basic education

Department:
Basic Education
**REPUBLIC OF SOUTH AFRICA**

# SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

## ELECTRICAL TECHNOLOGY: DIGITAL ELECTRONICS

## MAY/JUNE 2025

**MARKS: 200**

**TIME: 3 hours**

**This question paper consists of 18 pages, including a 1-page formula sheet and an 8-page answer sheet.**

## INSTRUCTIONS AND INFORMATION

1. This question paper consists of SIX questions.

2. Answer ALL the questions.

3. Answer the following questions on the attached ANSWER SHEETS:

   QUESTIONS 3.3.3, 3.4 and 3.5.2
   QUESTION 4.2.2
   QUESTIONS 5.3.2, 5.4.1, 5.4.2, 5.5.1, 5.5.2 and 5.8.3
   QUESTION 6.6.2 and 6.8

4. Write your centre number and examination number on every ANSWER SHEET and hand them in with your ANSWER BOOK, whether you have used them or not.

5. Sketches and diagrams must be large, neat and FULLY LABELLED.

6. Show ALL calculations and round off answers correctly to TWO decimal places.

7. Number the answers correctly according to the numbering system used in this question paper.

8. You may use a non-programmable calculator.

9. Calculations must include the following:

   9.1 Formulae and manipulations where needed

   9.2 Correct replacement of values

   9.3 Correct answer and relevant units, where applicable

10. A formula sheet is attached at the end of this question paper.

11. Write neatly and legibly. 2025

## QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided 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, e.g. 1.16 D.

1.1 A critical incident is an event where …

A a learner is injured without requiring first aid.
B pain is caused due to a soldering iron burn.
C a learner is injured and external emergency assistance is needed.
D the skin turns red when rinsing etching acid with water after a minor spillage. (1)

1.2 In a 555 timer, connected as an astable multivibrator, the … determine(s) the frequency of the output waveform.

A external trigger pulse width
B duty cycle set by the control voltage
C values of the external resistors and capacitor
D supply voltage to the 555 timers (1)

1.3 The purpose of the feedback resistor in an inverting summing amplifier is to …

A set the input impedance of the amplifier.
B ensure that the output voltage is zero when all input voltages are zero.
C increase the output impedance.
D determine the gain of the amplifier for the input signals fed to it. (1)

1.4 In a Schmitt trigger circuit, the term 'hysteresis' refers to the …

A delay between the input and output signals.
B amplification factor of the op amp.
C time lag between cause and effect.
D frequency response of the circuit. (1)

1.5 Introducing an op amp to the passive RC differentiator circuit …

A produces an output voltage proportional to the integral of the input voltage.
B improves input and output impedances.
C provides 100% feedback.
D filters out high-frequency noise. (1)

1.6 When a signal is applied to the inverting input terminal of an op amp, the … provide a phase shift.

A band-pass filters
B electrostatic charges
C internal amplifier circuits
D temperature measurements (1)

1.7 With reference to the supply voltage of a 555 IC and a 741 op amp, the …

A 741 op amp uses a dual voltage supply to amplify only negative signals.
B 555 IC uses a dual voltage supply to amplify both positive and negative signals.
C 555 IC uses the dual voltage supply to amplify only positive signals.
D 741 op amp uses a dual voltage supply to amplify both positive and negative signals. (1)

1.8 Two forms of connecting the LEDs of a seven-segment display internally is known as common …

A anode.
B cathode.
C A and B
D sourcing and sinking. (1)

1.9 A register where each bit shifts one place to the right until the complete four-bit value is stored in the register is known as a … register.

A parallel-in: parallel-out
B serial-in: serial-out
C parallel-in: serial-out
D serial-in: parallel-out (1)

1.10 … is the time it takes for the output of one flip-flop to reach the input of the next flip-flop in asynchronous counters.

A Propagation delay
B Frequency divider
C The counter's modulus
D Negative edge triggering (1)

1.11 In a J-K flip-flop, toggling is obtained 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)

1.12 The register in a microcontroller that stores a copy of the current instruction to be executed is known as the …

A program counter.
B memory address register.
C memory data register.
D current instruction register. (1)

1.13 Microcontrollers used in everyday devices include …

A light sensing and control devices.
B washing machines.
C fire-detection devices.
D All the above-mentioned (1)

1.14 The microcontroller bus that is used mainly for the CPU to issue instructions to both memory and input/output ports is known as the … bus.

A address
B system
C data
D control (1)

1.15 A pictorial representation of the sequence of steps and decisions in a computer programme to perform and complete processes is known as a/an …

A algorithm.
B flow chart.
C instruction.
D flow diagram. (1)
**[15]**

## QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 Define *health and safety equipment*. (2)

2.2 State TWO unsafe acts, regarding safety equipment, that are forbidden in an electrical technology workshop. (2)

2.3 State the purpose of the Occupational Health and Safety Act, 1993 (Act 85 of 1993). (2)

2.4 Explain why it is important for employers to inform employees about health and safety at the workplace. (2)

2.5 Briefly explain why discipline is considered an important work ethic with reference to the electrical technology workshop. (2)
**[10]**

## QUESTION 3: SWITCHING CIRCUITS

3.1 Explain the term *astable* with reference to multivibrator circuits. (2)

3.2 FIGURE 3.2 below shows a bistable multivibrator circuit with pushbutton switches on the input and monitored by two voltmeters on the output. Answer the questions that follow.

