basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

**SENIOR CERTIFICATE EXAMINATIONS/
NATIONAL SENIOR CERTIFICATE EXAMINATIONS**

ELECTRICAL TECHNOLOGY: DIGITAL ELECTRONICS

MAY/JUNE 2024

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 15 pages.

INSTRUCTIONS TO THE MARKERS

1.   All questions with multiple answers imply that any relevant, acceptable answer should be considered.

2.   Calculations:

   2.1   All calculations must show the formulae.

   2.2   Substitution of values must be done correctly.

   2.3   All answers MUST contain the correct unit to be considered.

   2.4   Alternative methods must be considered, provided that the correct answer is obtained.

   2.5   Where an incorrect answer could be carried over to the next step, the first answer will be deemed incorrect. However, should the incorrect answer be carried over correctly, the marker has to re-calculate the values, using the incorrect answer from the first calculation. If correctly used, the candidate should receive the full marks for subsequent calculations.

3.   This memorandum is only a guide with model answers. Alternative interpretations must be considered and marked on merit. However, this principle should be applied consistently throughout the marking session at ALL marking centres.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

1.1   D ✓   (1)

1.2   A ✓   (1)

1.3   C ✓   (1)

1.4   B ✓   (1)

1.5   C ✓   (1)

1.6   C ✓   (1)

1.7   D ✓   (1)

1.8   D ✓   (1)

1.9   B ✓   (1)

1.10   C ✓   (1)

1.11   B ✓   (1)

1.12   A ✓   (1)

1.13   A ✓   (1)

1.14   A ✓   (1)

1.15   C ✓   (1)
                                                                                                        [15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 Failure to use safety equipment.✓
Tampering or misusing safety equipment. ✓
Wilfully or recklessly operating machinery that threatens the health of the user. (2)

2.2 Furnishing false information to the inspector. ✓
Failure to comply with any performance or safety requirements made by the inspector. ✓
Obstructing the inspector in the performance of his/her duties. (2)

2.3 Manufacturers who design and manufacture articles for the use in industry must ensure that the product is safe to use ✓ and the information and processes for the use of the artefact manufactured is clear ✓ and would assist with safe operation of the artefact. (2)

2.4 It is an event that is not expected ✓ that would not require calling for outside emergency assistance. ✓ (2)

2.5 It can cause the heart muscle to contract so strongly✓ leading to heart failure. ✓ (2)

[10]

QUESTION 3: SWITCHING CIRCUITS

3.1 In electronic circuits, the pulses created by switch bouncing will be interpreted as information which may give a wrong output. ✓ (1)

3.2 3.2.1 Feedback is when a fraction of the output voltage ✓ is fed from the voltage divider R_2 and R_3 to the non-inverting input. ✓ (2)

3.2.2 When a positive trigger pulse is applied to the input, both plates ✓ of the capacitor immediately rise to the applied voltage.✓ (2)

3.2.3 When a negative trigger (reset) pulse is applied to the input, the op-amp compares the two voltages at its two input terminals. ✓ When the voltage on the inverting input becomes more negative than the voltage on the non-inverting input ✓the output goes high ($+V_{SAT}$) where it will remain.✓ (3)

3.2.4 Trigger pulse 2 is positive, ✓ and the voltage on the non-inverting input is negative. ✓ The circuit will only change state when a voltage which is more negative ✓ than the voltage present on the non-inverting input is applied to the inverting input. (3)

3.3 3.3.1 Monostable multivibrator.✓ (1)

