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Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

ELECTRICAL TECHNOLOGY: DIGITAL ELECTRONICS

2022

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 17 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 | C ✓ | (1) |
| 1.2 | C ✓ | (1) |
| 1.3 | B ✓ | (1) |
| 1.4 | D ✓ | (1) |
| 1.5 | A ✓ | (1) |
| 1.6 | B ✓ | (1) |
| 1.7 | C ✓ | (1) |
| 1.8 | D ✓ | (1) |
| 1.9 | C ✓ | (1) |
| 1.10 | A ✓ | (1) |
| 1.11 | D ✓ | (1) |
| 1.12 | B ✓ | (1) |
| 1.13 | A ✓ | (1) |
| 1.14 | D ✓ | (1) |
| 1.15 | C ✓ | (1) |
| | | [15] |

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

- 2.1 Machinery means any article or combination of articles assembled, arranged or connected ✓ and which is used or intended to be used for converting any form of energy to performing work. ✓ (2)
- 2.2 Critical incident is an event that causes a grave or severe physical injury ✓ to a person ✓, threatening their safety. (2)
- 2.3
- Sound the alarm system immediately. ✓
 - Use the correct fire extinguisher if you were trained to ✓
 - If there is a telephone nearby in a safe location, call your school secretary or principal to let them know of the situation. (2)
- 2.4 Due to the pandemic the mask protects oneself and others from viral infections ✓. Not using a mask will be an unsafe act because you are creating a life threatening unsafe act. ✓

OR

- Respirators and masks assist in preventing damage to the lungs when working in a contaminated area. (2)
- 2.5
- Make use of a chemical waste company to remove or to dispose of chemicals. ✓
 - Waste chemicals should NEVER be poured into toilets or down the drain as they can be harmful to the environment and the local sewerage system. ✓
 - Only neutralised chemicals can be disposed of safely.
- NOTE: If the candidate mentions safety considerations with reference to the working environment, 1 mark will be awarded, but not personal protective equipment. (2)
- [10]**

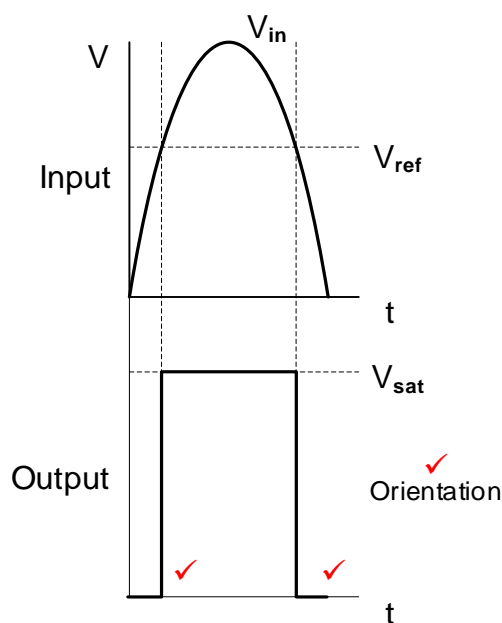
QUESTION 3: SWITCHING CIRCUITS

- 3.1 3.1.1 Monostable multivibrator ✓ (1)
- 3.1.2 Bistable multivibrator ✓ (1)
- 3.2 3.2.1 (a) Pull-up resistor. ✓
R₁ keeps the voltage on pin 4 high. (1)
- (b) To limit the current flowing to the LED. ✓ (1)
- 3.2.2 LED OFF ✓ (1)
- 3.2.3 When set is pressed, it pulls pin 2 'low' ✓ (0 V) and cause the output to go 'high'. ✓ (LED ON) (2)
- 3.2.4 Threshold pin 6 is connected to ground (0 V) so that the IC cannot reset ✓ itself keeping the output high ✓ when the set switch is pressed. (2)
- 3.3 3.3.1 R₂ sets the reference voltage ✓ on the inverting input. (1)
- 3.3.2 As the level of light increases the resistance of the LDR decreases, ✓ decreasing the voltage on the non-inverting input. ✓ (2)
- 3.3.3 The Op-amp compares the voltages on its two input terminals. ✓ When the voltage on the non-inverting input is higher than the voltage on the inverting input it drives the output of the Op-amp output into positive saturation. ✓ With the output being high, LED 2 will illuminate. ✓

OR

- The Op-amp compares the voltages on its two input terminals. When the voltage on the non-inverting input is lower than the voltage on the inverting input, it drives the output of the Op-amp output into negative saturation. With the output being low, LED 1 will illuminate. (3)
- 3.3.4 LED₁ on (forward biased) ✓
LED₂ off (reverse biased) ✓ (2)

