Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2023

ELECTRICAL TECHNOLOGY: DIGITAL ELECTRONICS

MARKS: **200**

TIME: **3 hours**

This question paper consists of 18 pages, including a 1-page formula sheet and 4 answer sheets.

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. An attempt to numerically determine the probabilities of various adverse events and the likely extent of the losses if the event occurs is known as …

A risk analysis
B quantitative risk analysis
C qualitative risk analysis
D dangerous practices (1)

1.2 When the input voltage to a non-inverting Schmitt trigger is smaller than the reference voltage, the output is driven into … saturation.

A positive
B negative
C both negative and positive
D zero (1)

1.3 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)

1.4 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)

1.5 The output waveform of a Schmitt trigger circuit will always be a … wave.

A sine
B triangular
C radio
D square (1)

1.6 To which input terminal of a 741-operational amplifier would a signal be connected if the output signal is in phase with the input signal?

A Terminal 2
B Terminal 3
C Terminal 1
D Terminal 4 (1)

1.7 Which 741-operational amplifier circuit would amplify an input signal in phase without distorting the output signal?

A Inverting amplifier
B Non-inverting amplifier
C Voltage-following amplifier
D Schmitt-trigger amplifier (1)

1.8 Simple memory circuits are divided into three groups according to their common operation. These three groups are:

A counter circuits, flip-flops and shift-register circuits
B pulse circuits, clocked circuits, and peripheral trigger circuits
C RS-latch circuits
D JK-latch circuits (1)

1.9 A combinational logic circuit combining an AND gate with an exclusive OR gate (XOR) is called the … circuit.

A half-adder
B full adder
C parallel adder
D arithmetic (1)

1.10 The function toggle is obtained in an active low JK flip-flop when the inputs are ...

A J = 0 and K = 0.
B J = 1 and K = 0.
C J = 0 and K = 1.
D J = 1 and K = 1. (1)

1.11 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)

1.12 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 In which ONE of the following devices would a microcontroller be found?

A Laptop
B Transistor radio
C Microwave oven
D Swimming-pool pump (1)

1.14 Microcontrollers can be programmed in various ways. One of the methods to program a microcontroller is to use a flow chart. A flow chart is defined as a ...

A block diagram with instructions in the order of execution.
B block diagram of the operation of the microcontroller.
C block diagram of the construction of the microcontroller.
D range of data that shows the flow of data to the microcontroller. (1)

1.15 ONE advantage of the serial peripheral interface bus (SPI) is that it …

A cannot transmit off the PCB.
B is susceptible to noise.
C supports high-speed full-duplex communication.
D supports only one master device on the bus. (1)

[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY (GENERIC)

2.1 State TWO factors needed to ensure a strong work ethic in a company. (2)

2.2 Define a *critical incident* in a workshop. (2)

2.3 Name ONE safety precaution you would observe when handling concentrated chemicals at a Printed Circuit Board (PCB) workstation. (1)

2.4 Differentiate between an *unsafe act* and a *calculated risk* in a workshop. (2)

2.5 Explain why you must protect yourself when helping a person who is being shocked by electricity. (1)

2.6 Explain why a person should not interfere with, or misuse, equipment in the workshop that is provided for health and safety. (2)

[10]