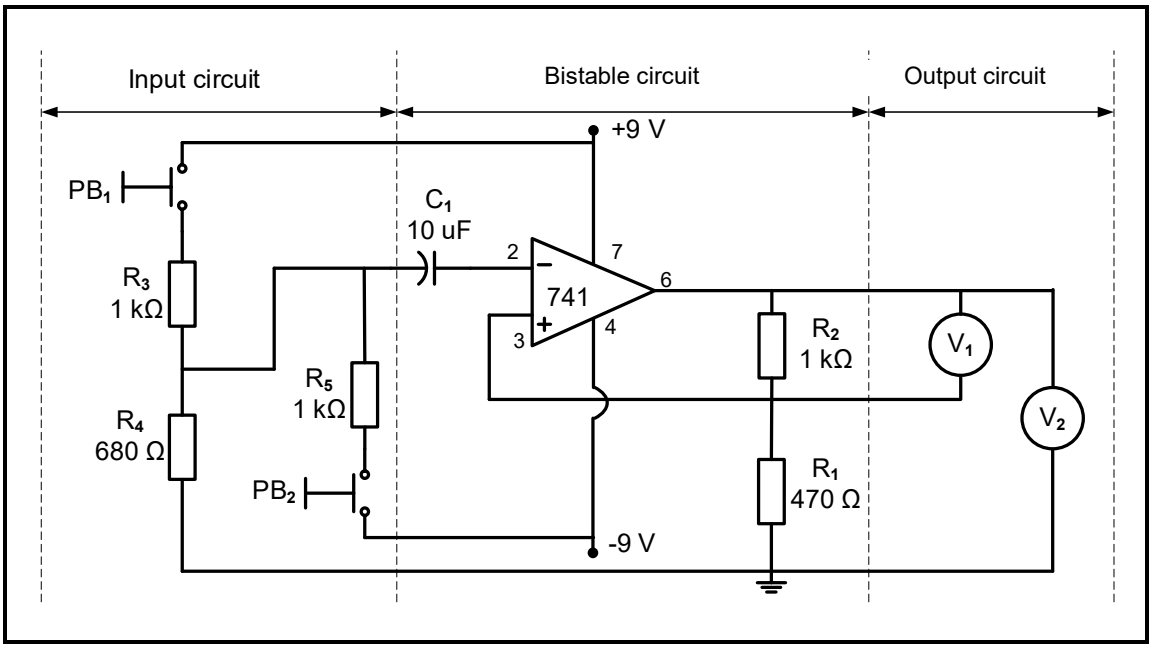



**FIGURE 3.2: BISTABLE MULTIVIBRATOR**

3.2.1 With reference to the input circuit, state why this is a bistable multivibrator circuit. (1)

3.2.2 State the purpose of $R_1$ and $R_2$. (2)

3.2.3 Explain the operation of the circuit in FIGURE 3.2 above when $PB_1$ is pressed. (4)

3.2.4 With reference to FIGURE 3.2.4 below, explain why the output did not change at trigger pulse 2.

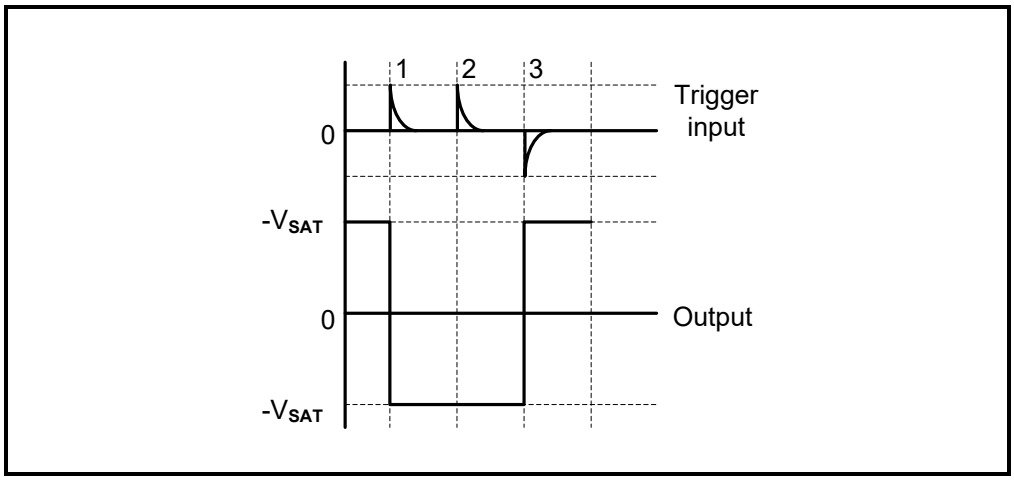



**FIGURE 3.2.4: BISTABLE INPUT vs OUTPUT SIGNALS** (2)

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

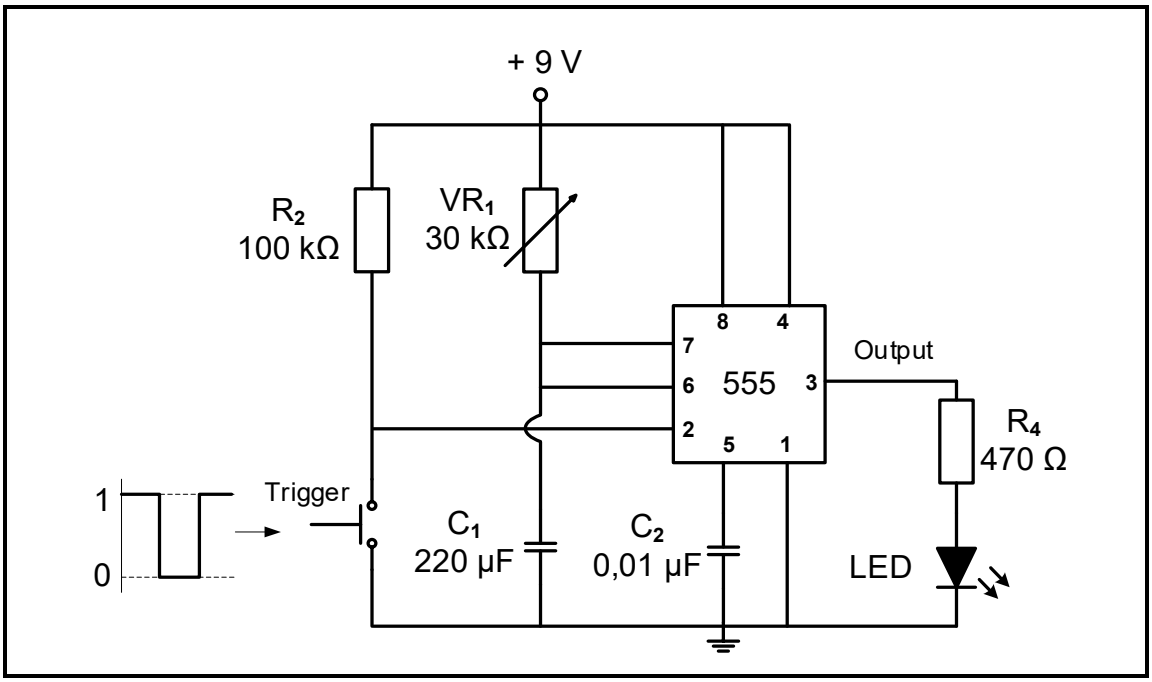



**FIGURE 3.3: MONOSTABLE MULTIVIBRATOR CIRCUIT**

3.3.1 Explain the purpose of $R_2$. (2)

3.3.2 Explain how the circuit in FIGURE 3.3 above can be improved to provide protection for pin 7 and pin 6. (2)

3.3.3 Draw the waveforms for the voltage across the capacitor and the correlating output on the ANSWER SHEET for QUESTION 3.3.3, when the variable resistor ($VR_1$) is set to 10 kΩ.

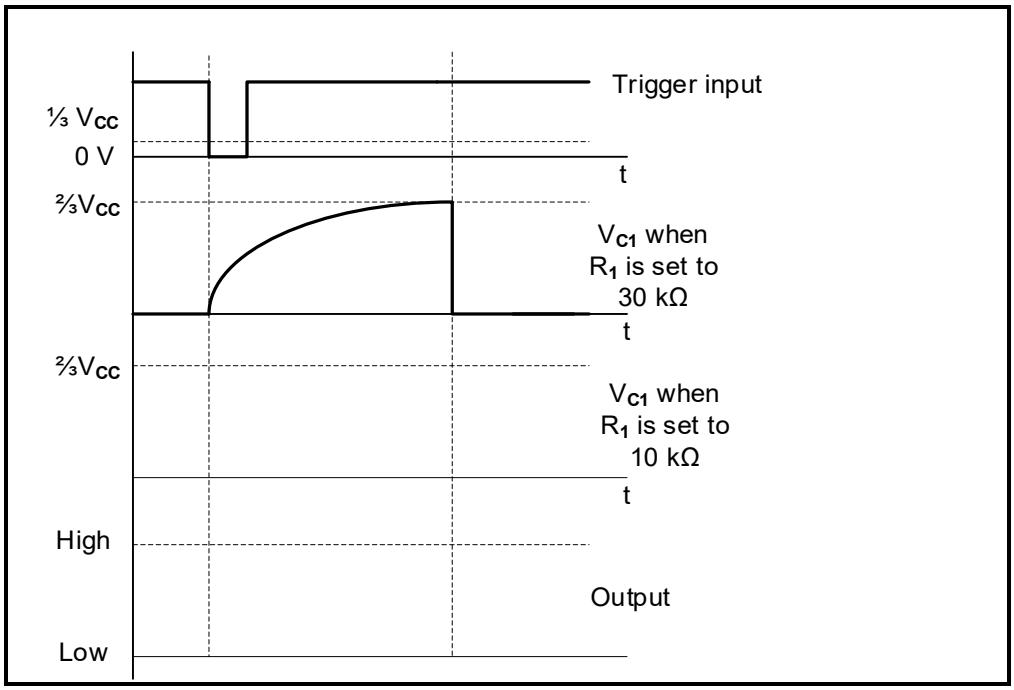



**FIGURE 3.3.3** (5)

3.4 Refer to FIGURE 3.4 below and complete the drawing by using the components in TABLE 3.4 on the ANSWER SHEET for QUESTION 3.4 to create an astable multivibrator.

