basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

ELECTRICAL TECHNOLOGY: DIGITAL ELECTRONICS

2023

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 16 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	B ✓	(1)
1.2	A ✓	(1)
1.3	C ✓	(1)
1.4	D ✓	(1)
1.5	B ✓	(1)
1.6	A ✓	(1)
1.7	C ✓	(1)
1.8	B ✓	(1)
1.9	C ✓	(1)
1.10	C ✓	(1)
1.11	B ✓	(1)
1.12	C ✓	(1)
1.13	A ✓	(1)
1.14	A ✓	(1)
1.15	C ✓	(1)
		[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 The purpose of the act is to provide good health and safety to all people at work ✓ especially when using machinery ✓ and for protection against the hazards arising out of activities of other ✓ people.
To establish an advisory council for occupational health and safety and related matters. (3)

2.2 An unsafe act may lead to an accident ✓ injuring an employee, this reduces the number of skilled personnel in the workplace ✓ therefore reducing the rate of productivity. (2)

2.3 Actions that will have serious consequences when they occur,✓ but there is a low chance of these risks happening. ✓ (2)

2.4
- Apply direct pressure to the wound using a cloth or gauze. ✓
- Apply continual pressure to a pressure point to stop all circulation to that part of the body. ✓ (2)

2.5 Not to be in direct contact with blood due to the risk of HIV infection. ✓ (1)
[10]

QUESTION 3: SWITCHING CIRCUITS

3.1 3.1.1 Bistable multivibrator ✓ (1)

3.1.2 Monostable multivibrator ✓ (1)

3.1.3 Astable multivibrator ✓ (1)

3.2 3.2.1 The purpose of variable resistor R_2 is to adjust the frequency ✓ of the output ✓ by changing the time constant of Capacitor C_1. (2)

3.2.2 As soon as the output goes high, ✓ the LED becomes forward biased and without a series resistor it would damage the LED✓ because of the excessive current flowing through the LED. ✓

OR

As soon as the output goes high, the current flowing through the LED will be too high without the series resistor and this may lead to damage to the LED. (3)

3.2.3 This circuit operates as an astable multivibrator because trigger pin 2 and threshold pin 6 ✓ are connected to capacitor C_1 ✓ causing the circuit output to trigger and change state ✓ as the capacitor charges to ⅔ and discharges to ⅓ of the supply voltage.✓ (4)

3.2.4 Capacitor C_1 will discharge through resistor R_2 to pin 7 and pin 1 down to ground. ✓ (1)

3.3 3.3.1 Because R_1=R_2, the voltage on pin 2 (inverting input) is half the supply voltage ✓ = 3 V✓

$$V_2 = \frac{6}{2} = 3\ V$$

(2)

3.3.2 6 V ✓ (1)

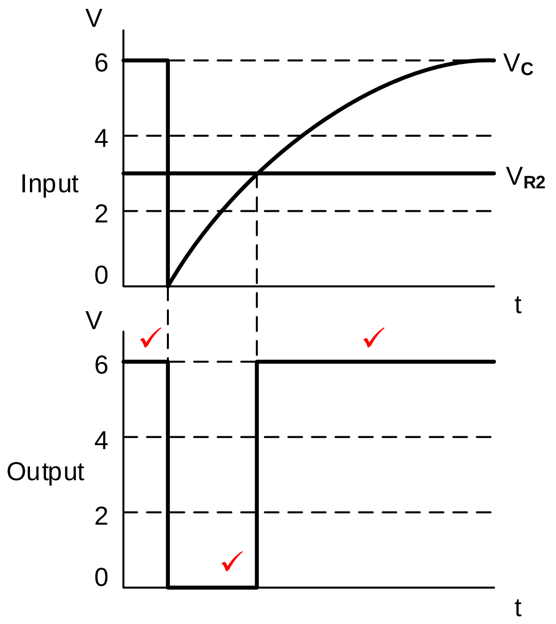
3.3.3 The output is high (6 V), ✓ because the voltage on the non-inverting input is higher than the voltage on the inverting input. ✓ (2)

3.3.4 0 V ✓, the switch connects pin 3 to 0 V ✓ and the capacitor will instantaneously discharge to 0 V. (2)

3.3.5
- The moment the switch is pressed, both plates of the capacitor and the voltage on the non-inverting input will be 0 V. ✓
- Because the voltage is higher on the inverting input (3 V), the output will be low (0 V). ✓
- The capacitor starts to charge and while the capacitor is charging the output remains low until the voltage across the capacitor reaches 3 V. ✓
- The moment the voltage across the capacitor exceeds 3 V, ✓ the output swings to high (6 V) ✓ where it will remain until the switch is pressed.