QUESTION 3: SWITCHING CIRCUITS

3.1 Name the type of the multivibrator that:

3.1.1 Produces one pulse cycle of 'high' and low' when a trigger pulse is applied (1)

3.1.2 Changes state when a trigger pulse is applied and remains in that state (1)

3.2 Draw a circuit diagram of an astable multivibrator. (5)

3.3 Refer to the circuit in FIGURE 3.3 below and answer the questions that follow.

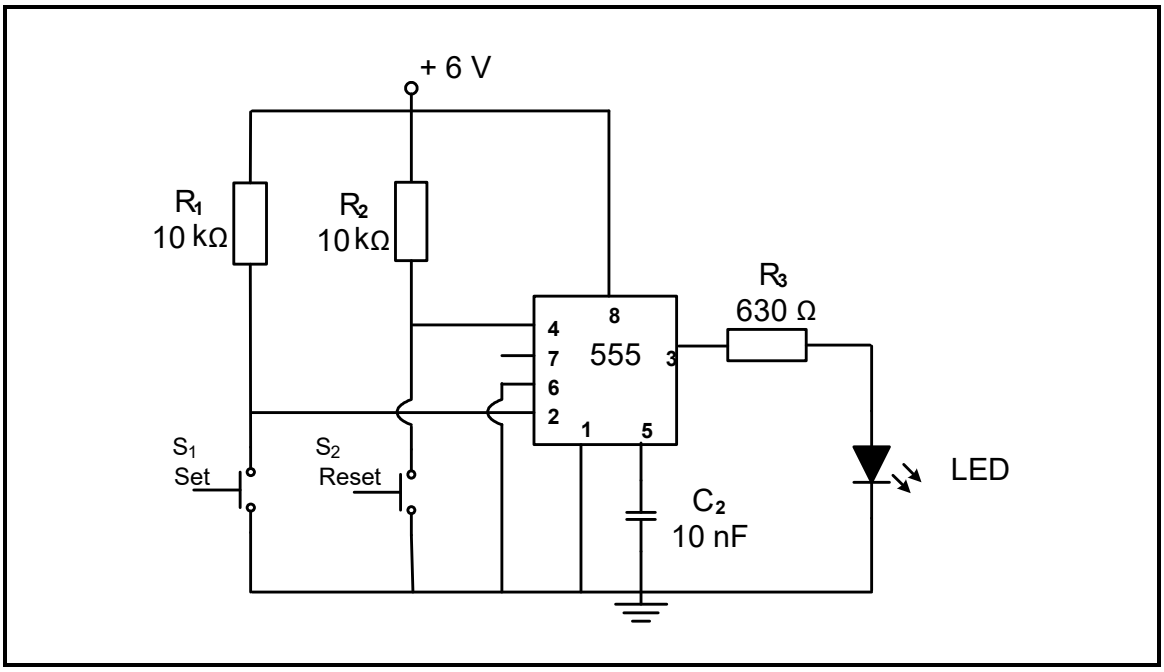

FIGURE 3.3: MULTIVIBRATOR

3.3.1 Identify the above multivibrator. (2)

3.3.2 State the function of R_1 and R_2. (2)

3.3.3 Describe what happens when the set switch, S_1, is pressed. (3)

3.3.4 Explain why threshold pin 6 is connected directly to ground. (3)

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

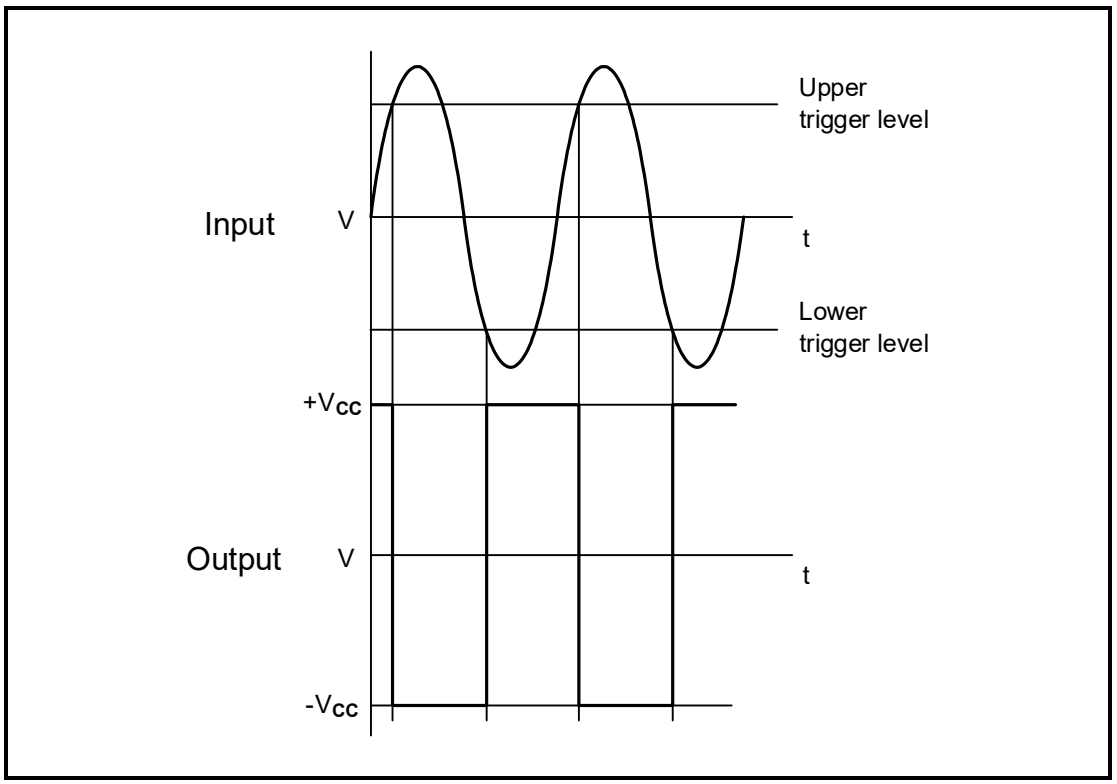

FIGURE 3.4: SCHMITT TRIGGER INPUT AND OUTPUT

3.4.1 State whether the output signal represents an inverting or a non-inverting Schmitt trigger. Motivate your answer. (3)

3.4.2 Draw the circuit diagram of the Schmitt trigger consisting of two resistors and a 741 op-amp that will produce the output signal in FIGURE 3.4. (7)

