Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2022

ELECTRICAL TECHNOLOGY: DIGITAL ELECTRONICS

MARKS: **200**

TIME: **3 hours**

This question paper consists of 19 pages, including a 1-page formula sheet and 5 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. Answer the following questions on the attached ANSWER SHEETS:

   QUESTION 5.3.2
   QUESTION 5.4
   QUESTION 5.5
   QUESTION 6.8

9. Write neatly and legible.

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 With reference to a monostable multivibrator, select the correct option:

A It is a free running oscillator
B It has ONE input
C The magnitude of the supply voltage determines the length the output is high
D It will stay high indefinitely (1)

1.3 An astable multivibrator has the following characteristics:

A Free running with NO external inputs
B Free running with TWO inputs
C TWO stable states with TWO inputs
D NO stable states with ONE input (1)

1.4 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)

1.5 A Schmitt trigger circuit works on the principle of:

A Inverting signals
B Amplifying signals
C Hysteresis
D Adding the signals together (1)

1.6 Pin 3 of a 555 Integrated Circuit (IC) is called:

A Vcc.
B Ground
C Output
D Input (1)

1.7 The maximum supply voltage for a 555 IC is:

A +15 V
B +12 V
C -12 V
D +5 V (1)

1.8 With reference to the LED seven segment display, common cathode refers to:

A The anodes of all eight LED's are connected to a common ground rail.
B The cathodes of all eight LED's are connected to a common positive rail.
C The anodes of all eight LED's are connected to a common positive rail.
D The cathodes of all eight LED's are connected to a common ground rail. (1)

1.9 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)

1.10 Active low latch flip-flop is also referred to as a …

A Master/Slave Latch.
B D Latch.
C $\overline{R}\overline{S}$ Latch.
D RS Latch. (1)

1.11 The ILLEGAL mode of operation for an Active High Latch (RS Latch) flip-flop occurs when:

A Both inputs are high
B Set input is high and Reset input is low
C Reset input is high and Set input is low
D Both inputs are low (1)

1.12 With reference to microcontrollers, a LED display would be an example of a(n) …

A output.
B input.
C controller.
D process. (1)

1.13 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)

1.14 With reference to microcontrollers, identify which ONE is NOT part of the microcontroller:

A Control Unit
B Serial Port
C Memory
D Arithmetic Logic Unit (1)

1.15 The term I^2C stands for:

A Inter-Integrated Circuit
B Integrated 2 Circuits
C Internal Inter Circuit
D Interconnected 2 Circuits (1)

[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 Define *major incident* with reference to the Occupational Health and Safety Act 1993. (2)

2.2 State ONE cause of unsafe acts in a workshop. (1)

2.3 Describe why the following are unsafe acts or unsafe conditions.

2.3.1 Running in the workshop (2)

2.3.2 Overloading electrical outlets with too many appliances (2)

2.4 Explain how you would conduct a qualitative risk analysis in your workshop at school. (3)

[10]