3.3.5



(3)

3.4 3.4.1 Inverting ✓ Schmitt trigger

(1)

3.4.2 -10 V ✓

(1)

3.4.3 Positive feedback ✓

(1)

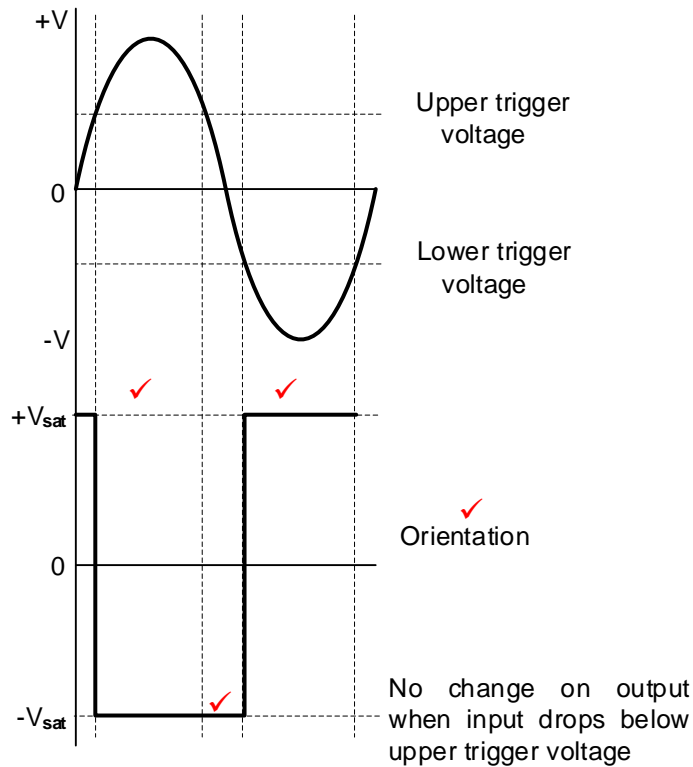
3.4.4 The moment the input voltage rises above 1 V ✓ the Op-amp output is driven into negative saturation. ✓ The output remains in this state until the input voltage falls below -1 V. ✓ The moment the input voltage falls below -1 V the output is driven into positive saturation. ✓

(4)

3.4.5 An increase in the value of R_1 will cause the trigger voltage level to increase. ✓

(1)

3.4.6



(4)

3.5 3.5.1 Negative feedback ✓

Controlling the gain of the amplifier. ✓

(2)

3.5.2

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

$$= - \left(0,4 \frac{78\,260}{10\,000} + 0,5 \frac{78\,260}{10\,000} + 0,25 \frac{78\,260}{10\,000} \right)$$

$$= -9\,V$$

(3)

3.5.3 When R_F increases the gain of the amplifier increase. ✓

(1)

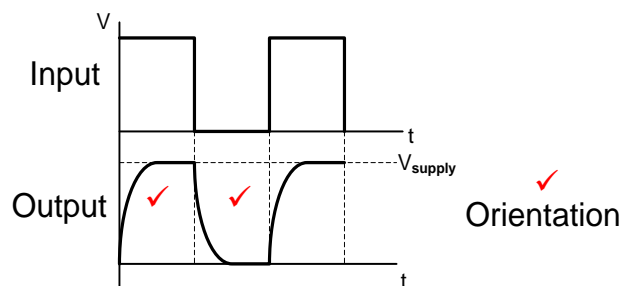
3.5.4 This amplifier is connected to a 9 V dual supply limiting the output to a maximum of $\pm 9\,V$. ✓ The output of the amplifier is already at $-9\,V$ with R_F set to $78,26\,k\Omega$. ✓ By increasing the value of R_F beyond $78,26\,k\Omega$, the gain increases further ✓ and the Op-amp is driven to saturation causing the output to be distorted. ✓

(4)

3.5.5 This limitation can be overcome by setting the supply voltage to be higher ✓ than the maximum possible output voltage. ✓ This limitation can be overcome by decreasing the V_{in} of each resistor respectively. This will bring the V_{out} within the maximum of $\pm 9\,V$.

(2)

3.6 3.6.1

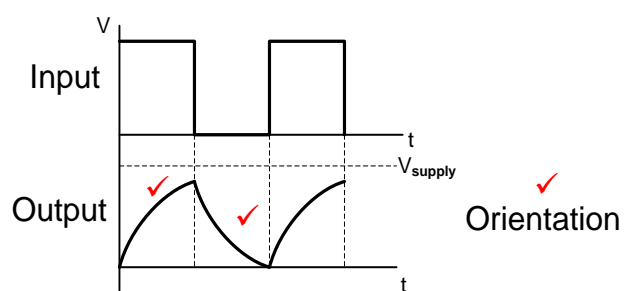


NOTE: square wave is accepted.