3.5 Refer to FIGURE 3.5 below and answer the questions that follow.

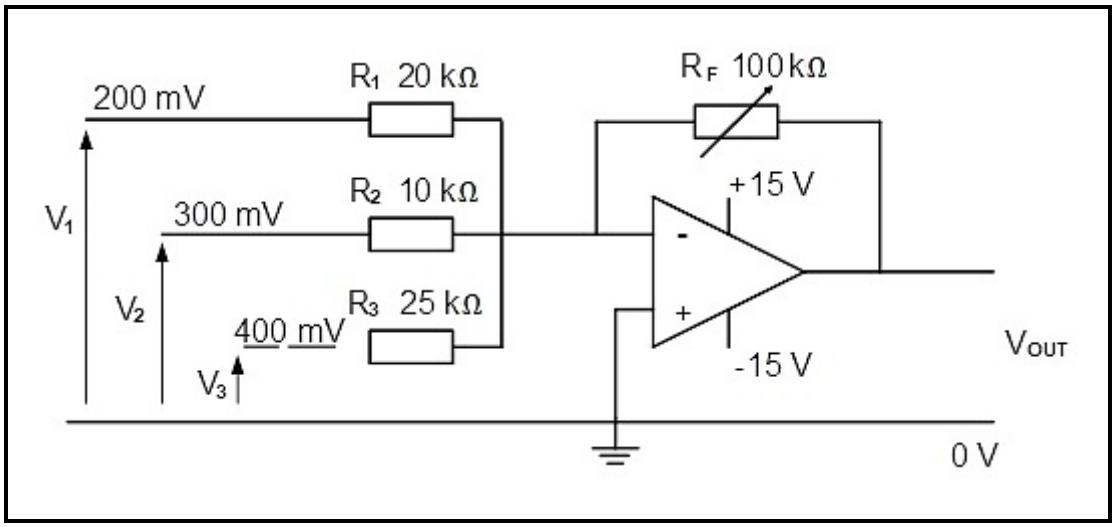

FIGURE 3.5: INVERTING SUMMING AMPLIFIER

Given:

V_1 = 200 mV
V_2 = 300 mV
V_3 = 400 mV
R_F = 100 kΩ
R_1 = 20 kΩ
R_2 = 10 kΩ
R_3 = 25 kΩ

3.5.1 Describe how the gain of this amplifier can be determined. (3)

3.5.2 Calculate the output voltage of the amplifier. (4)

3.5.3 Calculate the gain of the amplifier using voltage values. (3)

3.5.4 Explain the advantage of using a variable resistor in the feedback loop instead of a fixed resistor. (2)

3.5.5 What will happen to the output voltage if the value of R_2 is changed to 5 kΩ? (2)

3.6 Draw a circuit diagram of an op-amp integrator with input and output signals. (6)

3.7 Name THREE key operating points of the op-amp integrator circuit. (3)
[50]

QUESTION 4: SEMICONDUCTORS

4.1 Draw a neat IEC symbol of the 741-operational amplifier. (3)

4.2 Explain how a 100 mV sine wave signal would react if the gain of the circuit is 10 and the signal is connected to the ...

