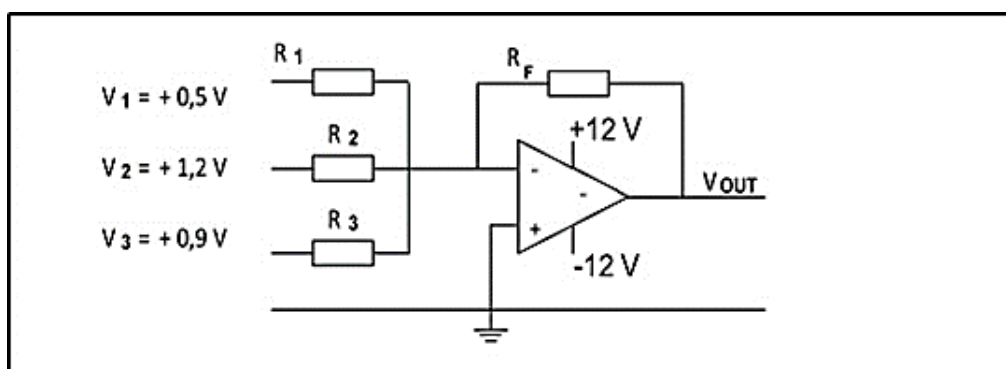
- 1.14 The term 'debugging' refers to:
- A Identify and remove errors
 - B Find bugs and kill them
 - C Find bugs and remove them
 - D All the above
- (1)
- 1.15 A(n) ... is a specialised op-amp circuit that compares two input voltages and produces an output that is always at either one of the two states.
- A integrator
 - B differentiator
 - C comparator
 - D Schmitt trigger
- (1)
[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

- 2.1 Give the meaning of the following with reference to the Occupational Health and Safety Act, 1993 (Act 85 of 1993).
- 2.1.1 Risk (1)
 - 2.1.2 Safe (1)
- 2.2 Explain the purpose of the Occupational Health and Safety Act. (2)
- 2.3 Name THREE unsafe conditions that cause most accidents in the workshop. (3)
- 2.4 Describe THREE standard treatments for electric shock after the electricity has been removed. (3)
- [10]**

QUESTION 3: SWITCHING CIRCUITS

- 3.1 Name ONE application of a monostable multivibrator. (1)
- 3.2 Name the type of the multivibrator that:
- 3.2.1 Produces one pulse cycle of 'high and low' when a trigger pulse is applied. (1)
- 3.2.2 Changes state when a trigger pulse is applied and remains in that state until the next trigger pulse is applied. (1)
- 3.3 FIGURE 3.3 and TABLE 3.3 below show the resistor values, output voltages and gain of a summing amplifier. Refer to FIGURE 3.3 and study TABLE 3.3 below to answer the following questions.

**FIGURE 3.3: SUMMING AMPLIFIER**

RESISTOR VALUES				OUTPUT	GAIN
R ₁	R ₂	R ₃	R _F	V _{OUT}	β (A _v)
20 kΩ	20 kΩ	20 kΩ	20 kΩ	B	1
20 kΩ	20 kΩ	20 kΩ	40 kΩ	+ 5,2 V	D
5 kΩ	10 kΩ	20 kΩ	40 kΩ	C	4,08
20 kΩ	20 kΩ	20 kΩ	A	+ 10,4 V	4

TABLE 3.3

- 3.3.1 State the function of a summing amplifier. (2)
- 3.3.2 Calculate the output voltage at **B**. (3)
- 3.3.3 Calculate the output voltage at **C**. (3)
- 3.3.4 Calculate the value of the feedback resistors at **A**. (3)
- 3.3.5 Calculate the total gain at **D**. (3)