If the output resembles the shape of a charging capacitor, but is not clipped at the top and bottom, 1 mark will be awarded for orientation.

(3)

3.6.2



NOTE: triangular wave is accepted.

(3)

[50]

QUESTION 4: SEMICONDUCTOR DEVICES

- 4.1 4.1.1
- Pin 6 sets the voltage at which the 555 IC will trigger. ✓
 - It is used to maintain the voltage across the timing capacitor ✓ which is then discharged through Pin 7. ✓
- (3)

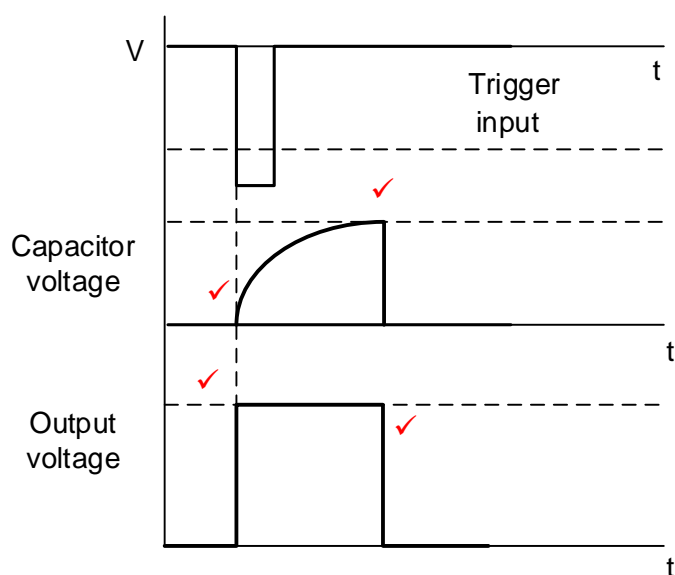
- 4.1.2 The 555 IC can only operate at power supply voltages between +5 V ✓ to +18 V ✓.
- (2)

- 4.1.3 The RS flip-flop stores the incoming information temporarily, ✓ until a new information is received. ✓
- (2)

- 4.2 4.2.1 Monostable multivibrator. ✓
- (1)

- 4.2.2
- As soon as the push-to-make switch is activated, it pulls Pin 2 to ground, activating the 555 circuit. ✓
 - The circuit is immediately set, setting both the output Pin 3 and discharge Pin 7 high ✓ which allows the timing capacitor to begin charging through resistor R_2 . ✓
 - When the threshold voltage on Pin 6 is reached, the 555 circuit will reset to zero and output Pin 3 will go low. ✓
- (4)

4.2.3



(4)

- 4.3 4.3.1 The LED will be flashing ON and OFF ✓ as the multivibrator changes its state at 1 Hz. ✓
- (2)

- 4.3.2 (a) The rate of the LED flashing ON and OFF would increase. ✓
- (1)

- (b) The rate of the LED flashing ON and OFF would decrease. ✓
- (1)

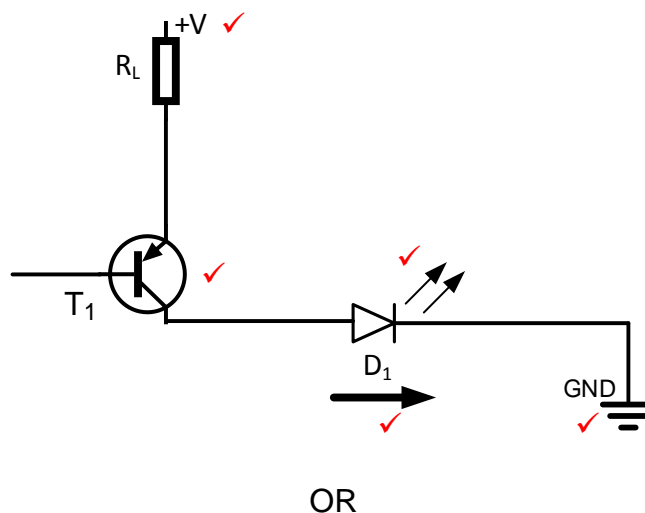
[20]

QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

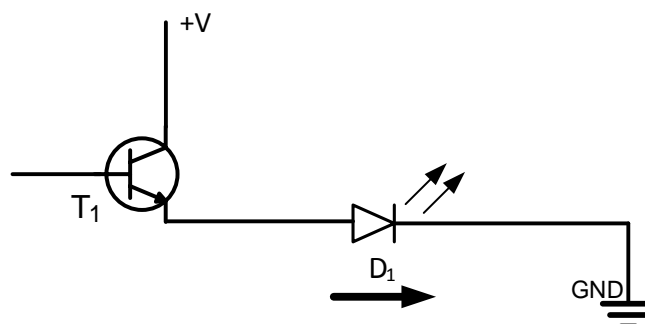
- 5.1 5.1.1
- In common anode all eight LEDs are internally connected together to a common positive voltage rail. ✓
 - In common cathode all eight LEDs are internally connected to a common 0 V ground. ✓

(2)

5.1.2



(5)



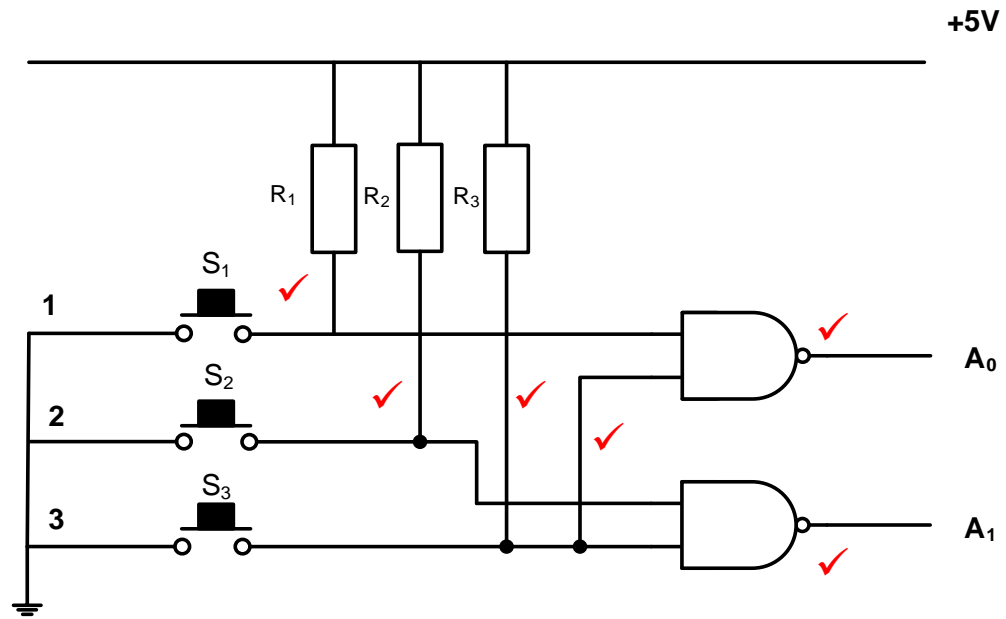
This drawing is given in the prescribed textbook. Even though it is incorrect, it will be marked as correct.

- 5.2 5.2.1 Light waves will pass through Grid A in the vertical plane only. ✓ This light will then be polarised as it passes in one plane only. ✓
- 5.2.2 No light waves will pass through Grid B. ✓ The light waves will be blocked.

(2)

(1)

5.3 5.3.1



(6)

5.3.2 W = 0 ✓

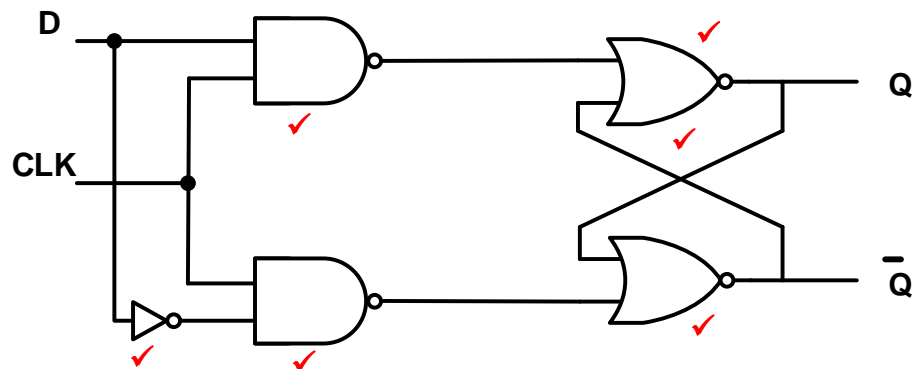
X = 1 ✓

Y = 0 ✓

Z = 0 ✓

(4)