4.2.1 inverting input of the component. (2)

4.2.2 non-inverting input of the component. (2)

4.3 FIGURE 4.3 shows an inverting amplifier with an input and an output signal that are applied to the circuit. Study the circuit and then answer the questions that follow.

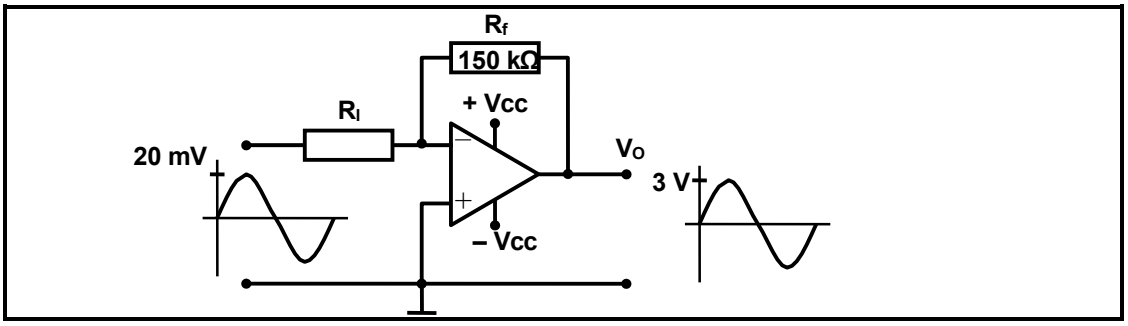

FIGURE 4.3

4.3.1 Is the output wave indicated correctly? Substantiate your answer. (2)

4.3.2 Calculate the value of the input resistor in the circuit. (3)

4.4 FIGURE 4.4 below shows the 555 IC. Answer the questions that follow.

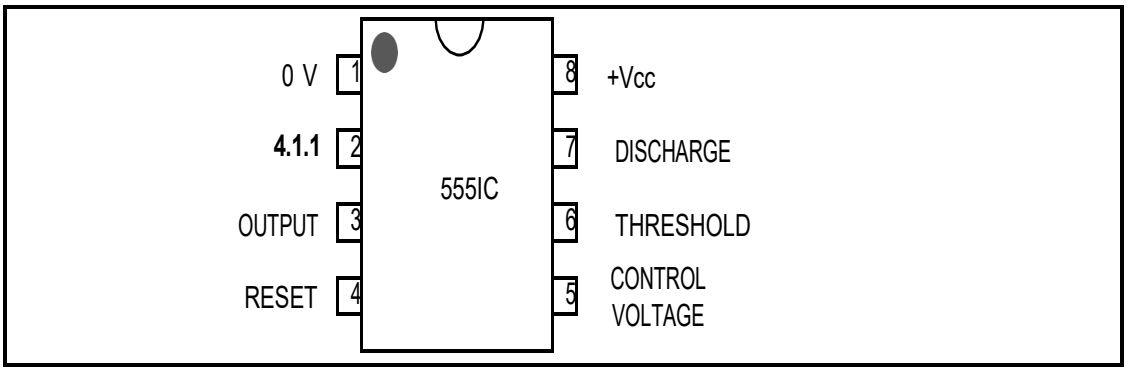

FIGURE 4.4 555 TIMER IC

4.4.1 Identify pin 2. (1)

4.4.2 Briefly describe the functions of pin 6 with reference to the 555 IC. (3)

4.4.3 State the supply voltage range at which the 555 IC operates. (2)

4.4.4 Explain the function of the SR flip-flop in the internal circuit of the 555 timer. (2)

[20]

QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

5.1 Explain the basic construction of a liquid crystal display (LCD). (4)

5.2 State and explain the difference between the two types of 7-segment LEDs that are available. (4)

5.3 State TWO maximum values that should be considered when working with a LED display unit. (2)

5.4 Answer the following questions with reference to encoders and decoders.

5.4.1 Complete the circuit diagram of a three-digit decimal input to two-bit binary output encoder on the ANSWER SHEET for QUESTION 5.4.1. (6)

5.4.2 FIGURE 5.4.2 below shows a circuit diagram of a two-digit binary input to four-digit decimal output decoder. Determine the output at **W**, **X**, **Y** and **Z** when input A is '0_2' and input B is '1_2'.