QUESTION 3: SWITCHING CIRCUITS

3.1 With reference to FIGURE 3.1 below, answer the following questions.

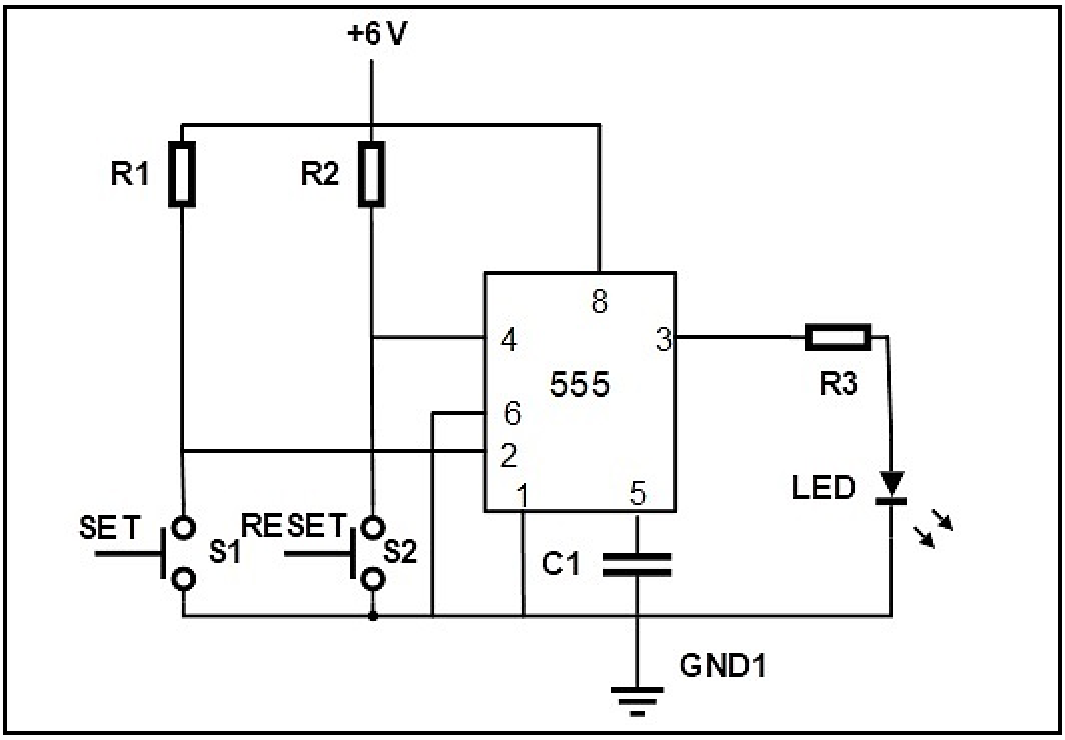

FIGURE 3.1: BI-STABLE MULTIVIBRATOR

3.1.1 Name TWO characteristics of the bi-stable multivibrator circuit in FIGURE 3.1 above. (2)

3.1.2 Explain what would happen in the circuit if R_3 were to be removed. (1)

3.1.3 Explain the importance (function) of R_3 in the circuit shown in FIGURE 3.1. (2)

3.1.4 Describe what happens when the SET switch, S_1 is pressed. (3)

3.1.5 Explain the function of R_1 and R_2 in the circuit. (2)

3.2 Draw a fully labelled circuit diagram for an astable multivibrator op amp circuit. (6)

3.3 With reference to the astable multivibrator op amp circuit, explain the term *feedback.* (3)

3.4 Name ONE application of a monostable multivibrator. (1)

3.5 Explain the principle of operation of a day/night switching circuit. (6)

3.6 Draw a fully labelled diagram of a typical hysteresis curve. (6)

3.7 Draw the output waveform of a 555 timer IC used as a Schmitt Trigger. Show at least TWO full cycles. (4)

3.8 FIGURE 3.8 and TABLE 3.8 below show the resistor values, output voltages and gain of a summing amplifier. Refer to FIGURE 3.8 and study TABLE 3.8 below to answer the following questions.