3.4 Refer to FIGURE 3.4 below and answer the questions that follow.

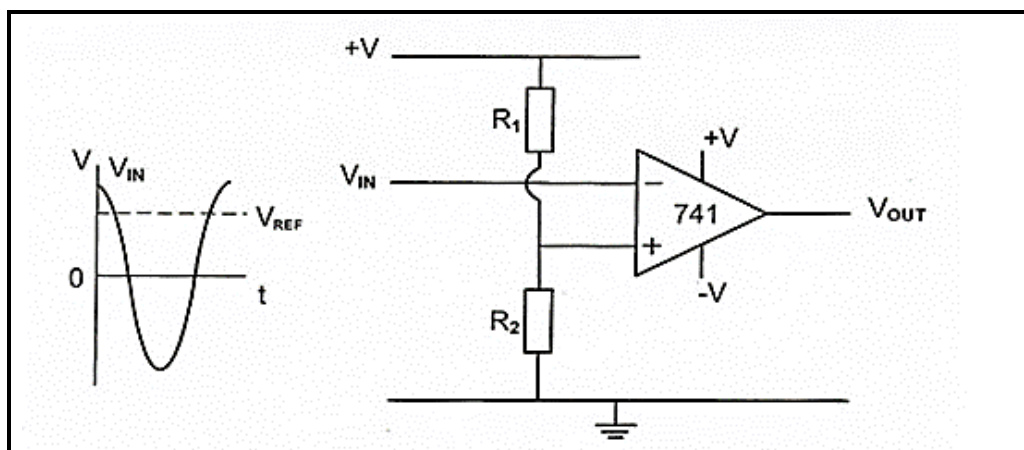


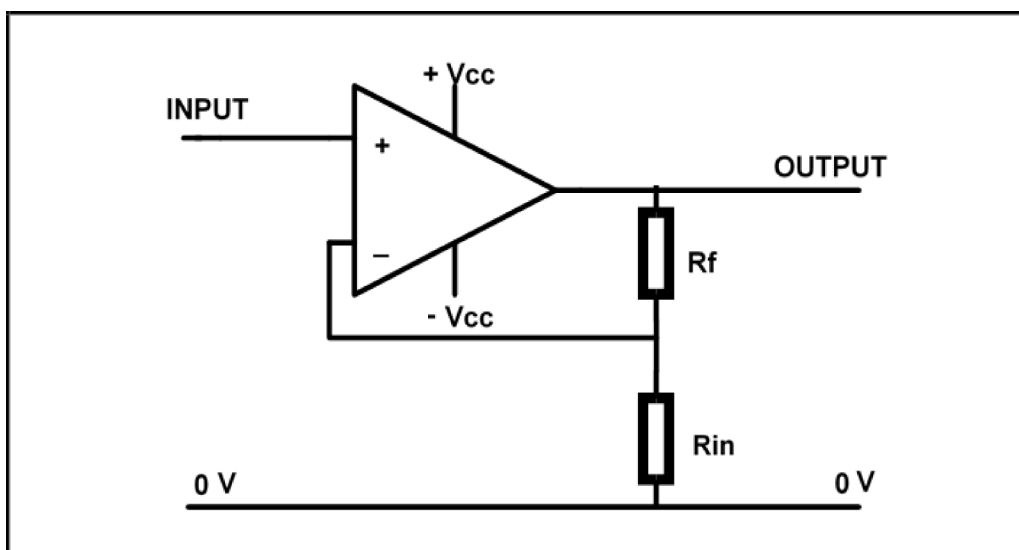
FIGURE 3.4: COMPARATOR

- 3.4.1 Explain what is meant with *open loop* with reference to FIGURE 3.4. (2)
- 3.4.2 Describe the principles of operation of a comparator. (6)
- 3.5 Draw the circuit diagram for a passive integrator. (4)
- 3.6 Name THREE key operating points of the op-amp integrator circuit. (3)
- 3.7 Explain how you would vary the length of time that a monostable multivibrator circuit output stays 'HIGH'. (3)
- 3.8 With reference to the astable multivibrator op-amp circuit, explain the term *feedback*. (3)
- 3.9 Draw a fully labelled circuit diagram for an astable multivibrator op-amp circuit. (6)
- 3.10 Explain the principle of operation of a day/night switching circuit. (6)

[50]

QUESTION 4: SEMICONDUCTOR DEVICES

- 4.1 Identify pin 7 of a 741 op-amp. (1)
- 4.2 Name the TWO primary building blocks of a 555 IC. (2)
- 4.3 Name TWO modes the 555 IC is set up to function in. (2)
- 4.4 With reference to FIGURE 4.4 below, answer the following questions.