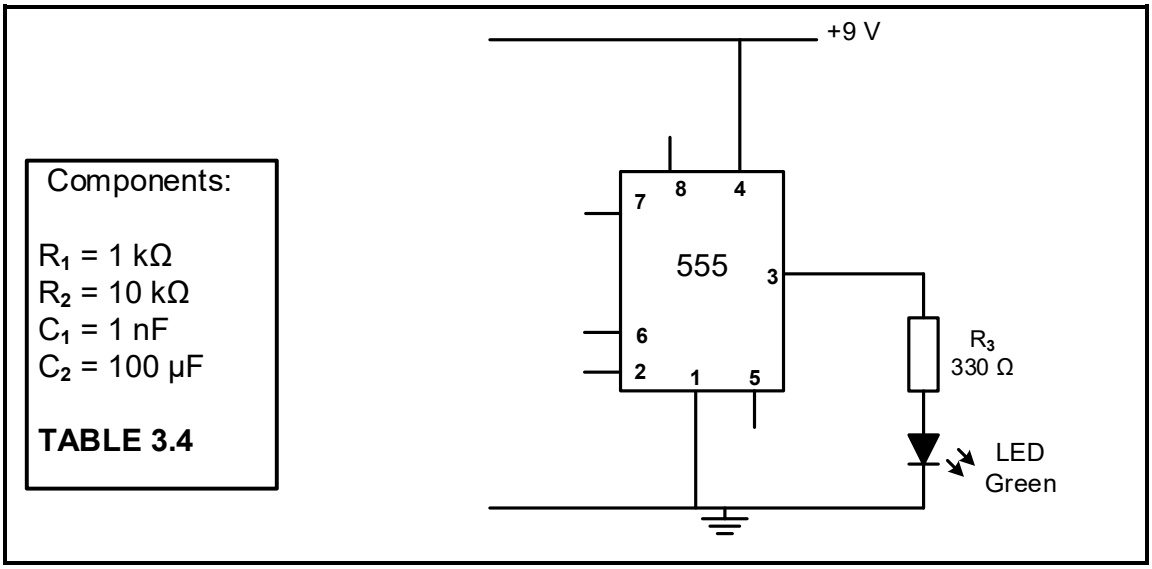



**FIGURE 3.4: 555 IC PARTIAL ASTABLE CIRCUIT** (8)

3.5 FIGURE 3.5 below shows the basic circuit diagram of a Schmitt trigger. Answer the questions that follow.

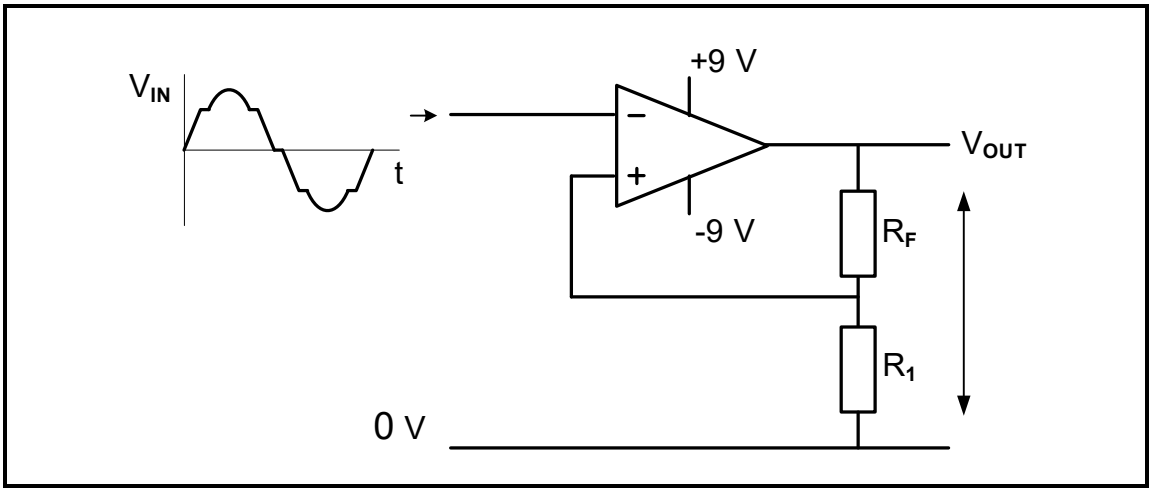



**FIGURE 3.5: INVERTING SCHMITT TRIGGER**

3.5.1 State TWO applications of Schmitt trigger circuits. (2)

3.5.2 Draw the output signal for the circuit in FIGURE 3.5 above on the ANSWER SHEET for QUESTION 3.5.2. (4)

3.6 Differentiate between a *Schmitt trigger* and a *comparator* with reference to their operation. (6)

3.7 FIGURE 3.7 and TABLE 3.7 below show the resistor values, output voltages and gain of a summing amplifier. Refer to FIGURE 3.7 and study TABLE 3.7 to answer the questions that follow.

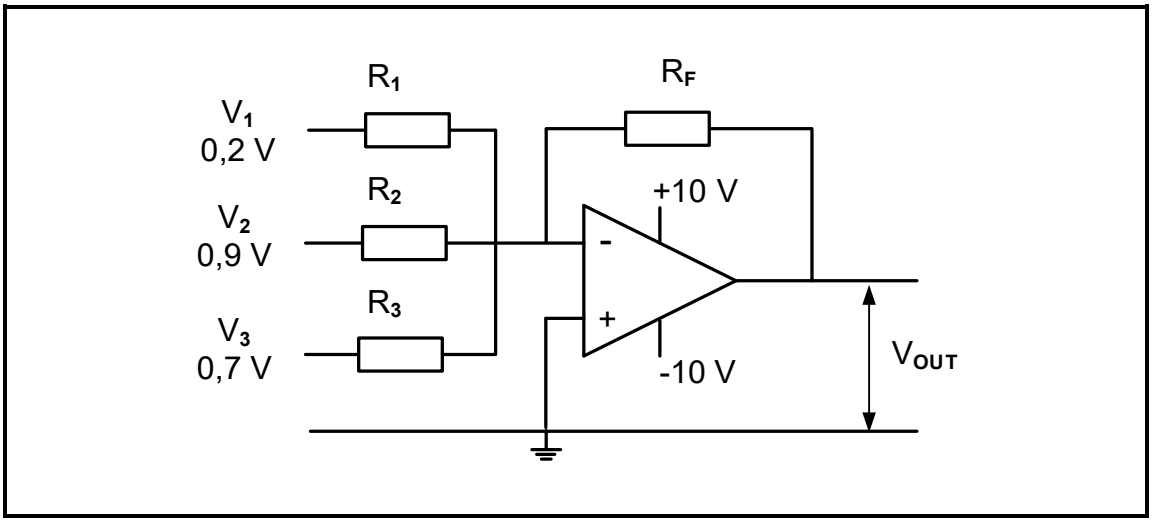



**FIGURE 3.7: SUMMING AMPLIFIER**

| RESISTOR VALUES | | | | OUTPUT | GAIN |
|---|---|---|---|---|---|
| **$R_1$** | **$R_2$** | **$R_3$** | **$R_F$** | **$V_{OUT}$** | **β ($A_V$)** |
| 10 kΩ | 10 kΩ | 10 kΩ | **A** | -1,8 V | **B** |
| 33 kΩ | 33 kΩ | 33 kΩ | 100 kΩ | **C** | -3,03 |
| 20 kΩ | 20 kΩ | 20 kΩ | 100 kΩ | -9 V | **D** |