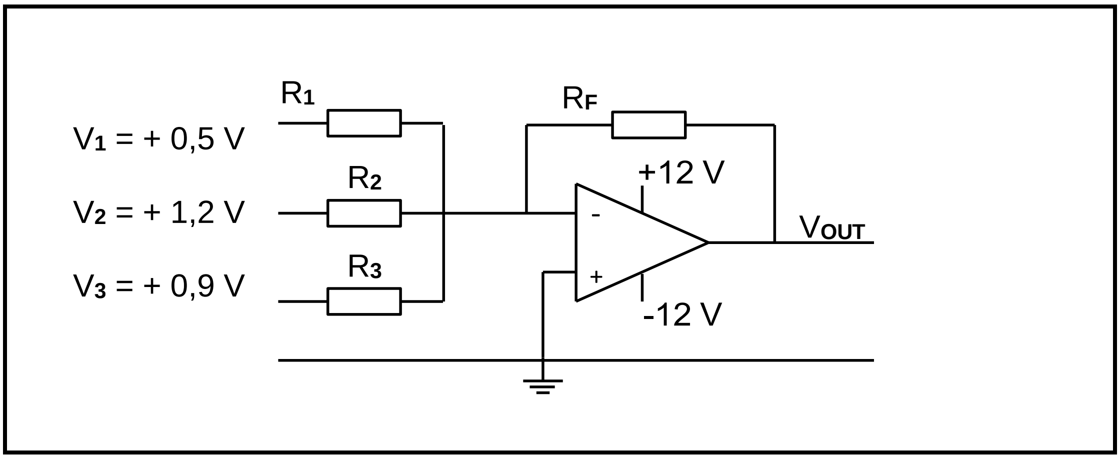

FIGURE 3.8: SUMMING AMPLIFIER

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 3.8

3.8.1 State the function of a summing amplifier. (2)

3.8.2 Calculate the output voltage at **B**. (3)

3.8.3 Calculate the output voltage at **C**. (3)

3.8.4 Calculate the value of the feedback at **A**. (3)

3.8.5 Calculate the total gain at **D**. (3)
[50]

QUESTION 4: SEMICONDUCTOR DEVICES

4.1 Name FOUR characteristics of an ideal operational amplifier. (4)

4.2 FIGURE 4.2 below shows the op amp as a non-inverting amplifier. Answer the questions that follow.

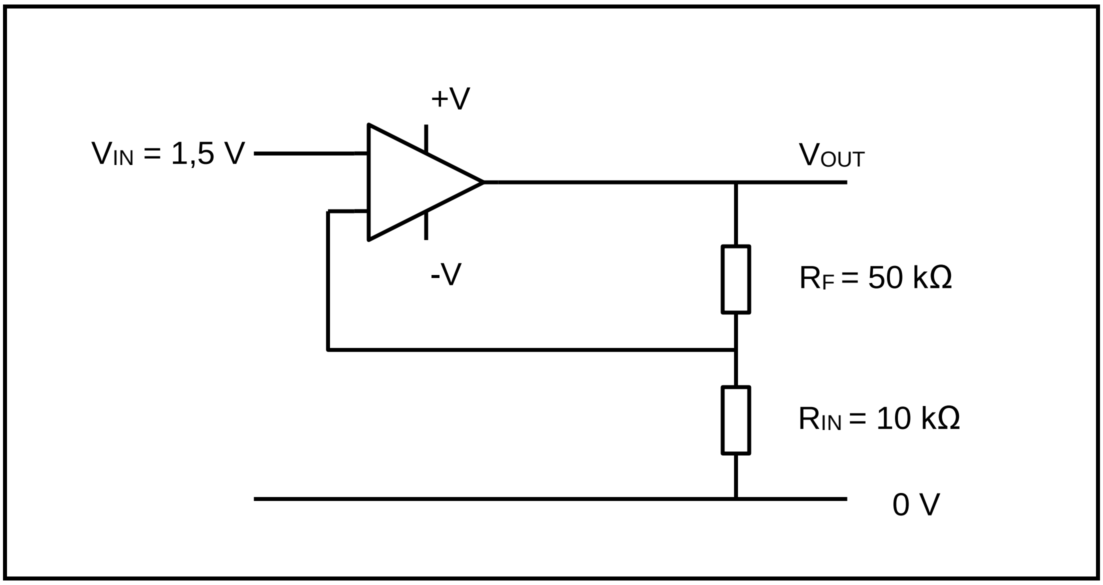

FIGURE 4.2: NON-INVERTING AMPLIFIER

Given:
V_{IN} = 1,5 V
R_F = 50 kΩ
R_{IN} = 10 kΩ

4.2.1 Calculate the voltage gain in FIGURE 4.2. (3)

4.2.2 Calculate the output voltage. (3)

4.2.3 Describe the effects of decreasing the feedback resistor. (2)

4.3 With reference to the 555 timer IC, answer the questions below.

4.3.1 Explain the function of pin 6 (threshold) on a 555 IC. (3)

4.3.2 State the voltage parameters between which a 555 timer can operate. (2)

4.3.3 Explain the astable mode of operation of a 555 timer. (2)

4.3.4 Name ONE method to identify pin 1. (1)

[20]

QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

5.1 Name TWO methods to display information in digital systems. (2)

5.2 Refer to transistor coupling as used in LED seven-segment displays and identify the circuit in FIGURE 5.2 below. (2)

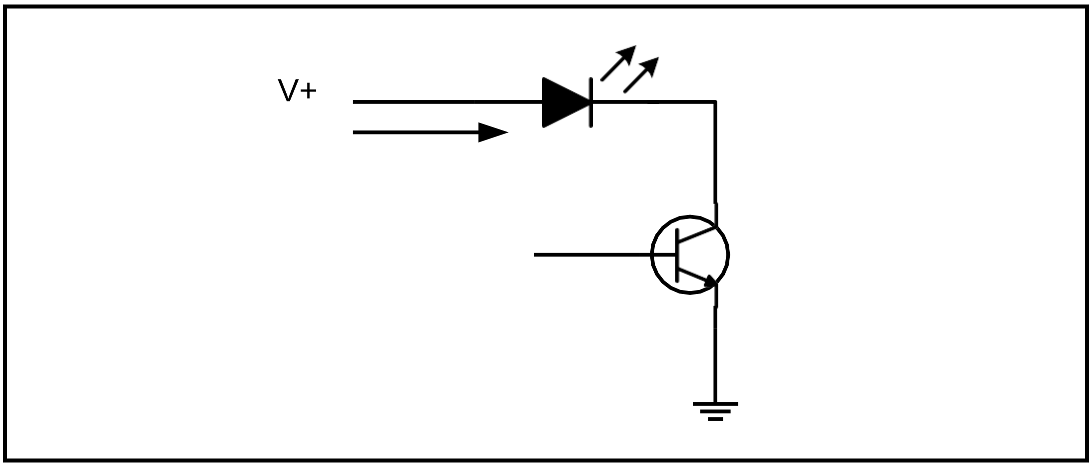

FIGURE 5.2

5.3 Refer to FIGURE 5.3 below and answer the questions that follow.

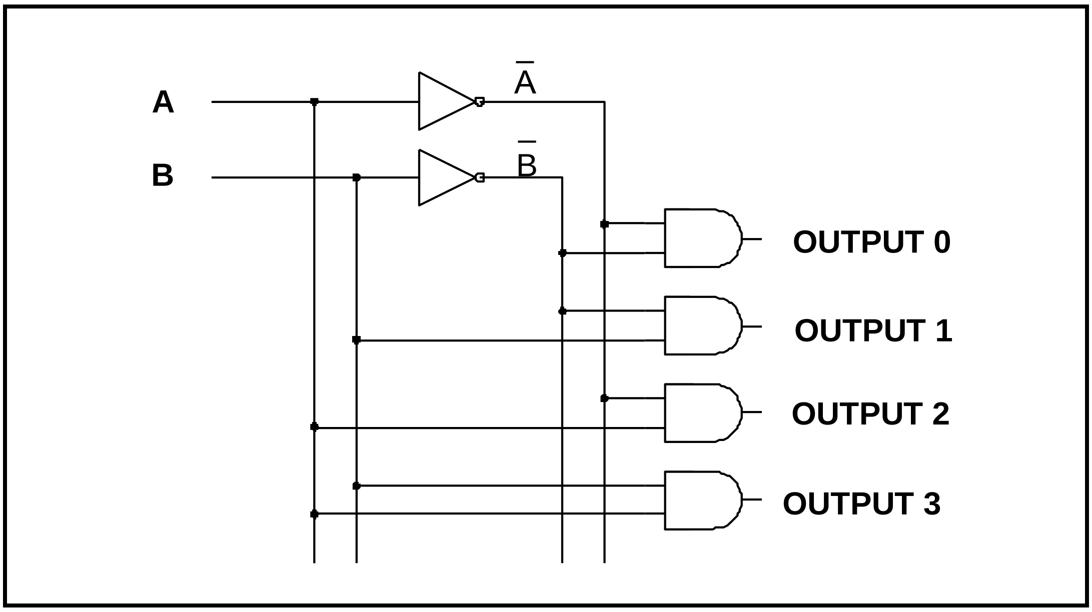

FIGURE 5.3

5.3.1 Identify the circuit in FIGURE 5.3. (1)

5.3.2 Complete the truth table of FIGURE 5.3 on the ANSWER SHEET for QUESTION 5.3.2. (3)

5.4 On the ANSWER SHEET for QUESTION 5.4, draw the logic circuit of a full adder using AND gates, exclusive OR gates and an OR gate. (8)

5.5 FIGURE 5.5 below shows a clocked RS flip-flop. Complete the output waveforms on the ANSWER SHEET for QUESTION 5.5.

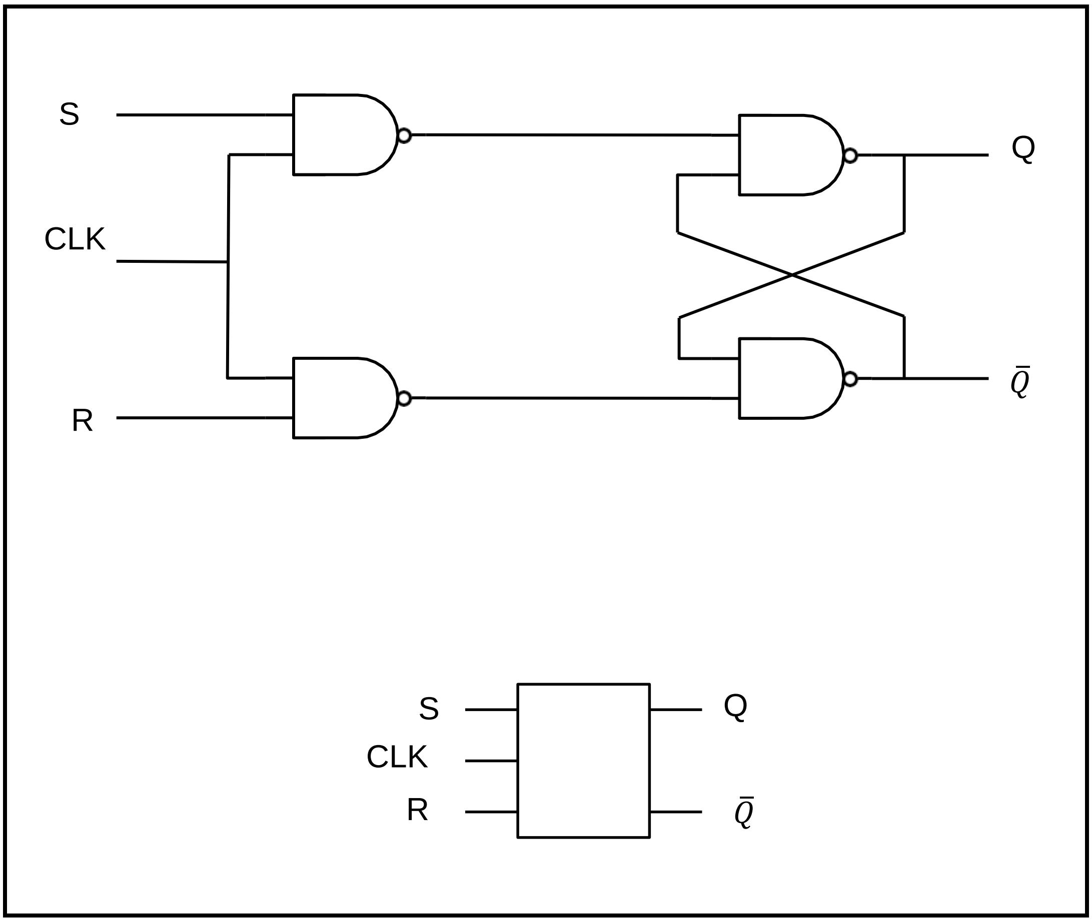

FIGURE 5.5: CLOCKED RS FLIP-FLOP (4)