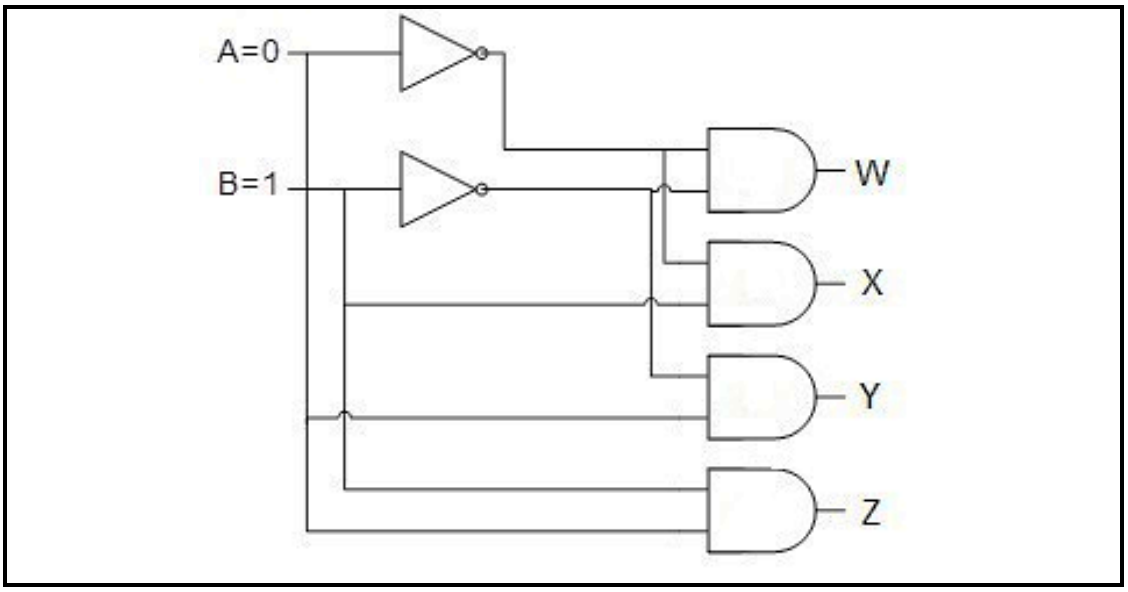

FIGURE 5.4.2 (4)

5.5 Draw a neatly labelled logic-gate diagram to show the composition of a full adder. (5)

5.6 FIGURE 5.6 below represents the logic symbol of a D-type flip-flop.

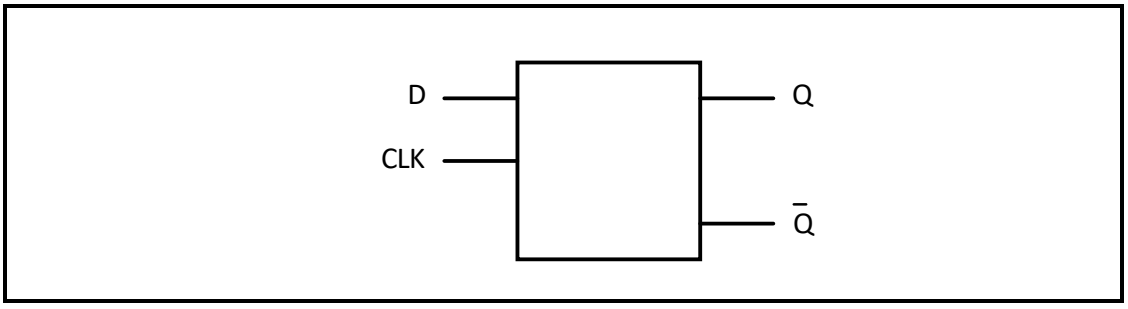

FIGURE 5.6

5.6.1 Complete the logic circuit of this flip-flop using the information given on the ANSWER SHEET for QUESTION 5.6.1. (6)