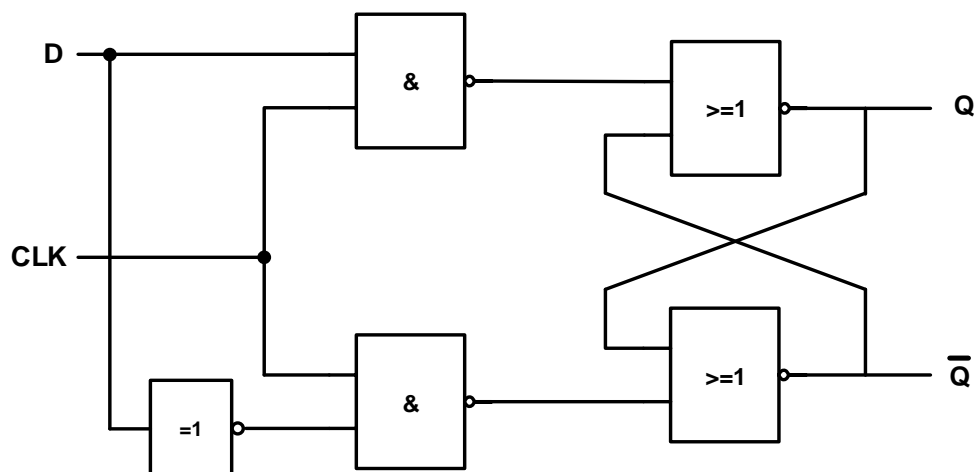
5.4 5.4.1



NOTE: 1 mark for each NAND gate = 2
 1 mark for each NOR gate = 2
 1 mark for the NOT gate
 1 mark for the latch = 1

OR

(6)



5.4.2

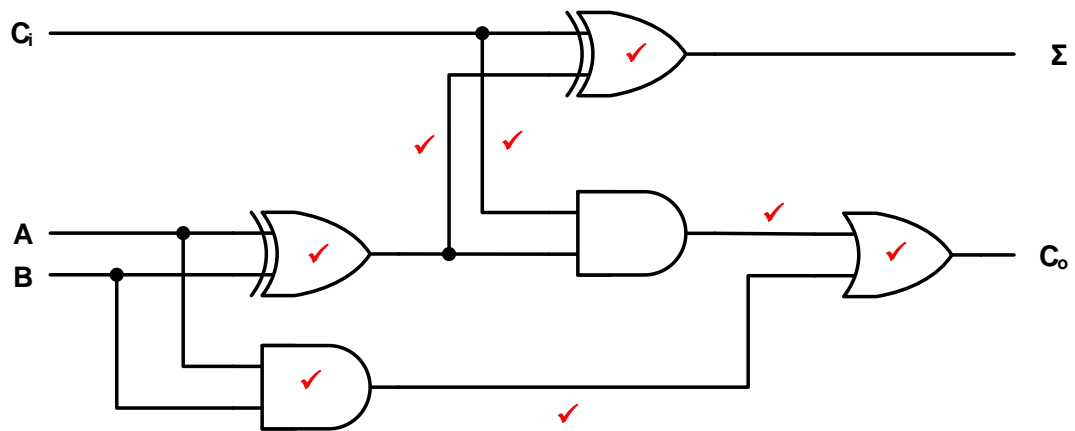
INPUTS		OUTPUTS	
CLK	D	Q	\bar{Q}
0	0	Latch	
0	1	Latch(Unchanged)	
1	0	0	1
1	1	1	0

TABLE 5.4.2

NOTE: 1 mark for each row of output

(3)