**TABLE 3.7**

3.7.1 Determine the value of the feedback resistor at **A** in TABLE 3.7 above. (1)

3.7.2 Determine the gain at **B** in TABLE 3.7 above. (1)

3.7.3 Calculate the output voltage at **C** in TABLE 3.7 above. (3)

3.7.4 Calculate the gain at **D** in TABLE 3.7 above. (3)

3.8 State TWO key operating principles of the op amp integrator circuit. (2)
**[50]**

## QUESTION 4: SEMICONDUCTOR DEVICES

4.1 Refer to FIGURE 4.1 below and answer the questions that follow.

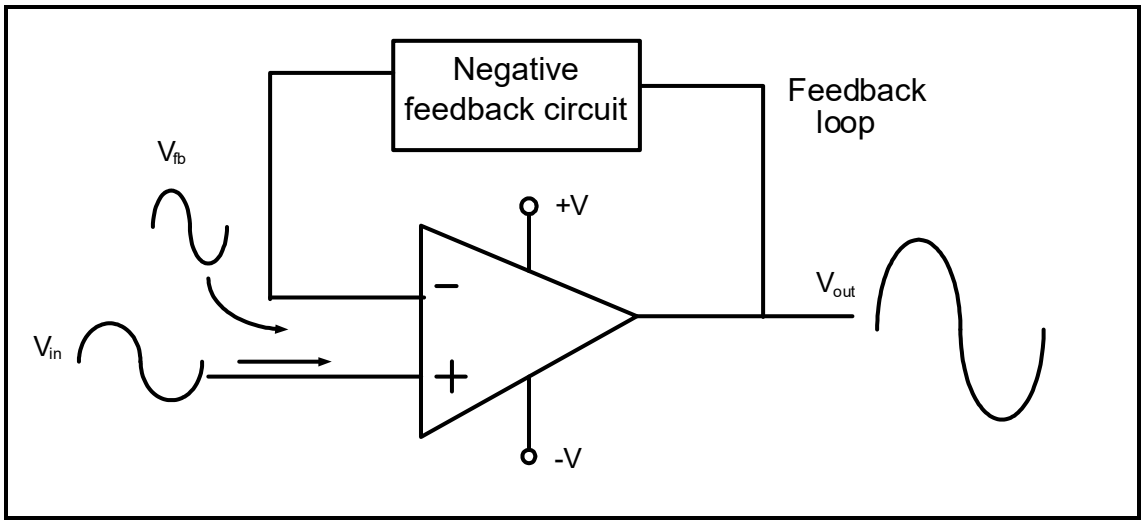



**FIGURE 4.1: FEEDBACK OF OP AMP**

4.1.1 State what would happen to the amplitude of the output signal when negative feedback is increased. (1)

4.1.2 Briefly describe the effect of the negative feedback circuit in FIGURE 4.1 above. (2)

4.2 Refer to FIGURE 4.2 below and answer the questions that follow.

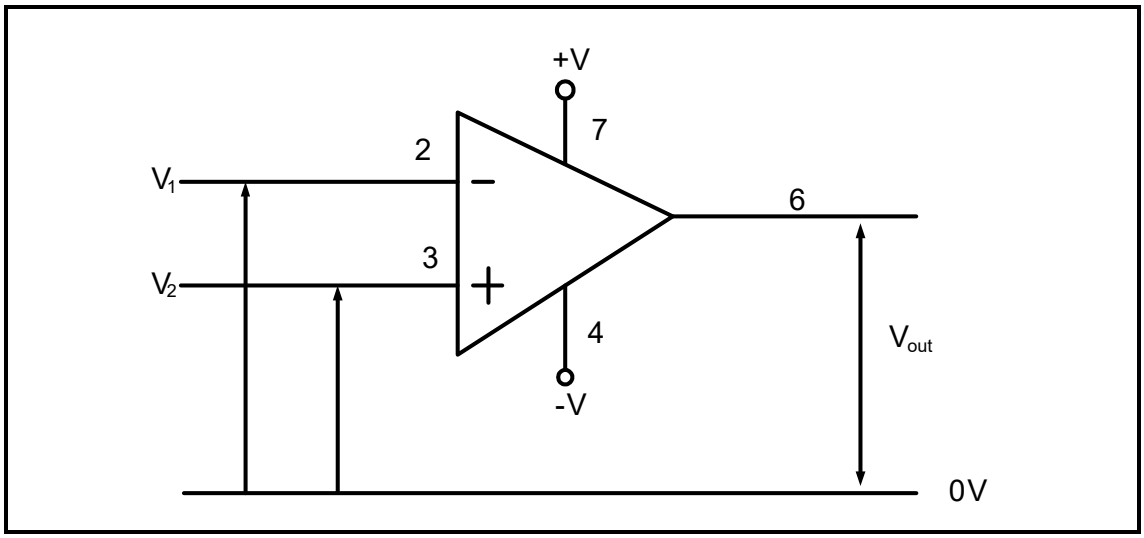



**FIGURE 4.2: IDEAL OPERATIONAL AMPLIFIER**

4.2.1 Explain why an ideal operational amplifier has infinite bandwidth. (1)

4.2.2 Draw the output of the op amp in FIGURE 4.2 above on the ANSWER SHEET for QUESTION 4.2.2 when the input at pin 2 and pin 3 is identical and in phase. (1)

4.2.3 Give TWO reasons why operational amplifiers are popular building blocks of analogue electronics circuits. (2)

4.3 Refer to FIGURE 4.3 below and answer the questions that follow.

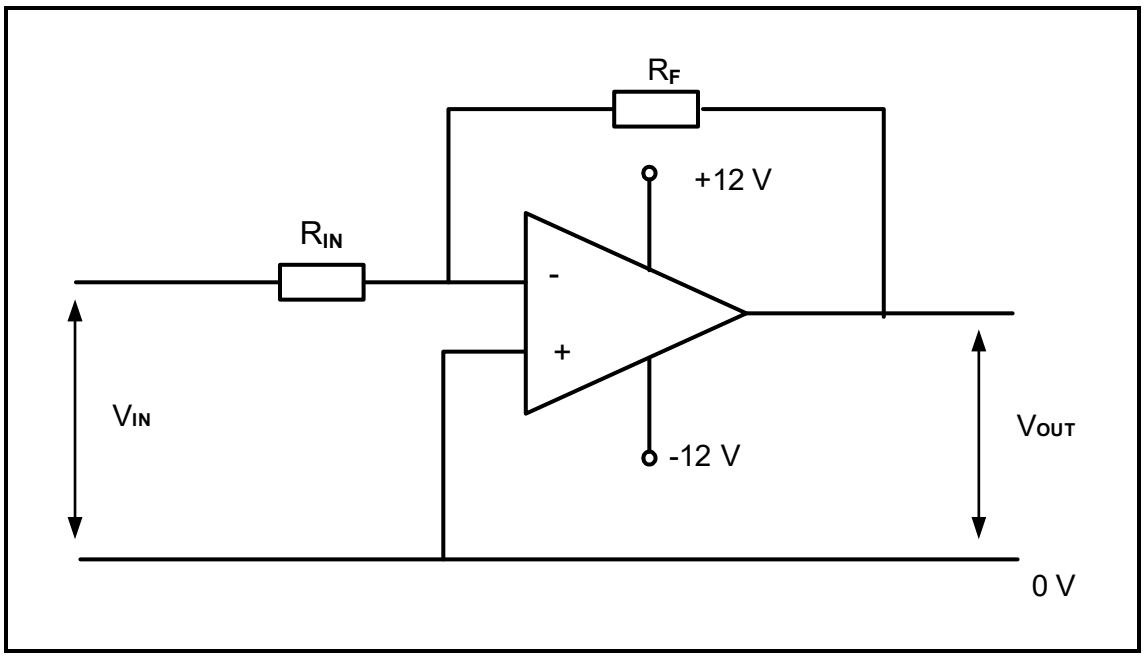



**FIGURE 4.3: INVERTING OPERATIONAL AMPLIFIER**

4.3.1 If $R_F$ was damaged and open circuit, explain what effect it would have on the output of the circuit. (1)

4.3.2 State the principle according to which the circuit in FIGURE 4.3 above operates to have a zero volt at the inverting input. (1)

4.3.3 Calculate the value of the feedback resistor if the input resistor of 15 kΩ is connected to an input voltage of 1 V, producing an output voltage of -12 V. (3)

4.4 FIGURE 4.4 below shows the internal layout of the 555 timer IC. Answer the questions that follow.

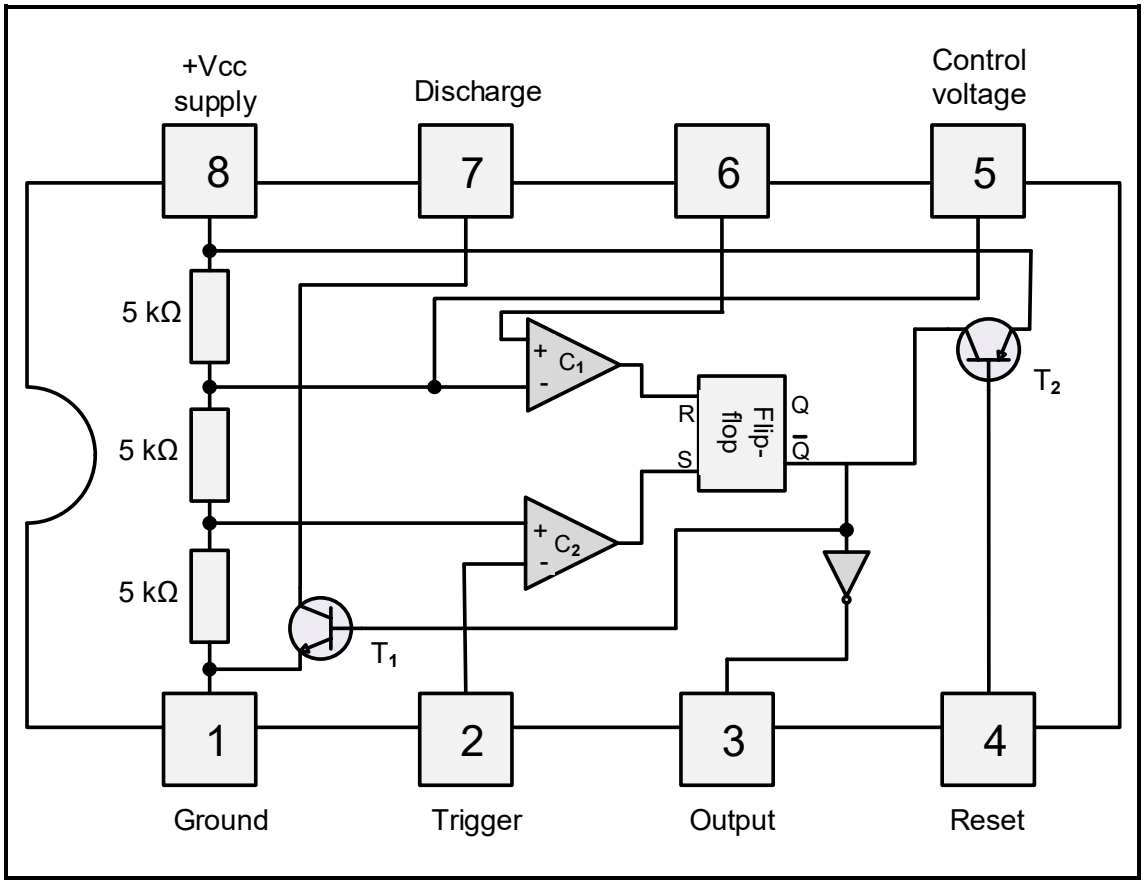



**FIGURE 4.4: INTERNAL LAYOUT OF A 555 TIMER IC**

4.4.1 State the function of the comparator's output. (1)

4.4.2 Explain what happens when the trigger voltage goes below ⅓$V_{CC}$. (2)

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

4.4.4 State TWO industrial applications of the 555 IC. (2)
**[20]**

## QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

5.1 Name ONE method of displaying information in digital systems other than an LED. (1)

5.2 Draw the circuit of a sinking digital output using an LED and a transistor. Indicate the direction of current flow at the output. (5)