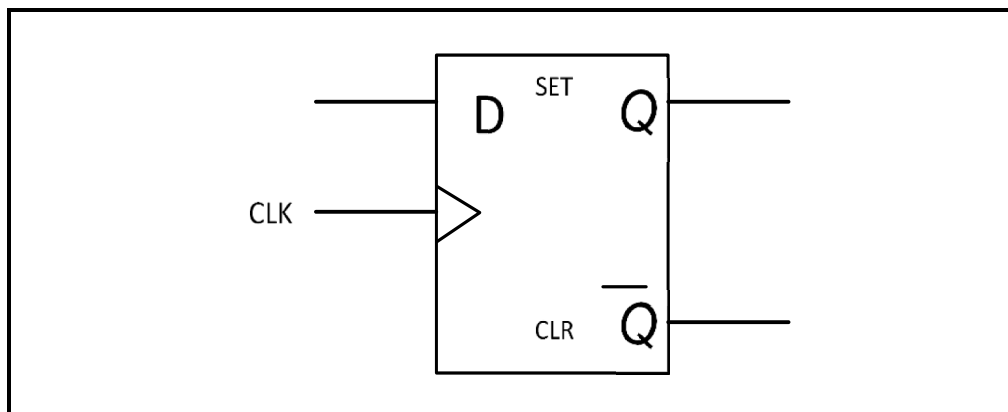
**FIGURE 4.4: OP-AMP**

- 4.4.1 Identify the op-amp in FIGURE 4.4. (1)
- 4.4.2 Calculate the gain of the amplifier if the feedback resistor has a value of $1\text{ k}\Omega$ and the input resistor has a value of $1\text{ 900 }\Omega$. (3)
- 4.5 With reference to the 555 timer IC, answer the questions below.
- 4.5.1 State the voltage parameters between which a 555 timer can operate. (2)
- 4.5.2 Explain the astable mode of operation of a 555 timer. (2)
- 4.5.3 Explain the function of pin 6 (threshold) on a 555 IC. (3)
- 4.6 With reference to op-amp characteristics, explain the term *bandwidth*. (4)

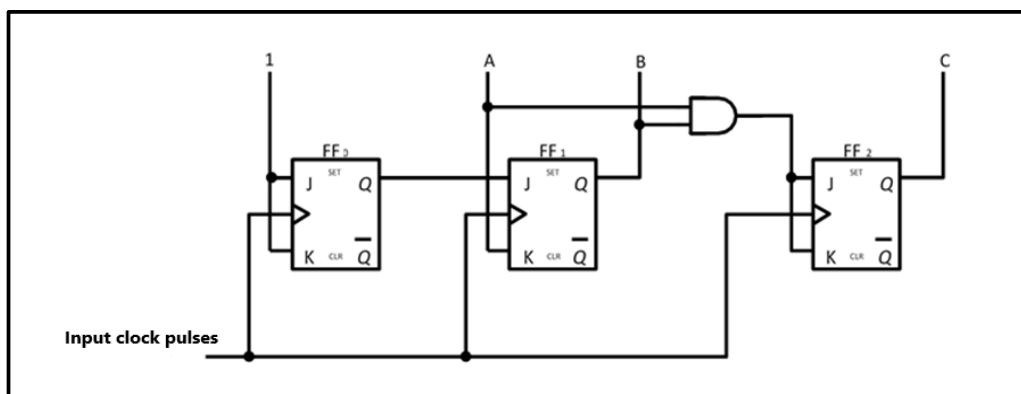
[20]

QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

- 5.1 State ONE application of the up/down counter. (1)
- 5.2 FIGURE 5.2 below represents the logic symbol of a flip-flop.

**FIGURE 5.2**

- 5.2.1 Identify the flip-flop in FIGURE 5.2. (1)
- 5.2.2 Explain how the circuit is designed to eliminate any illegal states in the operation of this flip-flop. (4)
- 5.2.3 Name TWO applications of this type of flip-flop. (2)
- 5.3 Refer to the LED seven-segment display and explain the difference between a *common anode* and a *common cathode*. (4)
- 5.4 Refer to FIGURE 5.4 below of a three-stage binary counter and answer the questions that follow.

**FIGURE 5.4**

- 5.4.1 Complete the timing diagrams for this counter on the ANSWER SHEET for QUESTION 5.4.1. (8)
- 5.4.2 State whether the circuit in FIGURE 5.4 is synchronous or asynchronous. (1)

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- 5.5 List FOUR types of shift registers that are available. (4)
- 5.6 Name TWO methods to display information in digital systems. (2)
- 5.7 Name TWO disadvantages of propagation delay. (2)
- 5.8 Explain the disadvantage of up/down counters in relation to normal up or down counter. (2)
- 5.9 Explain the difference between a *full sequence counter* and a *truncated counter*. (4)
- 5.10 Name TWO applications of counters. (2)
- 5.11 With reference to FIGURE 5.11 below, answer the questions follow.