5.6.2 Complete the truth table of this flip-flop in the table below on the ANSWER SHEET for QUESTION 5.6.2.

INPUT		OUTPUT	
CLK	**D**	**Q**	$\overline{\mathbf{Q}}$
0	**0**	**LATCH**	
0	**1**		
1	**0**		
1	**1**		

TABLE 5.6.2 (3)

5.7 Refer to FIGURE 5.7 below of a three-stage binary counter and answer the questions that follow.

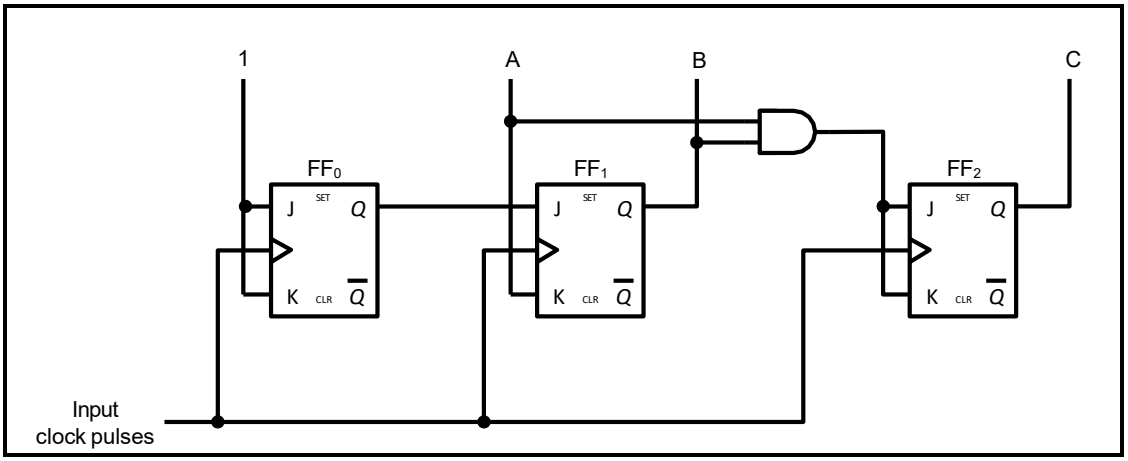

FIGURE 5.7

5.7.1 Complete the timing diagrams for this counter on the ANSWER SHEET for QUESTION 5.7.1. (8)

5.7.2 State whether the circuit in FIGURE 5.7 is synchronous or asynchronous. (1)

5.8 Discuss the difference in working principle between a *synchronous* and an *asynchronous ripple counter*. (4)

5.9 List THREE types of shift registers that are available. (3)

5.10 Draw a neatly labelled 3-bit series-in-parallel- out shift register by using D type-latches. (5)

[55]

QUESTION 6: MICROCONTROLLERS

6.1 Name TWO uses of a microcontroller in industrial control devices. (2)

6.2 Draw the sequential operating (scan) cycle of the CPU. (4)

6.3 Explain the difference between a *microprocessor* and a *microcontroller* with reference to the hardware of microcontrollers. (4)

6.4 Draw a neatly labelled block diagram showing the basic construction of a microcontroller. (6)

6.5 List THREE types of registers that are found in the central processing unit (CPU) of the microcontroller. (3)

6.6 Discuss the function of an analogue-to-digital converter in a microcontroller. (2)

6.7 Draw a labelled block diagram to show the basic layout of a full duplex communication system. (4)

6.8 Name TWO other communication systems in addition to simplex communication that are used in microcontrollers. (2)

6.9 Refer to registers within the CPU and answer the questions that follow.

6.9.1 Explain the function of a memory data register (MDR). (2)

6.9.2 Explain the function of a current instruction register (CIR). (3)

6.10 Give TWO disadvantages of a parallel communication system. (2)

6.11 Answer the questions that follow with reference to communication protocols.

6.11.1 Name THREE applications of the RS-485. (3)

6.11.2 State the line configuration of the RS-485. (1)

6.12 Discuss the difference between *legal* and *illegal data flow* within a flow chart. (4)

6.13 Complete the flow chart of a monitoring system at a fuel station on the ANSWER SHEET for QUESTION 6.13.

A fuel station has three tanks, each with a level-monitoring sensor. The sensors will be activated when the fuel level reaches the bottom of each tank. The alarm will sound if any of the sensors are activated. The system must include a reset function. NO time delay is needed. (8)