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

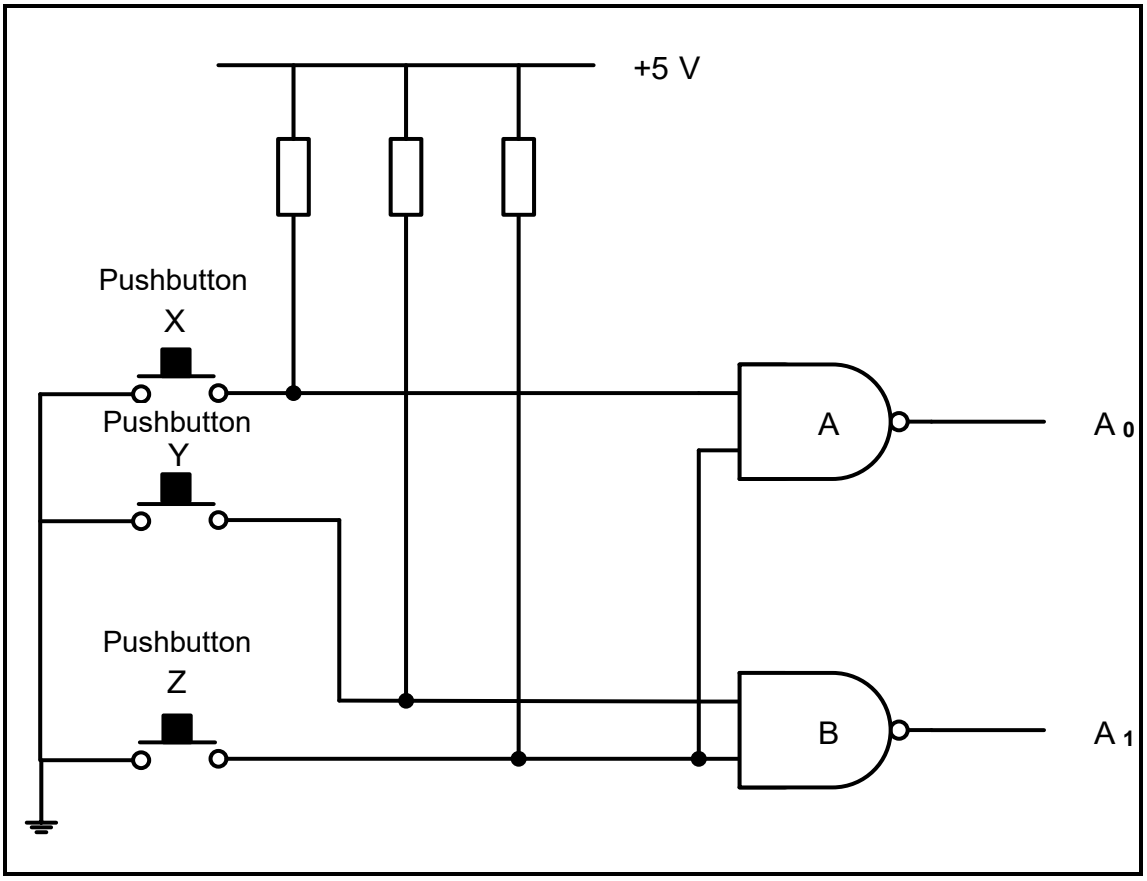



**FIGURE 5.3**

5.3.1 Identify the circuit in FIGURE 5.3 above. (1)

5.3.2 Complete the truth table of FIGURE 5.3 above on the ANSWER SHEET for QUESTION 5.3.2 by only indicating the HIGH output states of $A_1$ and $A_0$. (4)

5.4 Refer to FIGURE 5.4 of a half-adder below and answer the questions that follow.

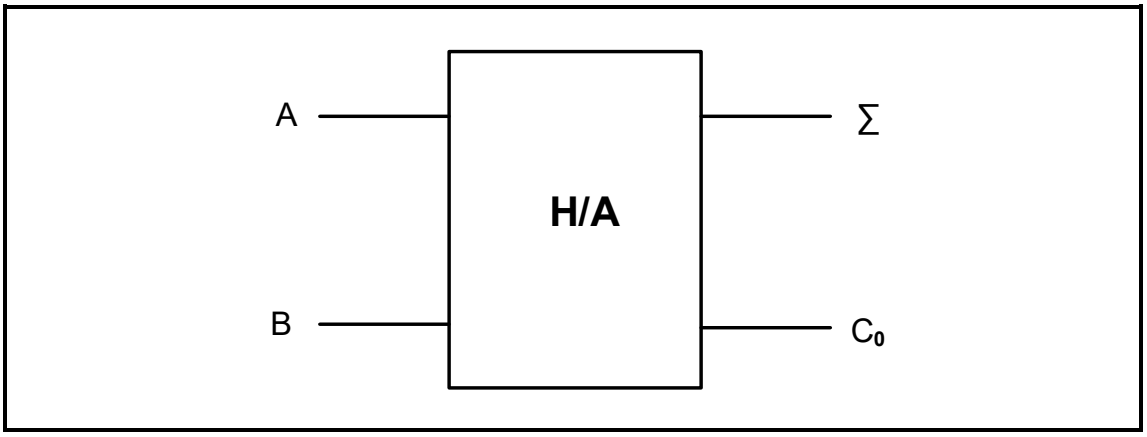



**FIGURE 5.4: HALF-ADDER**

5.4.1 Complete and label the logic circuit of the half-adder in FIGURE 5.4 above on the ANSWER SHEET for QUESTION 5.4.1. (6)

5.4.2 Complete the truth table for the half-adder in FIGURE 5.4 above on the ANSWER SHEET for QUESTION 5.4.2. (4)

5.5 Refer to FIGURE 5.5 of a clocked J-K-type flip-flop below and answer the questions that follow.

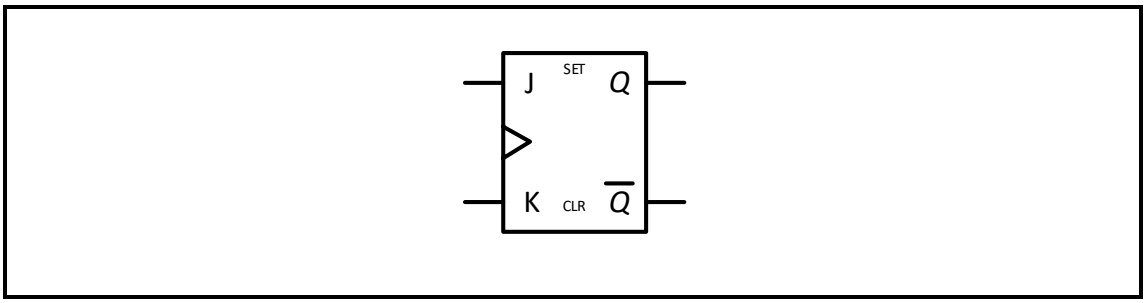



**FIGURE 5.5: CLOCKED J-K-TYPE FLIP-FLOP**

5.5.1 Using AND gates and NOR gates, complete the logic circuit of this flip-flop on the ANSWER SHEET for QUESTION 5.5.1. (6)

5.5.2 Study the inputs of J and K and complete the timing diagrams of the flip-flop in FIGURE 5.5 above on the ANSWER SHEET for QUESTION 5.5.2. Assume that Q starts low. (4)