3.3.2 Resistor R_2 keeps pin 2 high, ✓ keeping the monostable circuit in its steady state.✓ (2)

3.3.3
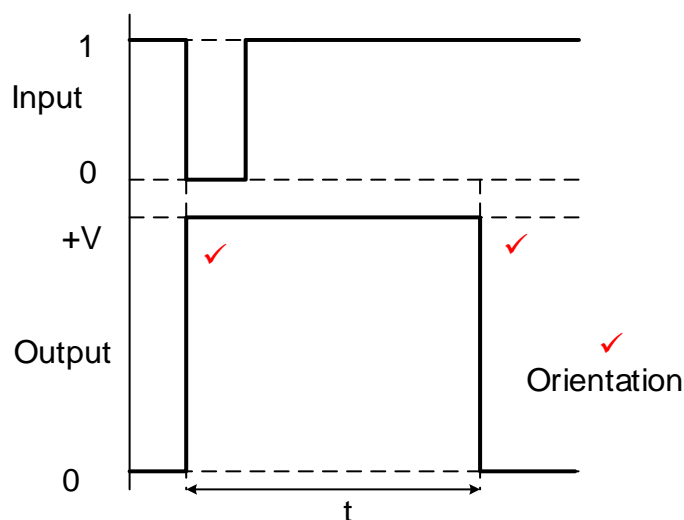
(3)

3.3.4 6 V, ✓ the circuit will return to its resting state when capacitor C_1 charges up to ⅔ V_{CC}.✓ (2)

3.4   3.4.1   The output of the circuit changes state continually because both trigger pin 2 ✓ and threshold pin 6 ✓ are connected to the top of the timing capacitor. This allows the circuit to repeatedly reset and trigger ✓ as the capacitor charges and discharges to ⅔ and ⅓ of the supply voltage ✓ producing a continual stream of high and low pulses at its output.   (4)
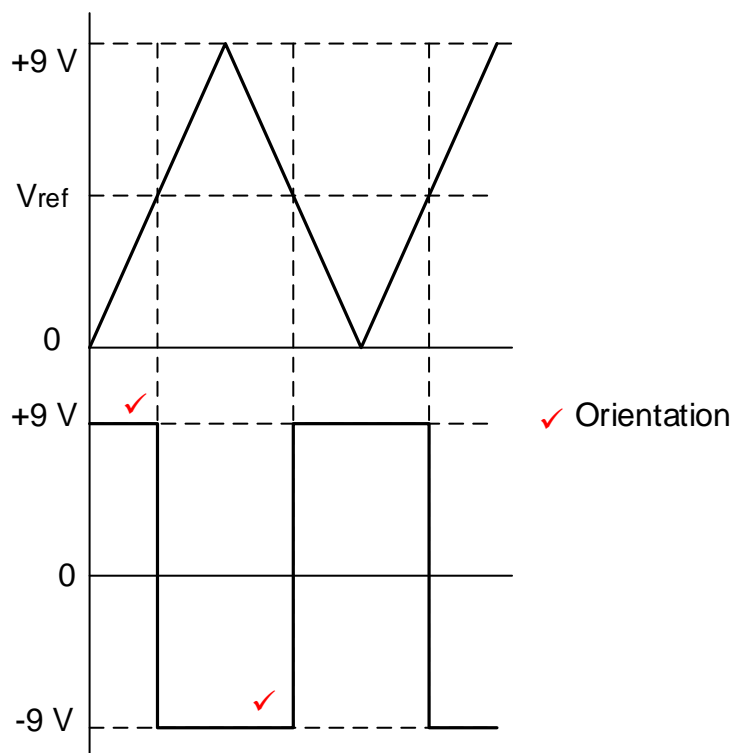
3.4.2   Pulse t_1 and t_2 are not equal because the capacitor charges through $R_1 + R_2$ ✓ to the threshold voltage and discharges through R_1 only. ✓   (2)

3.4.3
$$f = \frac{1}{T} \quad\checkmark$$
$$= \frac{1}{(70 \times 10^{-3} + 69,3 \times 10^{-3})} \quad\checkmark$$
$$= 7,18\ Hz \quad\checkmark$$
(3)

3.5   3.5.1 $V_{ref} = 4,5\ V$ ✓

Note: $V_{CC} = V_S - V_{R1}$
          $V_{CC} = 9 - 4,5$
                    $= 4,5\ V$

(1)

3.5.2   The voltage across R_2 is half of the supply voltage. ✓ For this to happen, $R_1 = R_2 = 2\ 200\ \Omega$. ✓   (2)

3.5.3

✓ Orientation

(3)

3.5.4   An increase in the value of R_1 means that $R_1 > R_2$ ✓ and will cause the voltage across R_2 to decrease. ✓   (2)