(5)

3.3.6

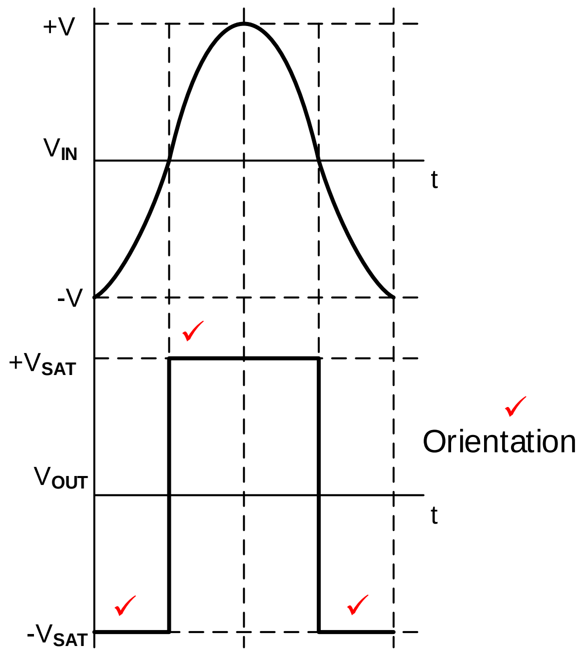


(3)

3.4 3.4.1 0 V. ✓ The inverting terminal is connected to ground. ✓ (2)

3.4.2 A Schmitt trigger is used to clean up distorted signals in radio receivers. ✓
A Schmitt trigger is used to convert analogue signals to digital signals. ✓ (2)

3.4.3



(4)

3.5 3.5.1 Because the gain is -1; $R_F = R_{IN} = 10\ k\Omega$, ✓ (1)

3.5.2

$$A_V = -\frac{R_F}{R_{IN}} \checkmark\checkmark$$
$$= -\frac{100 \times 10^3}{10 \times 10^3} \checkmark$$
$$= -10$$

OR

$$A_V = \frac{V_{OUT}}{V_1 + V_2 + V_3}$$
$$= \frac{-10}{0{,}3 + 0{,}4 + 0{,}3}$$
$$= -10$$

(3)

3.5.3

$$V_{OUT} = -\left(V_1 \frac{R_F}{R_1} + V_2 \frac{R_F}{R_2} + V_3 \frac{R_F}{R_3}\right) \checkmark$$
$$= -\left(1 \frac{20 \times 10^3}{10 \times 10^3} + 0{,}5 \frac{20 \times 10^3}{10 \times 10^3} + 0{,}5 \frac{20 \times 10^3}{10 \times 10^3}\right) \checkmark$$
$$= -4\ \text{V} \checkmark$$

(3)

OR

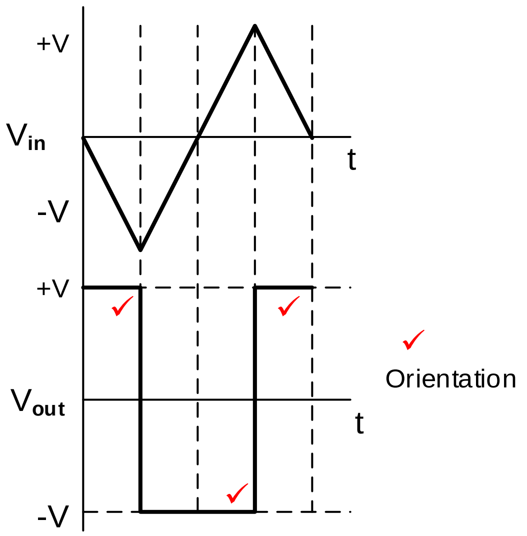
$$V_{OUT} = A_V(V_1 + V_2 + V_3)$$
$$= -2(1 + 0{,}5 + 0{,}5)$$
$$= -4\ V$$