5.5

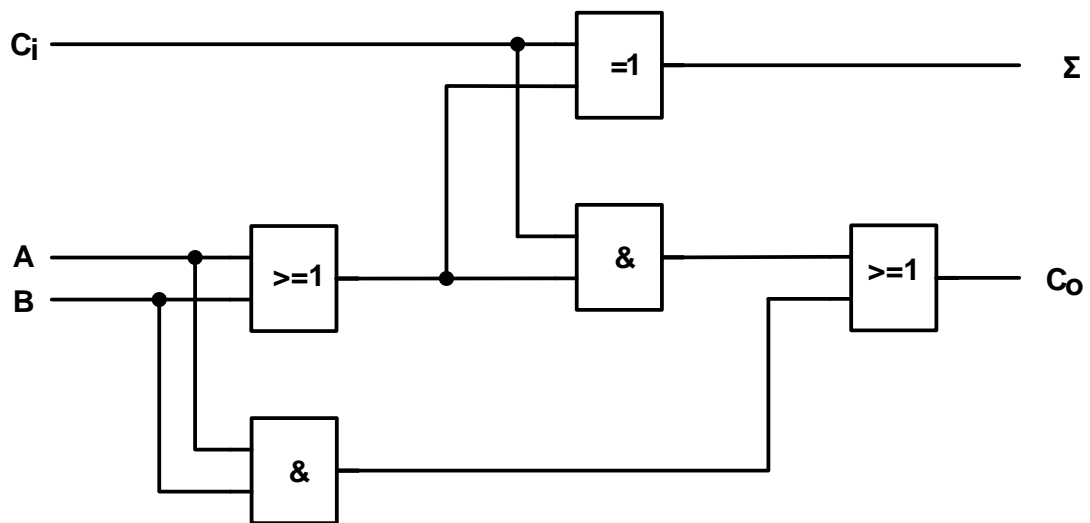
**NOTE:**

1 mark for each gate = 4

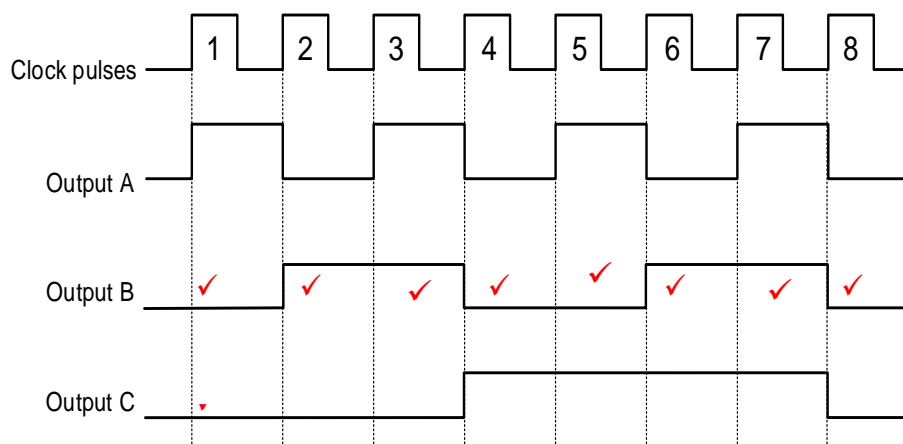
1 mark for each correct connection = 4

(8)

OR



5.6 5.6.1



NOTE: A mark is allocated for the correct count at each clock pulse.
e.g. the count at clock pulse 3 should be 011 and at clock pulse 8
the count should be 000.

(8)

5.6.2 The circuit in FIGURE 5.6 is synchronous. ✓

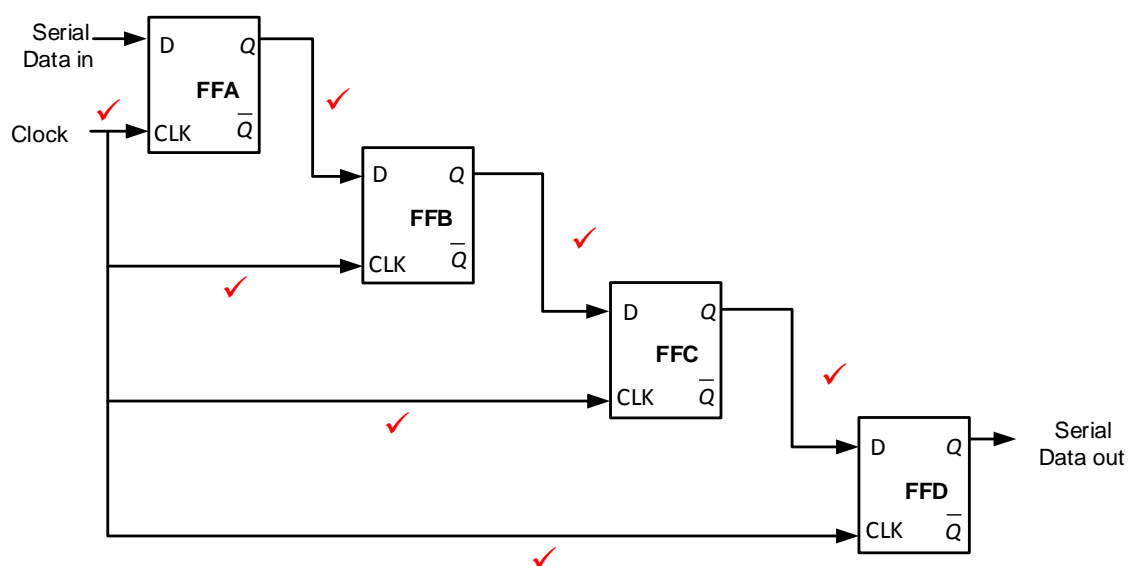
(1)