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

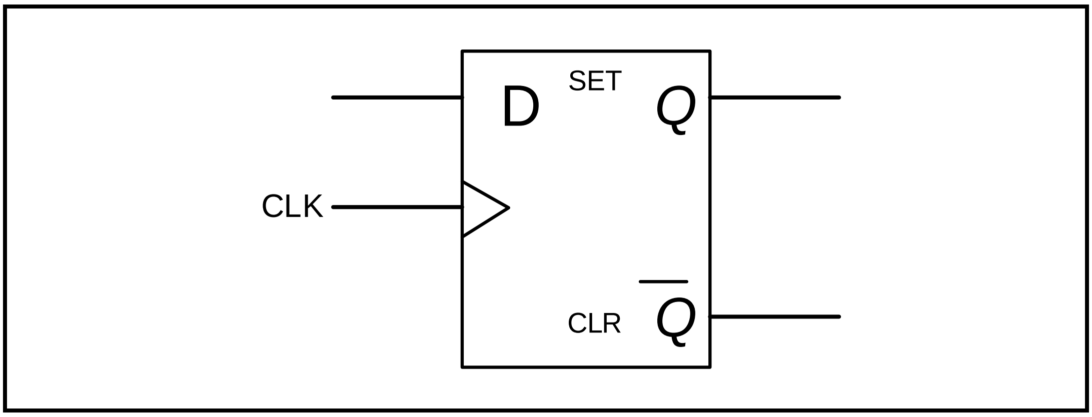

FIGURE 5.6: FLIP-FLOP

5.6.1 Identify the flip-flop in FIGURE 5.6. (1)

5.6.2 Explain how the circuit is designed to eliminate any illegal states in the operation of this flip-flop. (4)

5.6.3 Name TWO applications of this type of flip-flop. (2)

5.7 FIGURE 5.7 below shows a three-stage asynchronous ripple counter. Answer the questions that follow.

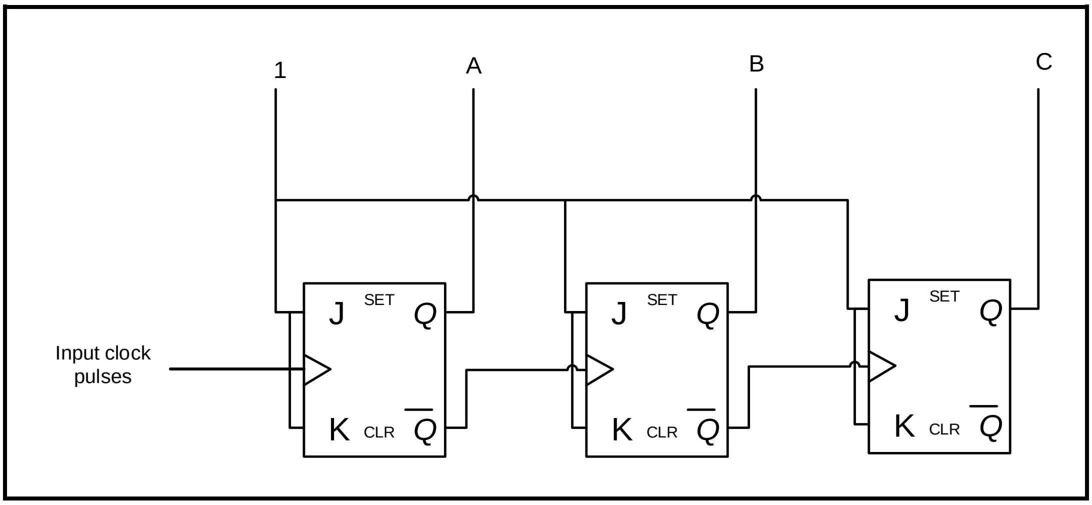

FIGURE 5.7: ASYNCHRONOUS RIPPLE COUNTER

5.7.1 Explain the principle of operation of the circuit in FIGURE 5.7. (8)

5.7.2 Explain why this counter in FIGURE 5.7 is referred to as an asynchronous counter. (2)

5.7.3 State the maximum number, in decimal numbers, that this counter in FIGURE 5.7 can count to. (3)

5.7.4 Explain why this counter in FIGURE 5.7 is referred to as a ripple counter. (2)

5.8 Refer to FIGURE 5.8 below which is a block diagram of a serial-in: serial-out shift register and answer the questions that follow.