5.6 Refer to the frequency divider in FIGURE 5.6 below and indicate the frequencies at **A**, **B** and **C**.

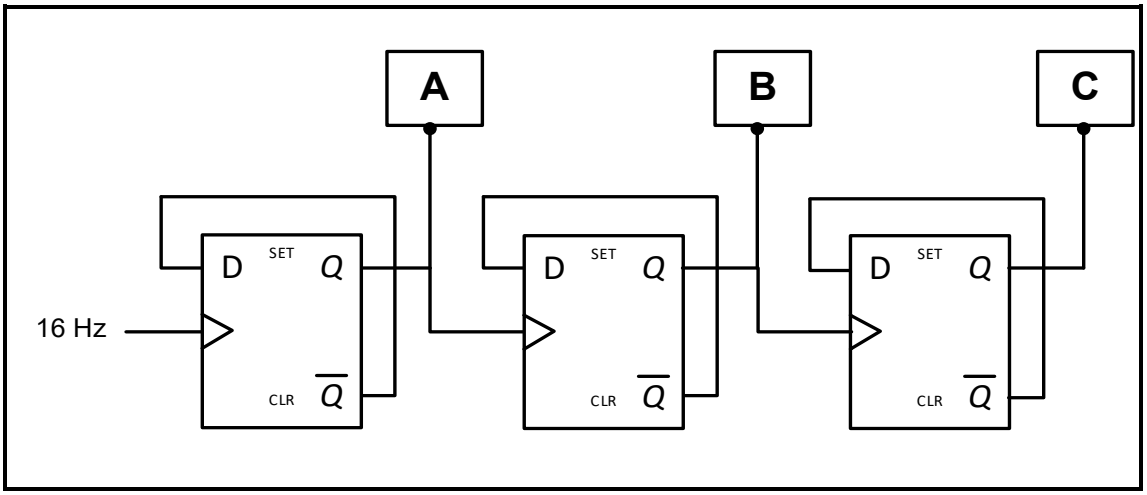



**FIGURE 5.6: FREQUENCY DIVIDER** (3)

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

5.8 Refer to FIGURE 5.8 below and answer the questions that follow.

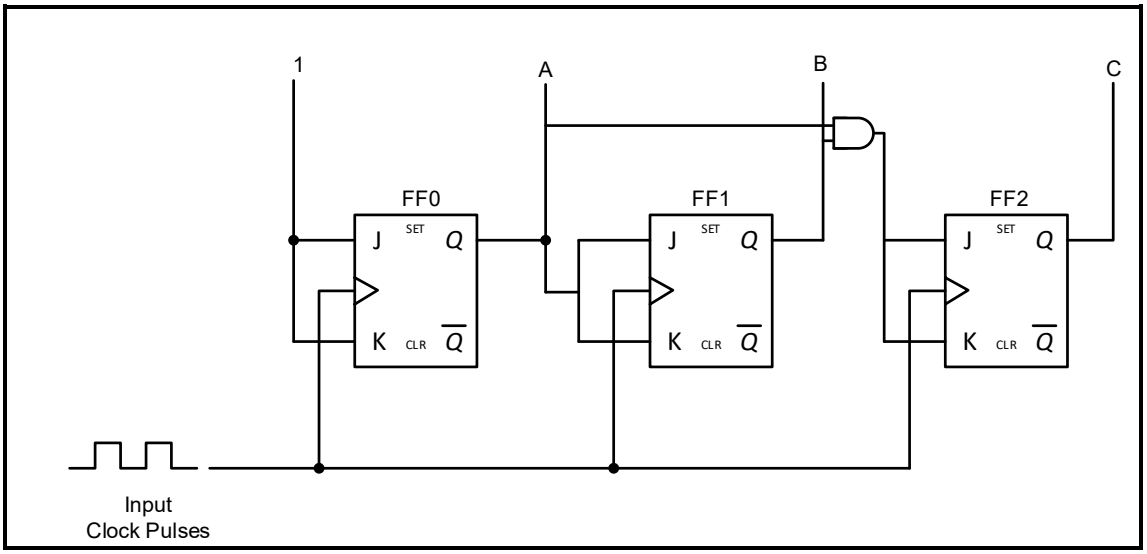



**FIGURE 5.8: COUNTER**

5.8.1 Identify the counter in FIGURE 5.8 above. (1)

5.8.2 State whether the counter in FIGURE 5.8 above is counting up or down. (1)

5.8.3 On the ANSWER SHEET for QUESTION 5.8.3, complete the truth table of this counter. (5)

5.9 Refer to the block diagram of a shift register in FIGURE 5.9 below and answer the questions that follow.

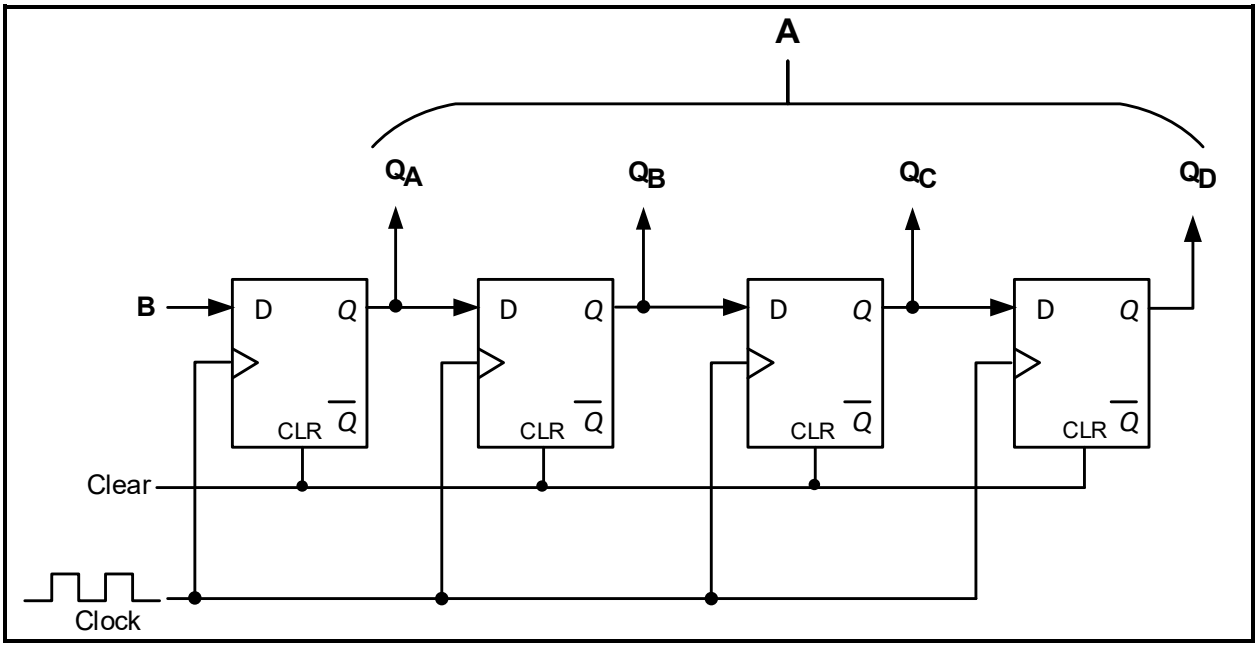



**FIGURE 5.9: SHIFT REGISTER**

5.9.1 Identify the shift register in FIGURE 5.9 above. (1)

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

5.9.3 Explain the operation of this register. (5)

5.10 Name TWO other types of shift registers, excluding the one identified in QUESTION 5.9.1 above, that are available. (2)
**[55]**

## QUESTION 6: MICROCONTROLLERS

6.1 Refer to microcontrollers and answer the questions that follow.

6.1.1 A single microcontroller can replace a wide variety of traditional discrete electronic components. State TWO advantages of using microcontrollers in IC format. (2)