5.7 Robotics ✓

CNC machines ✓

(2)

5.8



(7)
[55]

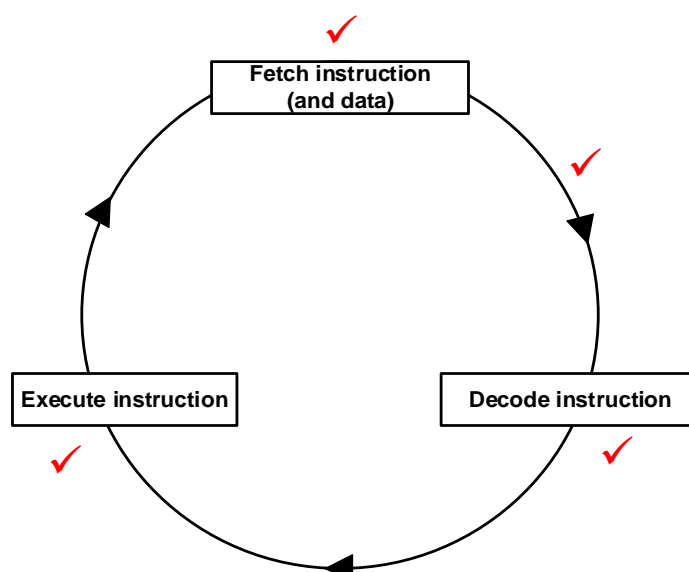
QUESTION 6: MICROCONTROLLERS

6.1 Microcontrollers are used in Industrial control devices:

- Industrial instrumentation ✓
- Monitoring ✓
- Process control
- Cooling systems

(2)

6.2



NOTE: 1 mark for each correct label = 3

1 mark for correct connection and direction = 1

(4)

6.3 A microprocessor is simply an IC which has only the Central Processing Unit (CPU) inside it. ✓

A microcontroller is essentially a complete, small scale computer ✓ with all the necessary devices required to function, ✓ embedded together on a single IC chip. ✓

OR

A microprocessor is an Integrated Circuit (IC) with only a Central Processing Unit (CPU).

A microcontroller is a complete, small scale computer with all the necessary devices required to function, embedded together on a single IC chip.

(4)

6.4 6.4.1 The Memory Data Register (MDR) stores a copy ✓ of the current instruction to be executed. ✓

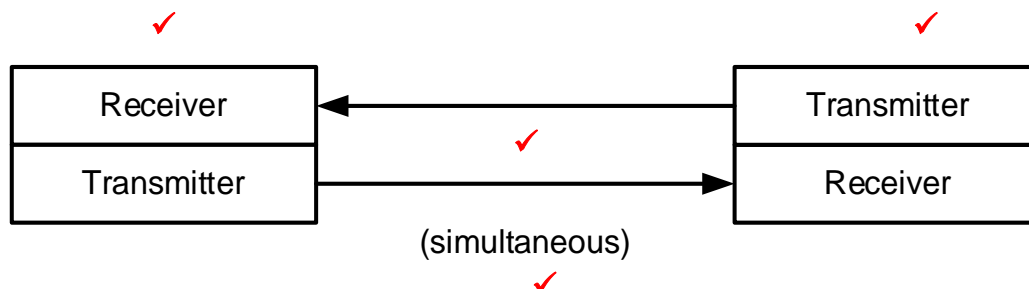
(2)

6.4.2 The Current Instruction Register (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)

6.5 The electrical (or mechanical) method ✓ of passing information between devices. ✓ (2)

6.6



(4)

6.7 6.7.1 Universal Asynchronous Receiver Transmitter ✓ (1)

- 6.7.2
- Reliable for high speed serial communication ✓
 - Uses less wires than parallel communication ✓
 - Useful for communicating serial data, i.e. text, numbers to a PC from a mouse or keyboard ✓
 - Easy and low-cost serial interface connection between two computer systems (3)

- 6.7.3
- On the transmit side, a UART creates the data packet – adding both sync, parity and stop bits to the eight-bit byte ✓
 - and sending that 'packet' out the transmission line (Tx) with precise timing. ✓
 - On the receiving end, the UART samples the Receive line (Rx) and at the same timing rates, picks out the sync and parity bits ✓
 - and produces the data in parallel form at its output. ✓
 - It has one start bit, eight data bits and one parity bit and one stop bit. Once the start bit has gone high, the next eight bits are data bits, followed by the parity bit. ✓
 - Once the stop bit has gone low it means the eight-bit data transfer is complete. ✓ (6)