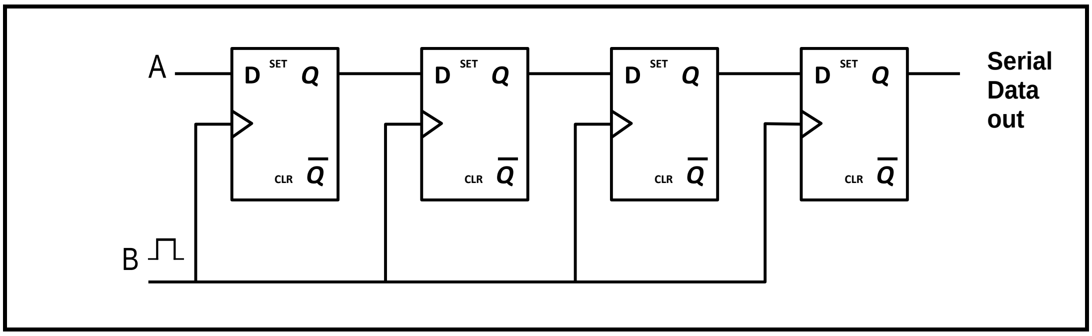

FIGURE 5.8

5.8.1 Label **A** and **B**. (2)

5.8.2 Explain the principle of operation of this register. (5)

5.9 Explain the difference between *combinational logic circuits* and *sequential logic circuits* with regards to their basic building elements. (2)

5.10 Name TWO types of shift registers, other than the serial-in: serial-out shift register, that are used in digital electronic circuits. (2)