[50]

TOTAL: 200

LEARNER NAME: _____

ANSWER SHEET

QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

5.4.1

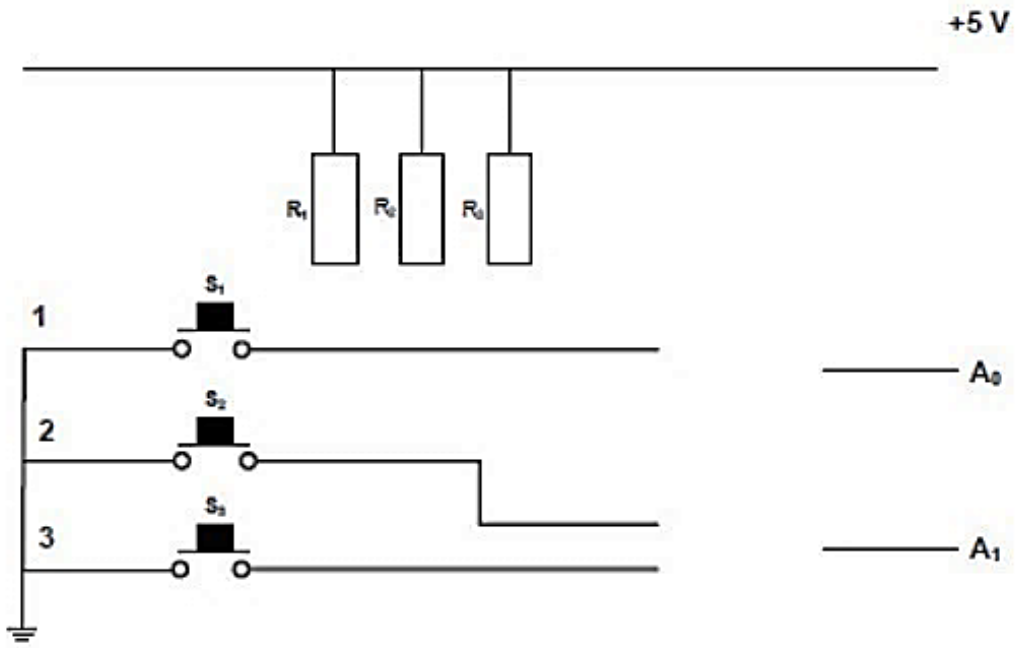

FIGURE 5.4.1 (6)

LEARNER NAME: _____

ANSWER SHEET

5.6.1

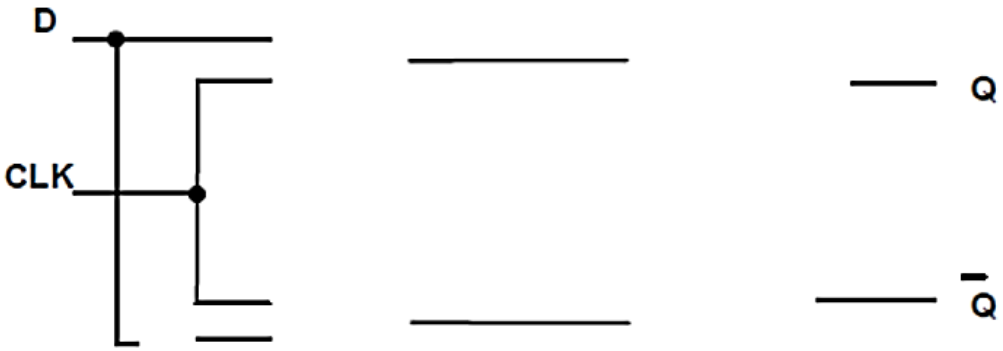

FIGURE 5.6.1 (6)

LEARNER NAME: _____

ANSWER SHEET

5.6.2

INPUTS		OUTPUTS	
CLK	D	Q	$\overline{Q}$
0	0	LATCH	
0	1		
1	0		
1	1		

(3)