6.1.2 Explain the basic function of the microcontroller. (3)

6.1.3 Draw a neatly labelled block diagram showing the basic construction of a microcontroller. (5)

6.1.4 Describe the memory address register (MAR) as a special purpose register. (2)

6.2 Refer to FIGURE 6.2 of asynchronous communication below and answer the questions that follow.

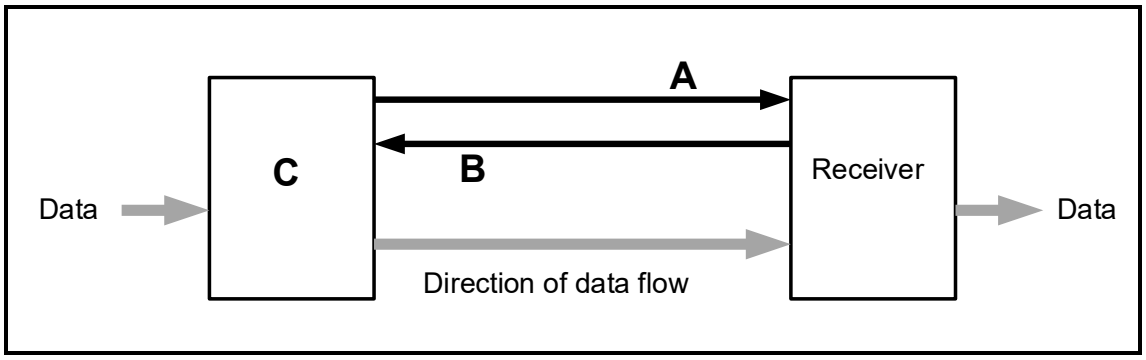



**FIGURE 6.2: ASYNCHRONOUS COMMUNICATION**

6.2.1 Label **A**, **B** and **C**. (3)

6.2.2 Explain the operation of asynchronous communication. (5)

6.3 Refer to communication protocol and answer the questions that follow.

6.3.1 Define *communication protocol*. (2)

6.3.2 State TWO types of communication protocols. (2)

6.4 Refer to communication in a microcontroller and define the term *interface*. (1)

6.5 Refer to communication peripherals and answer the questions that follow.

6.5.1 Explain the term *UART* as an asynchronous communication peripheral. (2)

6.5.2 List THREE advantages of the UART. (3)

6.5.3 Name TWO communication peripherals other than the universal asynchronous receiver transmitter (UART). (2)

6.6 Refer to RS-232 and RS-485 communication protocols and answer the questions that follow.

6.6.1 State THREE applications of RS-485. (3)

6.6.2 Complete TABLE 6.6.2 below on the ANSWER SHEET for QUESTION 6.6.2 by comparing the characteristics of RS-232 with RS-485 communication protocols.

| CHARACTERISTICS | RS-232 | RS-485 |
|---|---|---|
| Mode of operation | | Simplex OR<br>Half duplex OR<br>Full duplex |
| Line configuration | Single-ended | |

(2)

**TABLE 6.6.2**

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

6.8 Design a flow chart for a bistable device that has TWO stable states to turn on a siren. The siren stays high until it is reset by a reset switch. After resetting, the output returns to the low state which switches off the siren. The device has a single output.

Complete and label the flow chart for this device on the ANSWER SHEET for QUESTION 6.8. (9)

**[50]**

**TOTAL: 200**

## FORMULA SHEET

### SEMICONDUCTOR DEVICES

Gain $A_V = \frac{V_{OUT}}{V_{IN}} = -\left(\frac{R_F}{R_{IN}}\right)$ **OR** $A_V = 1 + \frac{R_F}{R_{IN}}$

$V_{OUT} = V_{IN} \times \left(-\frac{R_F}{R_{IN}}\right)$

$V_{OUT} = V_{IN} \times \left(1 + \frac{R_F}{R_{IN}}\right)$

### SWITCHING CIRCUITS

$V_{OUT} = -\left(V_1 \frac{R_F}{R_1} + V_2 \frac{R_F}{R_2} + ...V_N \frac{R_F}{R_N}\right)$

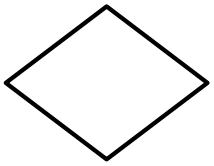
Gain $A_V = \frac{V_{OUT}}{V_{IN}} = \frac{V_{OUT}}{(V_1 + V_2 + ...V_N)}$

$V_{OUT} = -(V_1 + V_2 + ...V_N)$

$F = \frac{1}{T}$

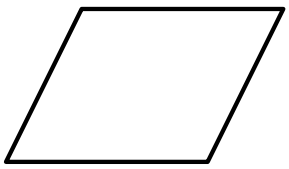
### FLOW CHART SYMBOLS USED IN PICAXE

Process

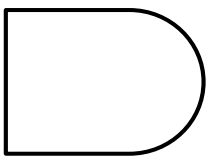


Decision

Terminator



Data



Wait

| **CENTRE NUMBER:** | | | | | | | |
|---|---|---|---|---|---|---|---|

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**ANSWER SHEET**

## QUESTION 3: SWITCHING CIRCUITS

3.3.3

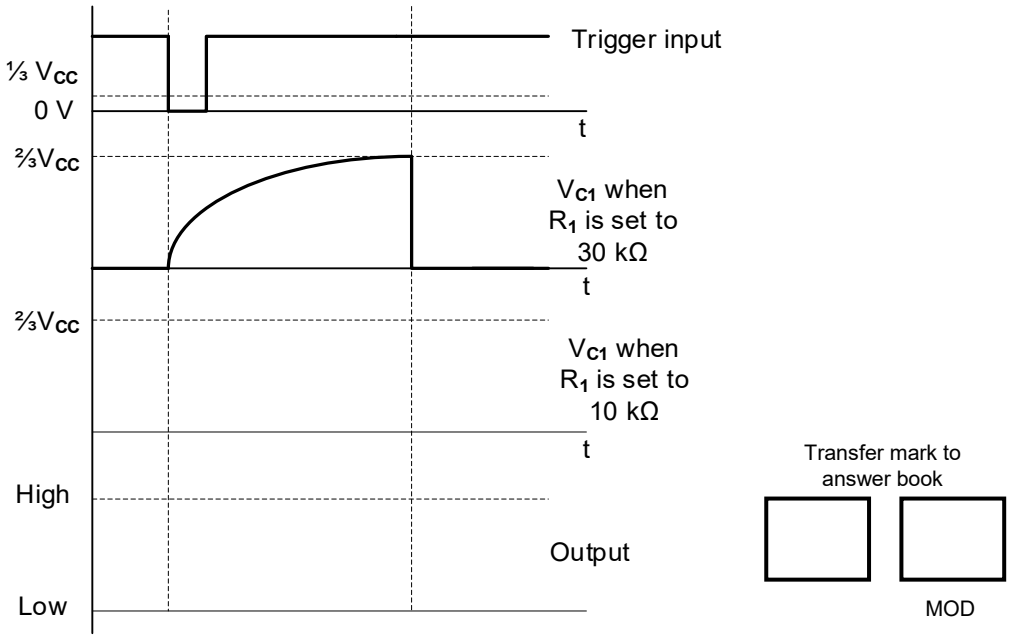


**FIGURE 3.3.3** (5)

3.4

| Components: |
|---|
| $R_1$ = 1 kΩ |
| $R_2$ = 10 kΩ |
| $C_1$ = 1 nF |
| $C_2$ = 100 µF |
| **TABLE 3.4** |