5.11 Explain the term *truncated counter.* (2)
[55]

QUESTION 6: MICROCONTROLLERS

6.1 Refer to the block diagram in FIGURE 6.1 below and answer the questions that follow.

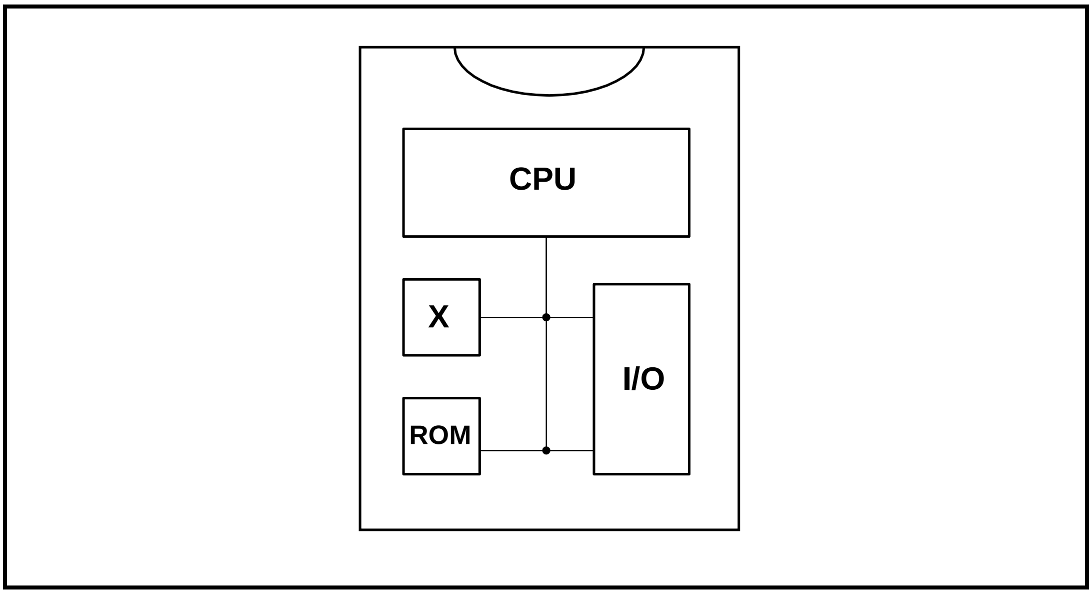

FIGURE 6.1

6.1.1 Identify the block diagram in FIGURE 6.1. (1)

6.1.2 Identify component **X**. (1)

6.1.3 Write out the abbreviation ROM in full. (1)

6.1.4 Explain the function of the RAM. (2)

6.2 Answer the questions with reference to the hardware of a microcontroller.

6.2.1 Explain the term *discreet logic*. (2)

6.2.2 Explain the term *integrated logic*. (2)

6.3 Answer the questions with refence to the registers of a CPU.

6.3.1 Name ONE type of special-purpose register. (1)

6.3.2 Describe the function of an accumulator. (2)

6.4 Answer the following questions with reference to communication in a microcontroller.

6.4.1 Explain the function of the system bus. (3)

6.4.2 Name the THREE busses in a microcontroller. (3)

6.4.3 State TWO advantages of synchronous communication when compared to asynchronous communication. (2)

6.4.4 State TWO disadvantages of parallel communication when compared to serial communication. (2)

6.5 Answer the following questions with reference to RS-485 communication protocol.

6.5.1 State the logic operating values which is represented by -200 mV and 200 mV. (2)

6.5.2 State THREE applications of the RS-485. (3)

6.5.3 Explain the differences between *simplex communication* and *half duplex communication.* (4)

6.6 Answer the following questions with reference to the software of microcontrollers.

6.6.1 Explain the difference between an *algorithm* and a *program*. (4)

6.6.2 Explain the term *looping (repetition).* (2)

6.7 Answer the following questions with reference to data flow diagram symbols in PICAXE.

6.7.1 Explain the function of the symbol referred to in FIGURE 6.7.1. (2)

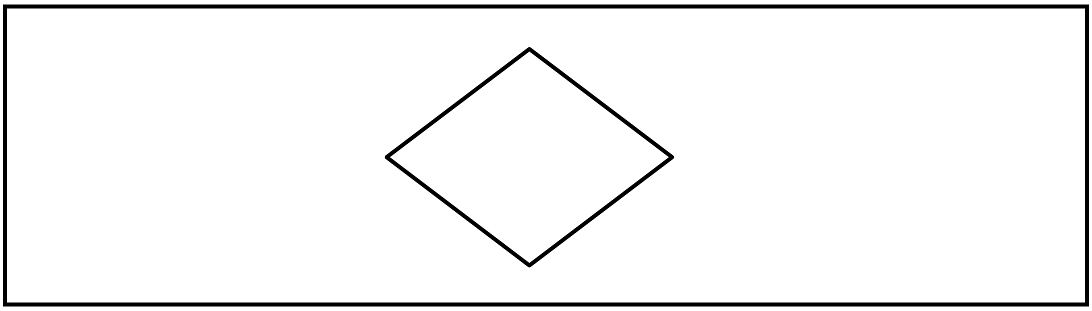

FIGURE 6.7.1

6.7.2 Explain where a terminator symbol will be used in a flowchart. (1)

6.8 Study the PICAXE circuit in FIGURE 6.8 below and design a flow diagram for the circuit. Complete your answer on the ANSWER SHEET for QUESTION 6.8.

SCENARIO:

When the on/off switch is activated, the program must execute as follows:

a S_3 must be pushed to activate the OUTPUT LED (the LED will come on for either 5 or 2 seconds). S_3 is a push-button.

b S_2 must be used to select one of TWO timers (one set to 5 seconds and the other to 2 seconds). S_2 is a toggle switch.

c S_1 must allow the user to repeat the program or to stop it. S_1 is a toggle switch.

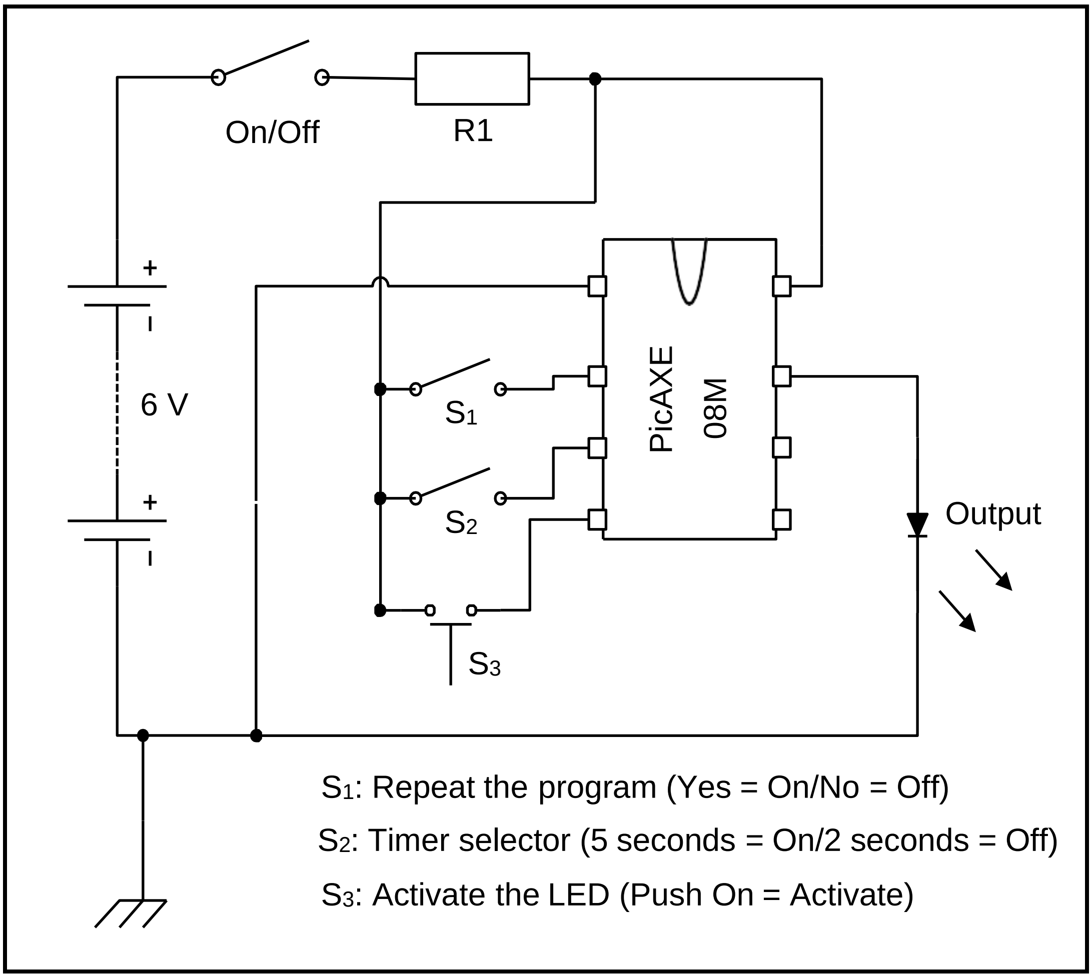

FIGURE 6.8: PICAXE CIRCUIT (10)