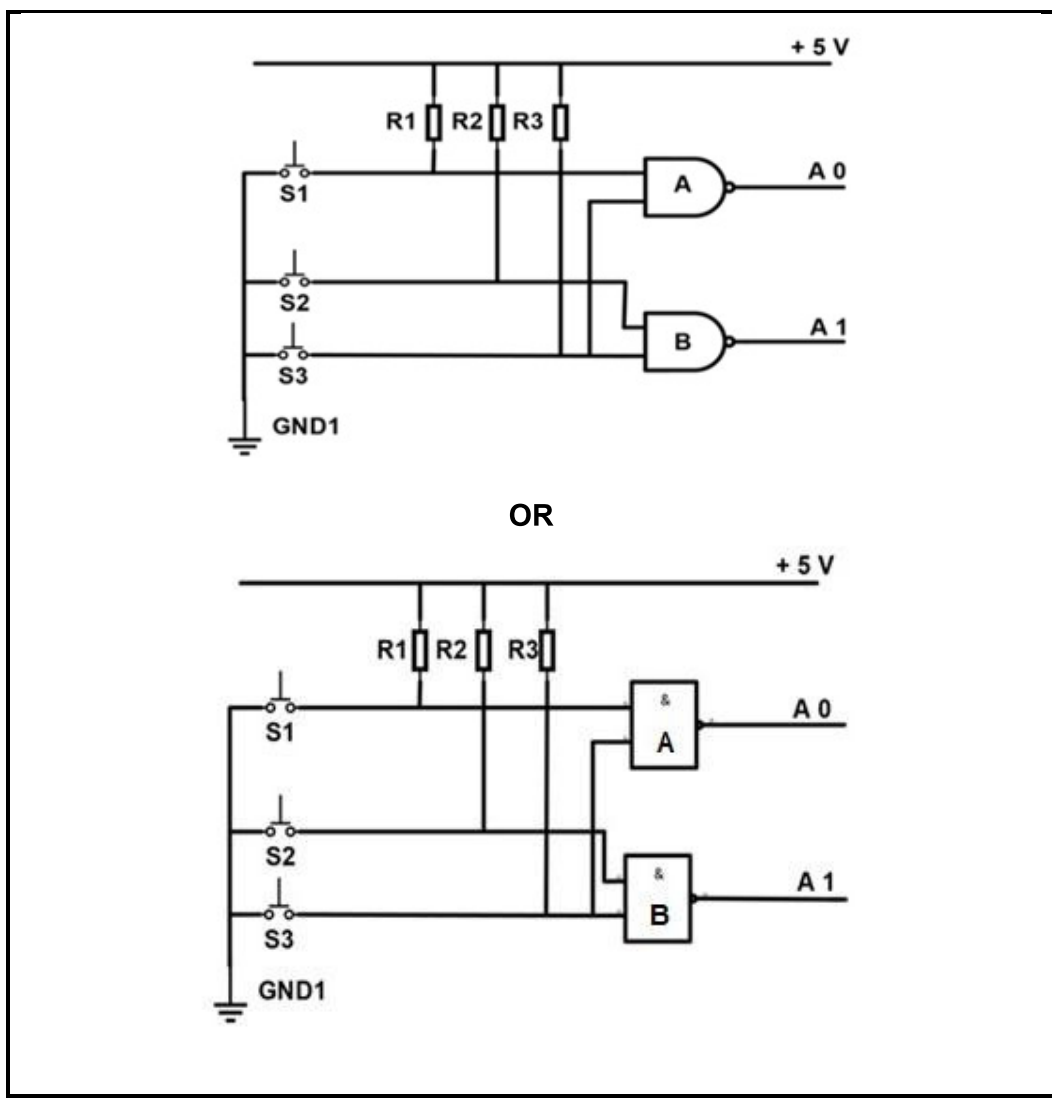


FIGURE 5.11

- 5.11.1 Identify the circuit in FIGURE 5.11. (1)