3.6   3.6.1   A summing amplifier makes it possible to feed a number of different signal voltages ✓ into a circuit and provide one output signal ✓ consisting of the sum of all the input signals.✓   (3)
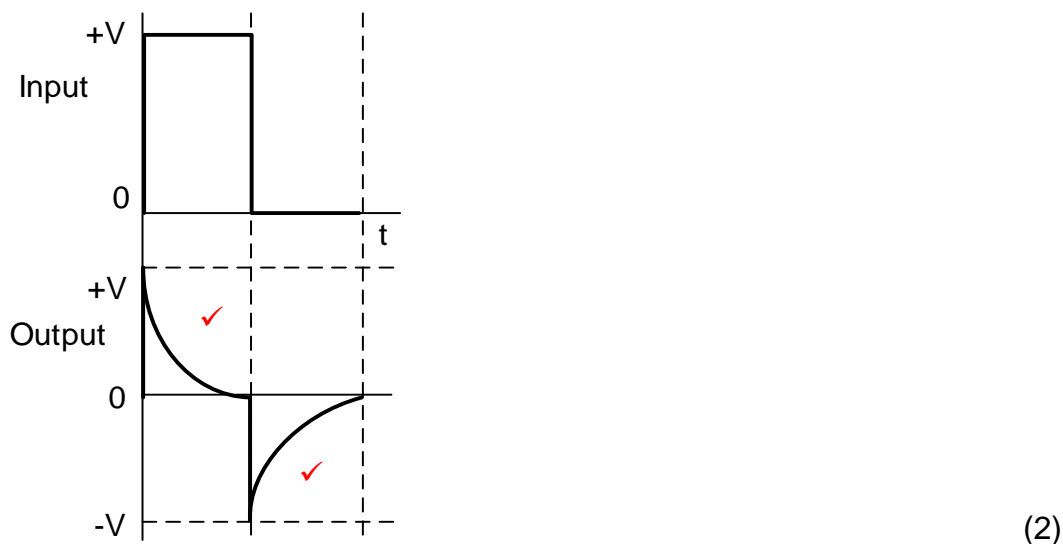
        3.6.2

$$V_{OUT} = -\left(V_1\frac{R_F}{R_1} + V_2\frac{R_F}{R_2} + V_3\frac{R_F}{R_3}\right) \qquad ✓$$

$$= -\left(0{,}1 \times \frac{33000}{2200} + 0{,}2 \times \frac{33000}{2200} + 0{,}3 \times \frac{33000}{2200}\right) \qquad ✓$$

$$= -9\ V \qquad ✓ \qquad (3)$$

        3.6.3   When R$_F$ is set to 2200 Ω the gain of the amplifier is 1 ✓ and the output voltage is the sum of the input voltages.   (1)

3.7   3.7.1

(2)

        3.7.2   When a square wave is applied to the input, both plates of the capacitor immediately charges up to the potential of the input. ✓ The left hand plate of the capacitor is kept at that potential for as long as the square wave is high. ✓ The right hand plate of the capacitor will discharge through the resistor to 0 V ✓ at a rate determined by the RC time constant of the circuit.   (3)

        3.7.3
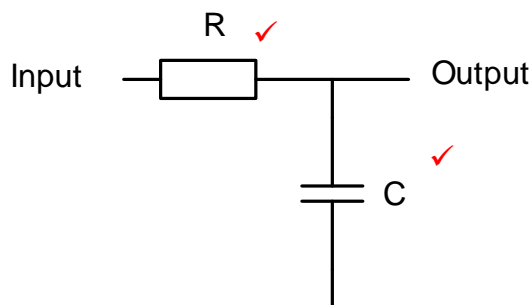
(2)

[50]

QUESTION 4: SEMICONDUCTOR DEVICES

4.1   4.1.1   Positive.✓
                In-phase (1)

       4.1.2   Zero.✓ (1)

4.2   4.2.1   Op-amps are not frequently used in an open loop mode because of
                their very high gain ✓   which creates poor stability of the output
                voltage. ✓ (2)

       4.2.2   The op-amp should be able to amplify any input of any frequency✓
                from 0 Hz (DC) through radio frequency ✓ and higher.
                                        OR
                It means the range of input signal frequencies the device can operate
                on without the output waveform being distorted. (2)