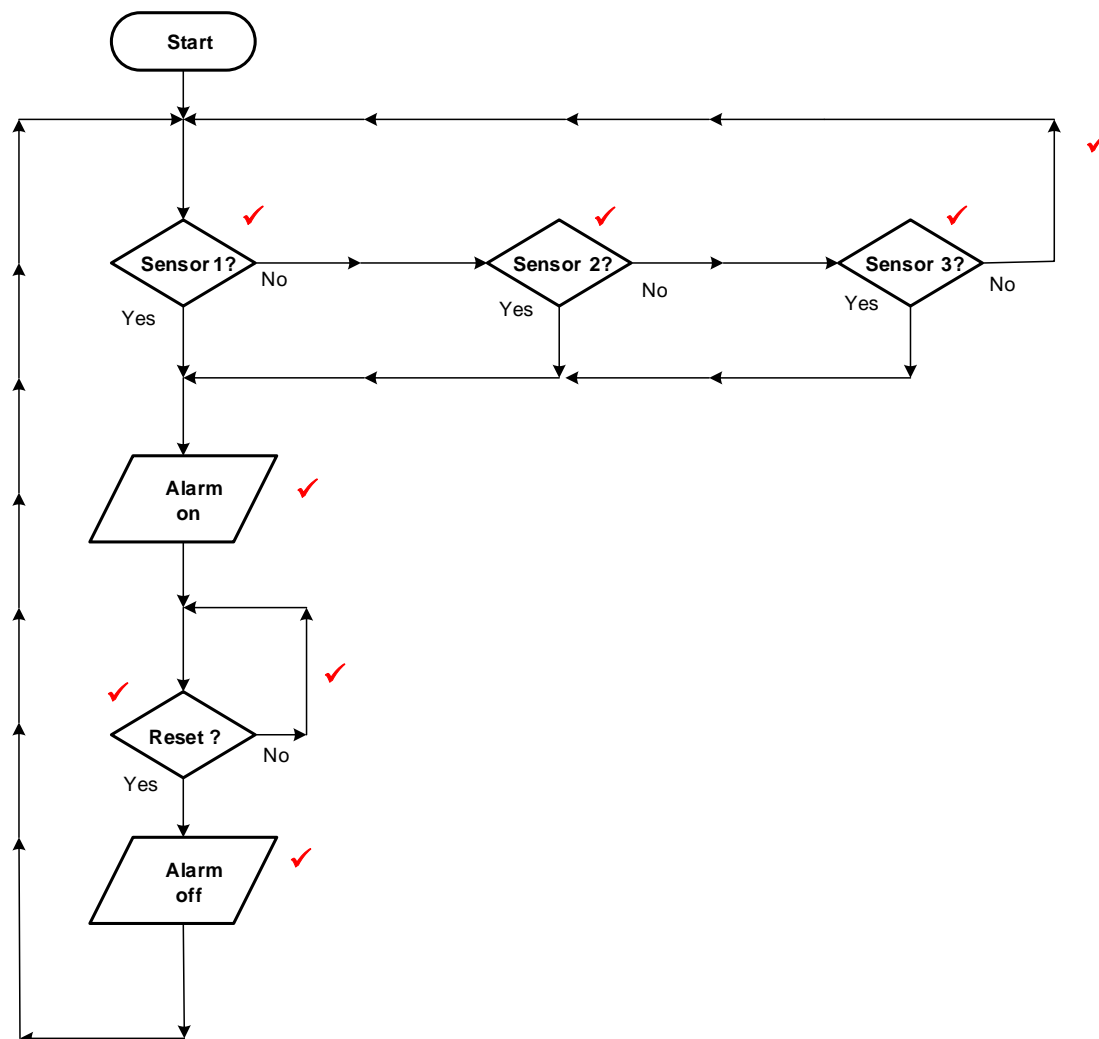
6.8 6.8.1 Point of sale (POS) terminals ✓
 Metering instruments ✓
 Large special automated machines ✓
 Modems
 Computer Numerically Controlled machines (CNC)
 Robots
 Embedded control computers
 Medical instruments and equipment (3)

6.8.2 Differential ✓ (1)

6.9 The ADC detects a continuously variable (analogue) signal and changes ✓ this analogue signal, ✓ without altering its essential content, into a multi-level (digital) signal. ✓ (3)

6.10 An algorithm is a precise set of procedures to be followed in order to solve a problem, ✓ being independent of any computer language. ✓
A flowchart is a pictorial version of an algorithm ✓ and shows the flow of a program. ✓ (4)

6.11



NOTE: 1 mark for each correctly labelled symbol = 6
1 mark for each correctly placed flow line = 2

(8)
[50]

TOTAL: 200