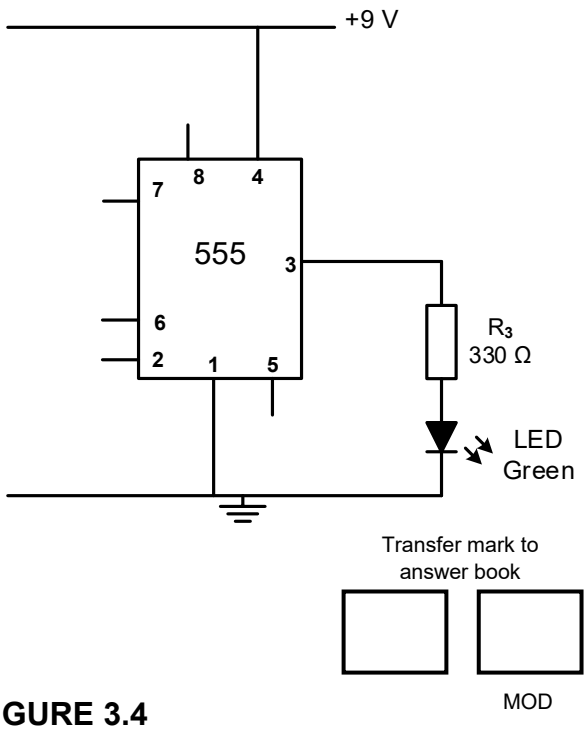


**FIGURE 3.4** (8)

| **CENTRE NUMBER:** | | | | | | | |
|---|---|---|---|---|---|---|---|

| **EXAMINATION NUMBER:** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

**ANSWER SHEET**

3.5.2

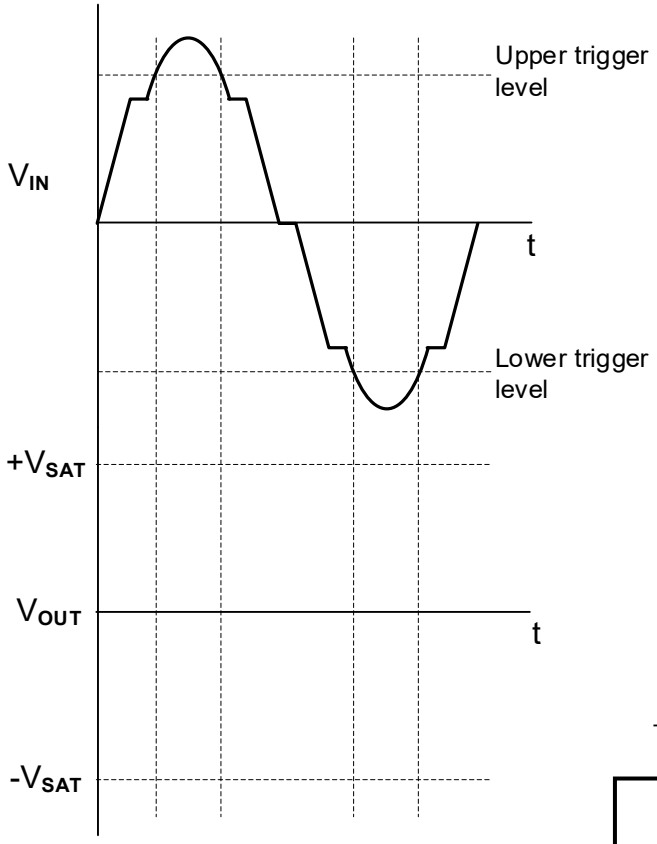


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**FIGURE 3.5.2** (4)

| **CENTRE NUMBER:** | | | | | | | |
|---|---|---|---|---|---|---|---|

| **EXAMINATION NUMBER:** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

**ANSWER SHEET**

## QUESTION 4: SEMICONDUCTOR DEVICES

4.2.2

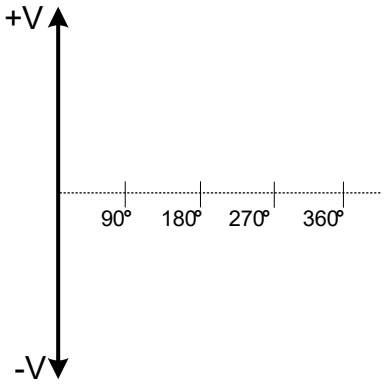


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**FIGURE 4.2.2** (1)

| **CENTRE NUMBER:** | | | | | | | |
|---|---|---|---|---|---|---|---|

| **EXAMINATION NUMBER:** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

**ANSWER SHEET**

## QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

5.3.2

| **INPUTS** | **OUTPUTS** | |
|---|---|---|
| Pushbutton | $A_1$ | $A_0$ |
| X | | |
| Y | | |
| Z | | |

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**TABLE 5.3.2** (4)

5.4.1

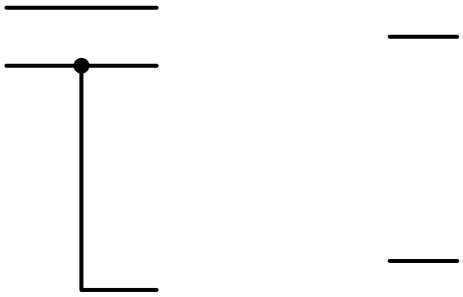

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**FIGURE 5.4.1** (6)

| **CENTRE NUMBER:** | | | | | | | |
|---|---|---|---|---|---|---|---|

| **EXAMINATION NUMBER:** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

**ANSWER SHEET**

5.4.2

| **INPUTS** | | **OUTPUTS** | |
|---|---|---|---|
| A | B | ∑ | $C_0$ |
| 0 | 0 | | 0 |
| 0 | 1 | 1 | |
| 1 | 0 | 1 | |
| 1 | 1 | 0 | |

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**TABLE 5.4.2** (4)

5.5.1

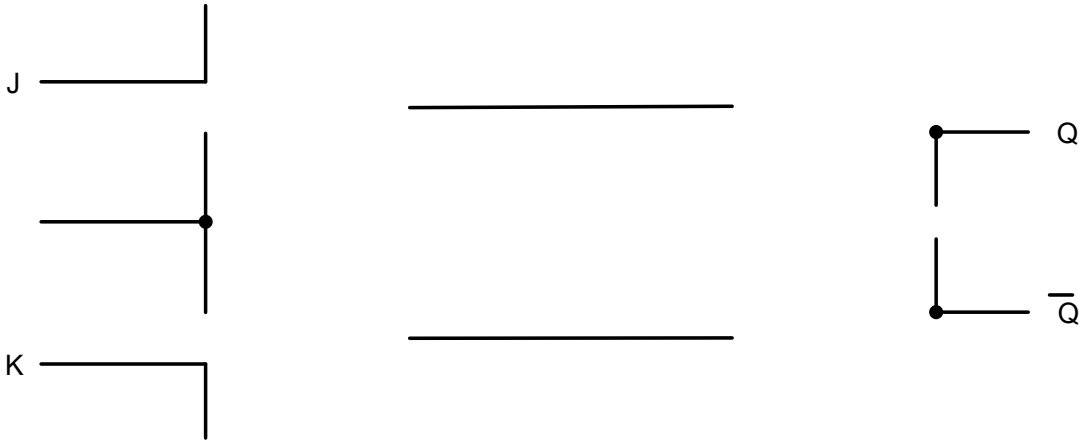


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**FIGURE 5.5.1** (6)

| **CENTRE NUMBER:** | | | | | | | |
|---|---|---|---|---|---|---|---|

| **EXAMINATION NUMBER:** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

**ANSWER SHEET**

5.5.2

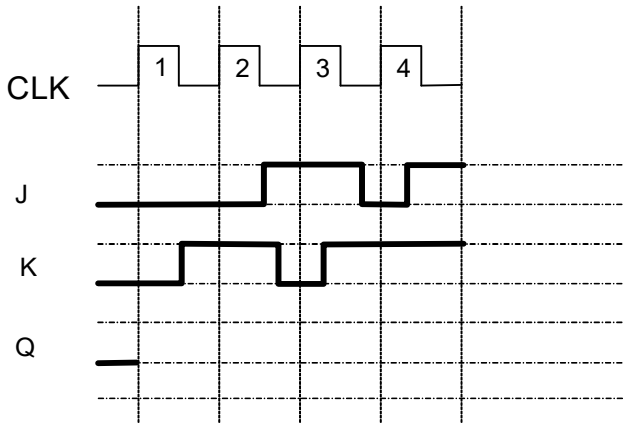


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**FIGURE 5.5.2** (4)

5.8.3

| **CLOCK PULSES** | **BINARY COUNT SEQUENCE** | | |
|---|---|---|---|
| | C | B | A |
| 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 |
| 2 | 0 | 1 | |
| 3 | 0 | | 1 |
| 4 | | 0 | 0 |
| 5 | 1 | 0 | |
| 6 | 1 | 1 | 0 |
| 7 | 1 | 1 | 1 |
| 8 | 0 | 0 | |

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**TABLE 5.8.3** (5)

| **CENTRE NUMBER:** | | | | | | | |
|---|---|---|---|---|---|---|---|

| **EXAMINATION NUMBER:** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

**ANSWER SHEET**

**QUESTION 6: MICROCONTROLLERS**

6.6.2

| CHARACTERISTICS | RS-232 | RS-485 |
|---|---|---|
| Mode of operation | | Simplex OR<br>Half duplex OR<br>Full duplex |
| Line configuration | Single-ended | |

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**TABLE 6.6.2** (2)

| **CENTRE NUMBER:** | | | | | | | |
|---|---|---|---|---|---|---|---|

| **EXAMINATION NUMBER:** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

**ANSWER SHEET**

6.8

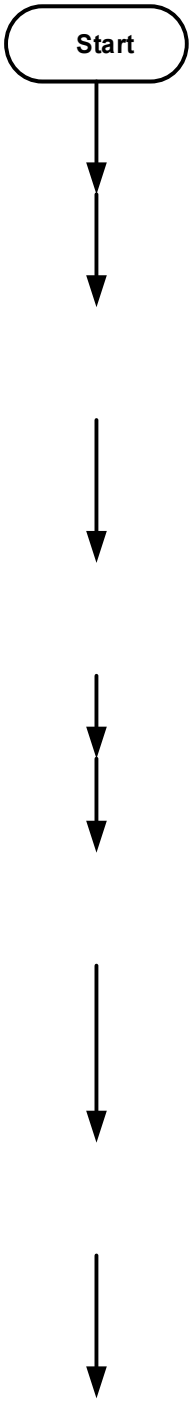


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**FIGURE 6.8** (9)