       4.2.3
$$V_{out} = V_{IN} \times \left(-\frac{R_F}{R_{IN}}\right) \qquad ✓$$
$$= 60 \times 10^{-3} \times \left(-\frac{10 \times 10^3}{1 \times 10^3}\right) \qquad ✓$$
$$= -0{,}6V \qquad ✓$$
$$= -600 \ mV$$
(3)

4.3
$$R_F = R_{IN}\left(\frac{Vout}{V_{in}} - 1\right) \qquad ✓$$
$$= 2 \, X \, 10^3 \left(\frac{4}{0{,}5}\right) - 1 \qquad ✓$$
$$= 15\ 999 \ \Omega$$
$$= 16 \ k\Omega \qquad ✓$$
(3)

4.4   4.4.1   Discharge pin ✓ (1)

       4.4.2   • Pulse width modulator ✓
                • Linear ramp generator (1)

       4.4.3   Pin 4 is the reset input for the flip-flop and as soon as the reset pin is
                0 V, the 555 IC will discharge through the transistor, ✓ and the output
                pin 3 will be low ✓
                                        OR
                (The reset pin 4 is used to reset the IC i.e it causes the output to return
                to zero volts if it is connected to zero volts). (2)

       4.4.4   • Monostable ✓
                • Bistable ✓
                • Astable Mode (2)

       4.4.5   The pin sets the voltage at which a 555 IC will trigger ✓. It is used to
                maintain the voltage across the timing capacitor which is discharged
   with the help of pin 7. ✓ (2)

[20]

QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

5.1 • Polarisation is the application of a polarising filter as a grid ✓ that allows light wave of a single orientation to pass. ✓
• In a LCD display two layers of polarized glass can be aligned or misaligned electrically to pass or block light wave. ✓ (3)
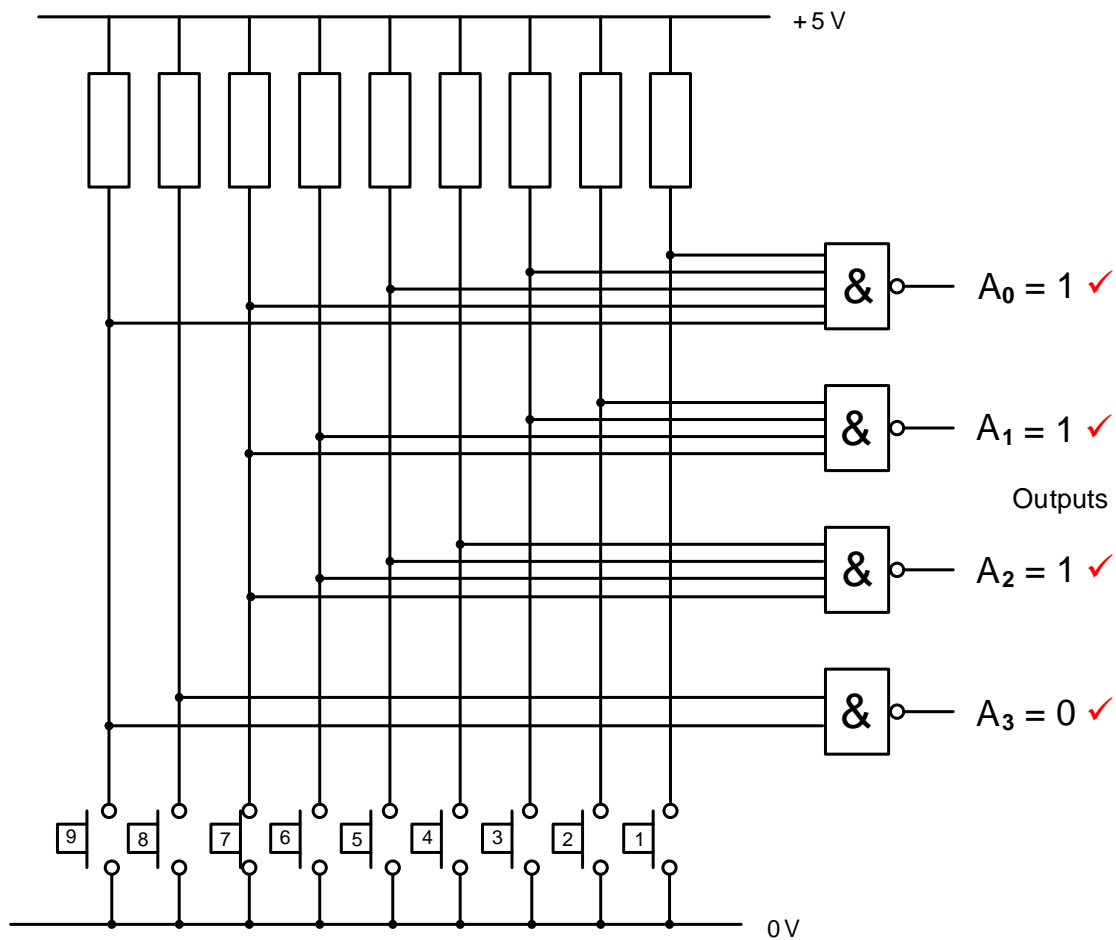
5.2 • In COMMON ANODE the anodes of all eight LED's are connected together✓to a common positive voltage rail. ✓
• In COMMON CATHODE all eight LED cathodes are internally connected ✓ to a common 0 V (ground). ✓ (4)
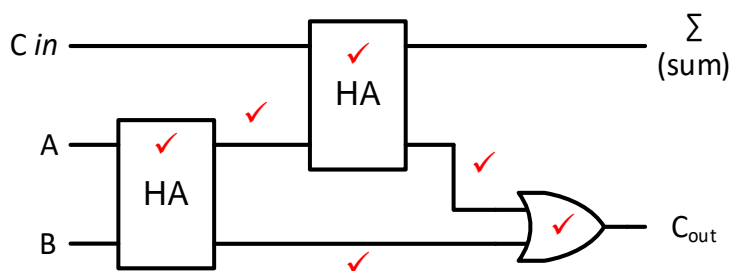
5.3
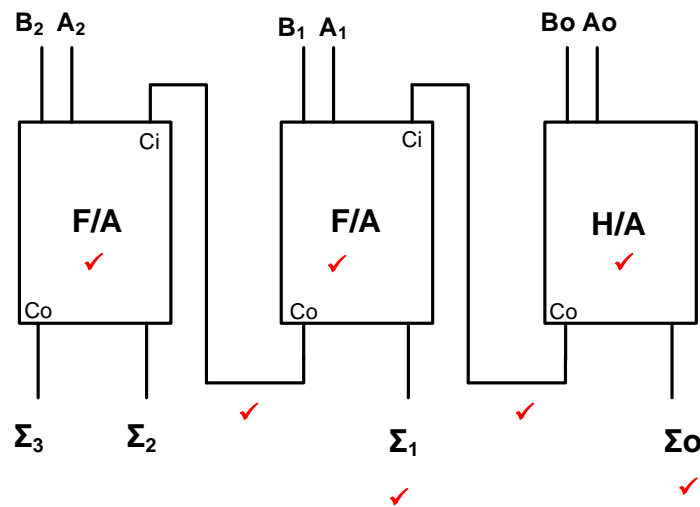
(7)

5.4

(4)