TABLE 5.6.2

ANSWER SHEET

5.7.1

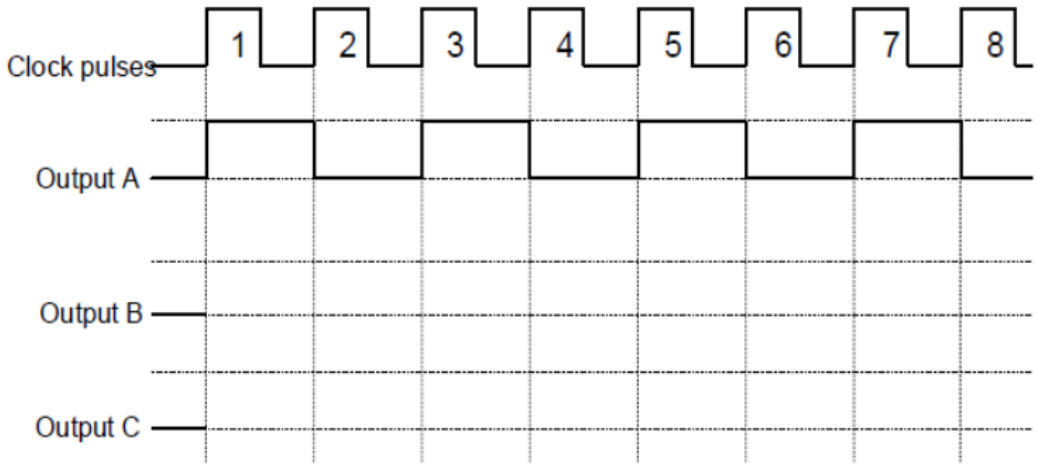

FIGURE 5.7.1 (8)

LEARNER NAME: _____

ANSWER SHEET

QUESTION 6: MICROCONTROLLERS

6.13

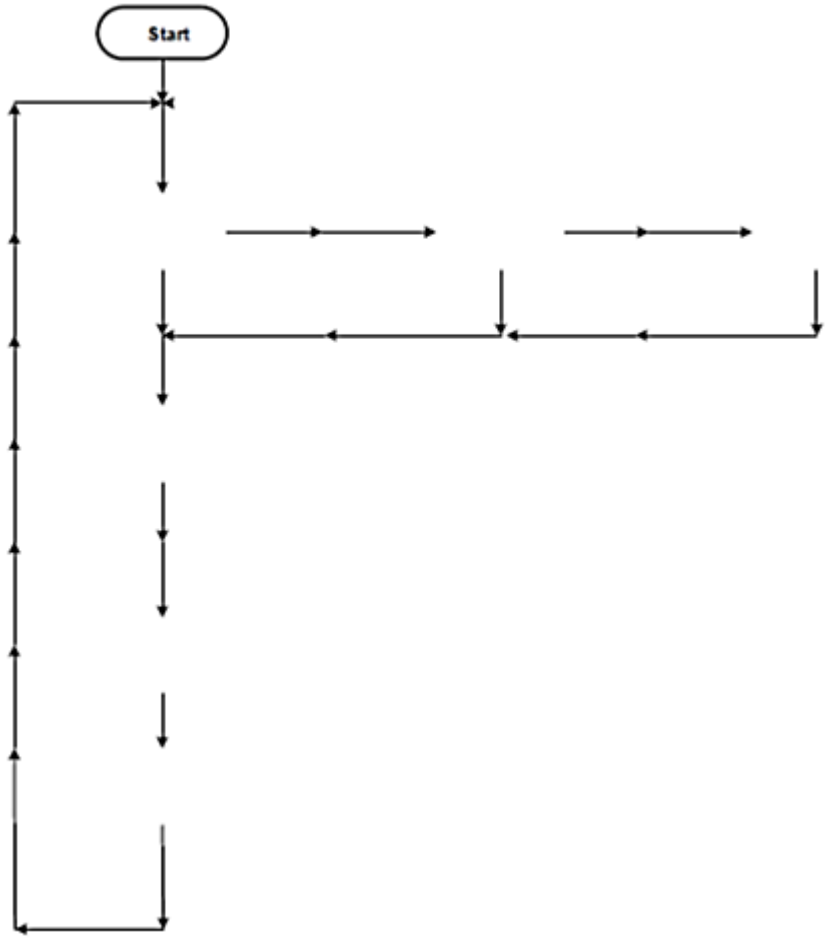

FIGURE 6.13 (8)

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. $f = \frac{1}{2\pi\sqrt{6RC}}$