- 5.11.2 Draw a truth table for the circuit in FIGURE 5.11. (5)
- 5.11.3 Explain the function of the circuit in FIGURE 5.11. (2)
- 5.12 State TWO maximum values that should be considered when working with a LED display unit. (2)
- 5.13 Draw a fully labelled circuit diagram of a D latch flip-flop using NAND gates, EXCLUSIVE OR gates and an INVERTER. (8)
- [55]**

QUESTION 6: MICROCONTROLLERS

- 6.1 State ONE type of *communication protocol*. (1)
- 6.2 Define *communication protocol*. (2)
- 6.3 Answer the questions that follow with reference to communication protocols.
- 6.3.1 Name THREE applications of the RS-485. (3)
- 6.3.2 State the line configuration of the RS-485. (1)
- 6.4 Explain the difference between a *microprocessor* and a *microcontroller* with reference to the hardware of microcontrollers. (4)
- 6.5 Refer to a serial communication interface and answer the questions that follow.
- 6.5.1 Write out the acronym UART in full. (4)
- 6.5.2 Explain the function of the UART. (5)
- 6.6 Answer the following questions with reference to communication in a microcontroller.
- 6.6.1 Explain the function of the system bus. (3)
- 6.6.2 Name the THREE busses that forms part of the system bus in a microcontroller. (3)
- 6.6.3 State TWO advantages of synchronous communication when compared to asynchronous communication. (2)
- 6.6.4 State TWO disadvantages of parallel communication when compared to serial communication. (2)
- 6.7 Draw a flow diagram for a monostable device that has only one stable state. The program switches the output on and off every 5 seconds and then returns to the original state. (10)

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- 6.8 Refer to communication in a microcontroller and answer the questions that follow.
- 6.8.1 Draw the block diagram of a microcontroller, clearly indicating the THREE system buses. (6)
- 6.8.2 Define the term *interface*. (1)
- 6.9 List THREE types of registers that are found in the central processing unit (CPU) of the microcontroller. (3)
- [50]**
- TOTAL: 200**

FORMULA SHEET**SWITCHING CIRCUITS**

1. Gain $A_V = \frac{V_{OUT}}{V_{IN}} = -\left(\frac{R_f}{R_{in}}\right)$ inverting operational amplifier
2. Gain $A_V = \frac{V_{OUT}}{V_{IN}} = 1 + \left(\frac{R_f}{R_{in}}\right)$ non- inverting operational amplifier
3. $V_{OUT} = V_{IN} \times \left(-\frac{R_f}{R_{in}}\right)$ inverting amplifier
4. $V_{OUT} = -(V_1 + V_2 + V_3)$ summing up op-amp
5. $f_r = \frac{1}{2\pi\sqrt{LC}}$
6. $f = \frac{1}{2\pi\sqrt{6RC}}$

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QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

ANSWER SHEET 5.4.1

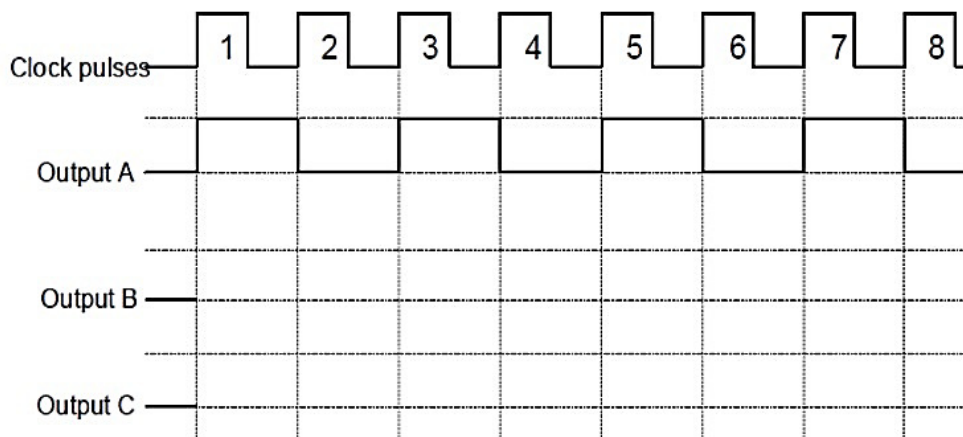


FIGURE 5.4.1