5.5 Pulse triggering is when a circuit changes state ✓ at any time during the 'high'✓ period of a clock pulse. (2)
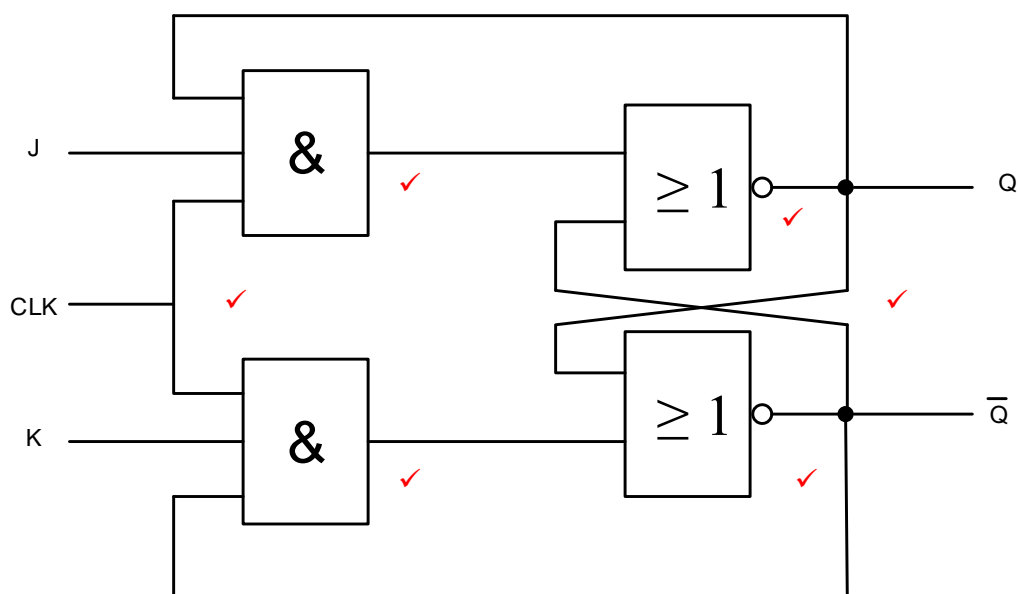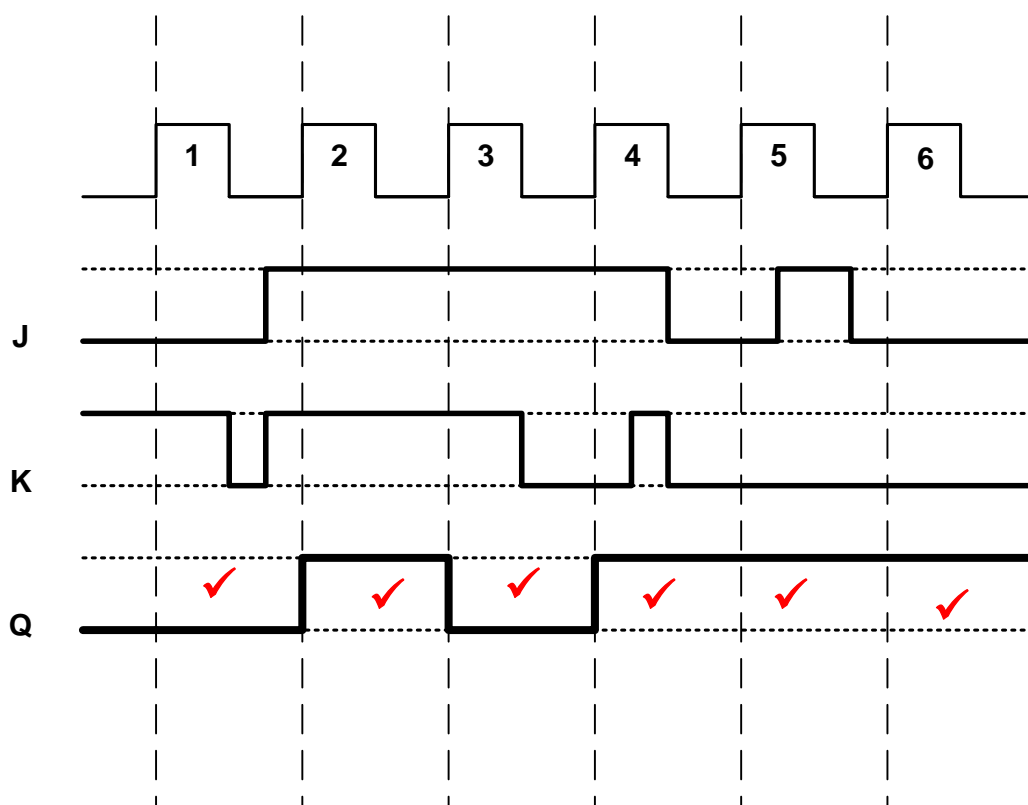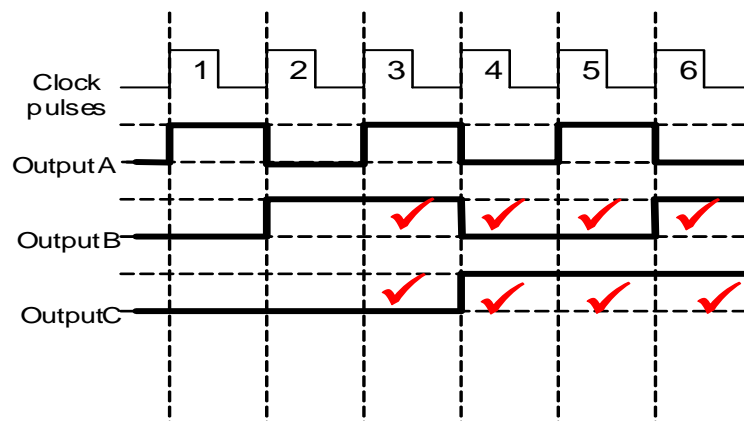
5.6