[50]

TOTAL: 200

FORMULA SHEET

SWITCHING CIRCUITS

1. $\text{Gain } A_V = \frac{V_{OUT}}{V_{IN}} = -\left(\frac{R_f}{R_{in}}\right)$ inverting operational amplifier

2. $\text{Gain } A_V = \frac{V_{OUT}}{V_{IN}} = 1 + \left(\frac{R_f}{R_{in}}\right)$ 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. $f = \frac{1}{2\pi\sqrt{6RC}}$

ANSWER SHEET 5.3.2

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QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

5.3.2

Inputs		**Outputs**			
A	**B**	**0**	**1**	**2**	**3**
0	0	1	0	0	0
0	1	0	1		0
1	0	0	0	1	
1	1	0	0	0	

ANSWER SHEET 5.4

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QUESTION 5.4

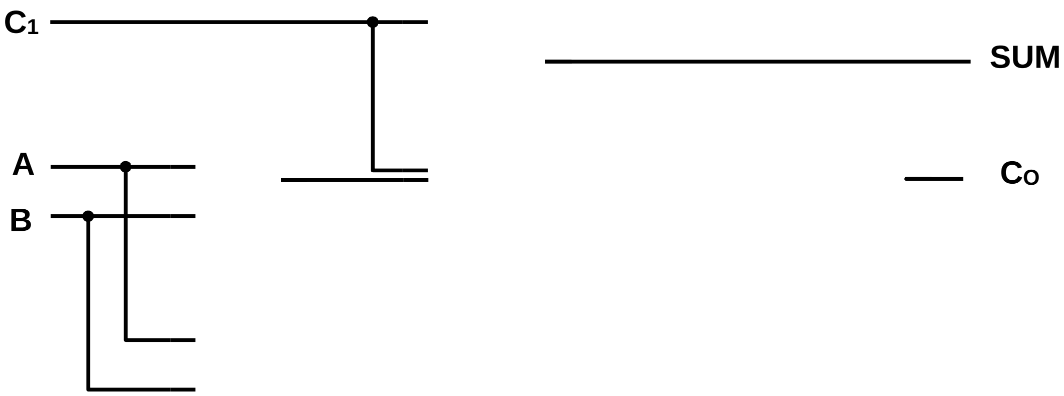

FIGURE 5.4

ANSWER SHEET 5.5

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QUESTION 5.5

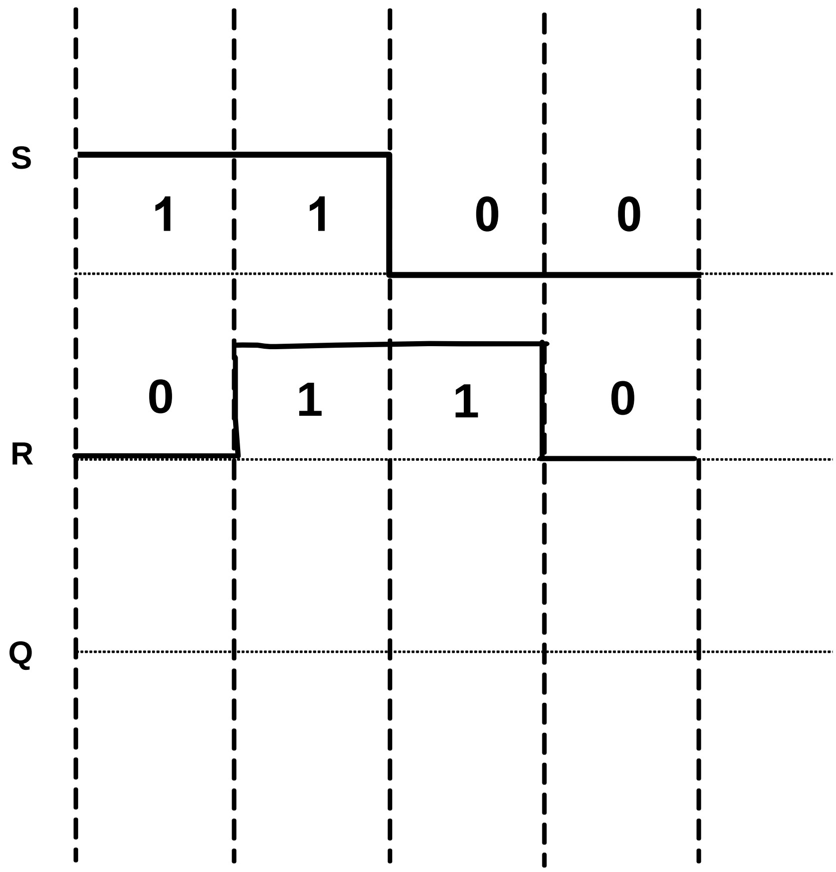

FIGURE 5.5

ANSWER SHEET 6.8

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QUESTION 6.8