(6)

5.7   5.7.1

(6)

5.7.2

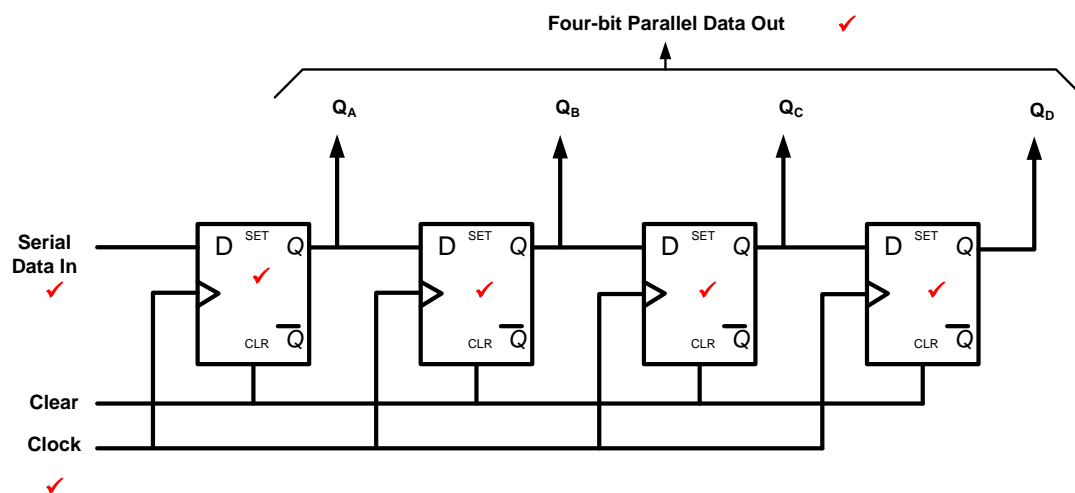(6)

5.8.1

(8)

5.8.2   Asynchronous ✓   (1)

5.9   Up/Down counters are slower than regular Up or Down counters. ✓   (1)
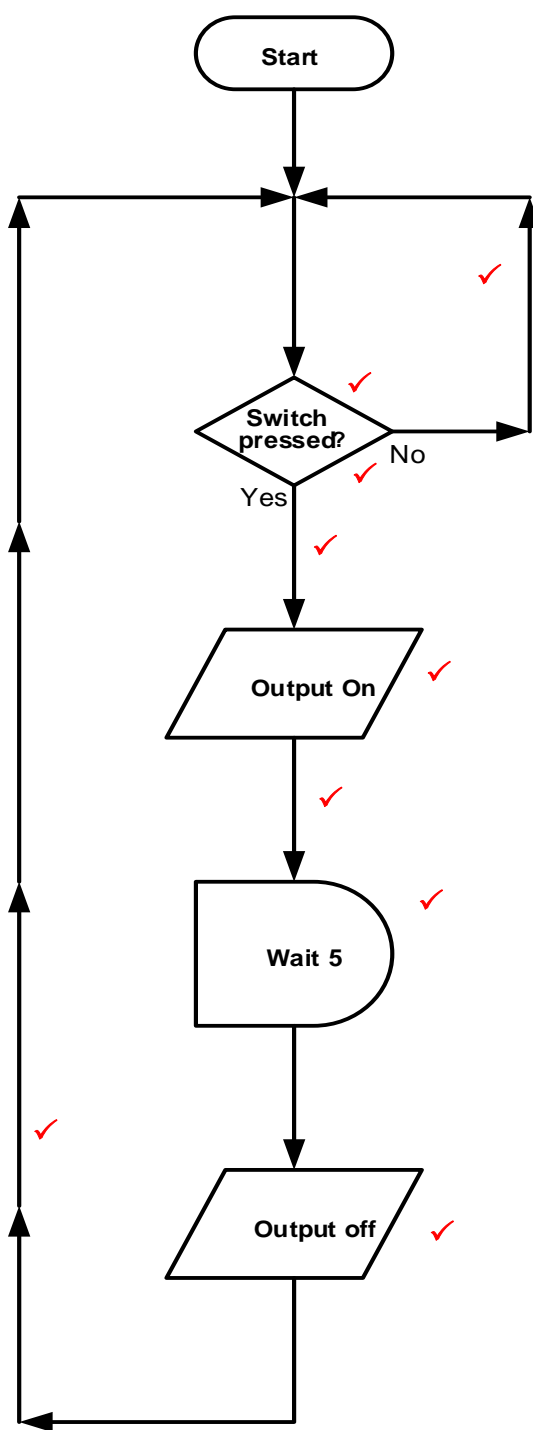
5.10

(7)
[55]

QUESTION 6: MICROCONTROLLERS

6.1   Microcontrollers are used in Commercial devices:

- Refrigeration control ✓
- Lighting, advertising and illumination of spaces ✓
- Stock control   (2)

6.2   6.2.1   Microcontroller ✓   (1)

       6.2.2   The RAM stores all the data ✓ that is required to be processed by the CPU during the execution of programmes. ✓   (2)

       6.2.3   Central Processing Unit ✓   (1)

6.3   6.3.1   A = CPU ✓
               B = Memory ✓
               C = System Bus ✓   (3)

       6.3.2 (a) The control bus is used mainly for the CPU to issue control instructions ✓ to both memory as well as input/output ports. ✓   (2)

       6.3.2 (b) The data bus is the 'highway' along which all data is transferred, ✓ sent and received ✓ between CPU, memory and both input and output ports. ✓   (3)

       6.3.3   Interface is a shared boundary ✓ across which two separate components of a computer system exchanges information. ✓   (2)

6.4   6.4.1   The CIR splits the instruction into two parts. ✓ One part is decoded by the control unit ready for execution, ✓ the other part is the address of the data stored that needs to be used together with that instruction. ✓   (3)

       6.4.2   The accumulator stores data ✓ that is needed for any arithmetic operation. ✓   (2)

       6.4.3   Special purpose register ✓
               General purpose register ✓   (2)

6.5   6.5.1   Communication protocol is a set of rules ✓ that allow two electronic devices to connect and exchange data. ✓   (2)

       6.5.2   Simplex communication is where all data and information travels in only one direction ✓ from transmitter to receiver. ✓
               Half duplex communication is where the two devices take turn in communicating, ✓ one after the other. ✓   (4)

6.6   6.6.1   SPI is a synchronous serial communication data link that operates in full duplex ✓ (signals carrying data in both directions simultaneously). It uses separate clock and data lines as well as a select line ✓ to choose the device chosen to receive data. ✓   (3)

        6.6.2   The SPI:
                  is susceptible to noise ✓
                  can only travel short distances ✓
                  cannot transmit off the PCB
                  is slightly more expensive   (2)

6.7   6.7.1   1200 metres ✓   (1)

        6.7.2   Simplex or half duplex ✓   (1)

        6.7.3   • Point of sale terminals ✓
                  • Metering instruments ✓
                  • PLC's
                  • CNC machines
                  • Robots
                  • Embedded control computers
                  • Medical instruments   (2)

6.8   In the cycle, the CPU fetches a program instruction from its memory, ✓ decodes the instruction, ✓ considers all inputs and then executes that instruction. ✓   (2)

6.9

(9)
[50]

TOTAL: **200**