3.5.4 An increase in R_F increases the gain ✓of the summing amplifier.

OR

R_F is directly proportional to the gain (1)

3.6 3.6.1



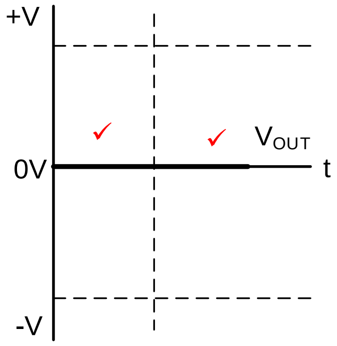
(4)

3.6.2 The polarity of the output depends on whether the input voltage increases in value ✓ or decreases in value. ✓ (2)

[50]

QUESTION 4: SEMICONDUCTOR DEVICES

4.1



(2)

4.2 4.2.1 Non-inverting amplifier. ✓ (1)

4.2.2 It means that the operational amplifier can operate within an infinite range of frequencies ✓ with the same amount of amplification or gain.✓ (2)

4.2.3
$$A_V = \left(1 + \frac{R_F}{R_{IN}}\right) \quad ✓$$
$$= \left(1 + \frac{47 \times 10^3}{10 \times 10^3}\right) \quad ✓$$
$$= 5{,}7 \quad ✓$$
(3)

4.2.4
$$A_V = \frac{V_{OUT}}{V_{IN}} \quad ✓$$
$$V_{OUT} = A_V \times V_{IN} \quad ✓$$
$$= 5{,}7 \times 100 \times 10^{-3}$$
$$= 0{,}57\ V/570\ mV \quad ✓$$
(3)

4.3 4.3.1 A = Control voltage ✓
B = Trigger ✓ (2)

4.3.2 The discharge pin provides the discharge path ✓ for the timing capacitor and the timing resistor. ✓ (2)

4.3.3 Comparator 1 compares the threshold voltage on pin 6 ✓ to 2/3rd of the supply voltage on the non-inverting input ✓ and provides a relevant output ✓ which is fed to the RS flip-flop. (3)

4.3.4
- Basic timing functions, like turning a light on (or off) for a certain length of time. ✓
- Pulse, oscillation and waveform generation ✓
- Digital logic probes
- To produce musical notes of a particular frequency
- In industrial applications
- Creating a warning light that flashes on and off

(2)
[20]

QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

5.1 5.1.1 A sinking output has the transistor collector ✓ connected to the LED's cathode. ✓
A sourcing output has the transistor emitter✓ connected to the LED's anode. ✓
A sourcing output has the transistor emitter connected to the LED's cathode.
A sinking output uses a npn transistor. (1 mark)
A sourcing output uses a pnp transistor. (1 mark) (4)

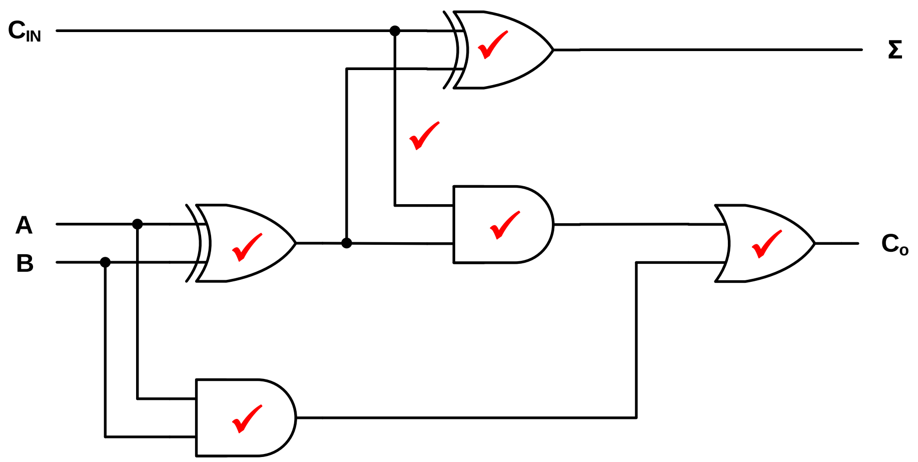
5.1.2 Liquid Crystal Display✓ (LCD) (1)

5.2 5.2.1

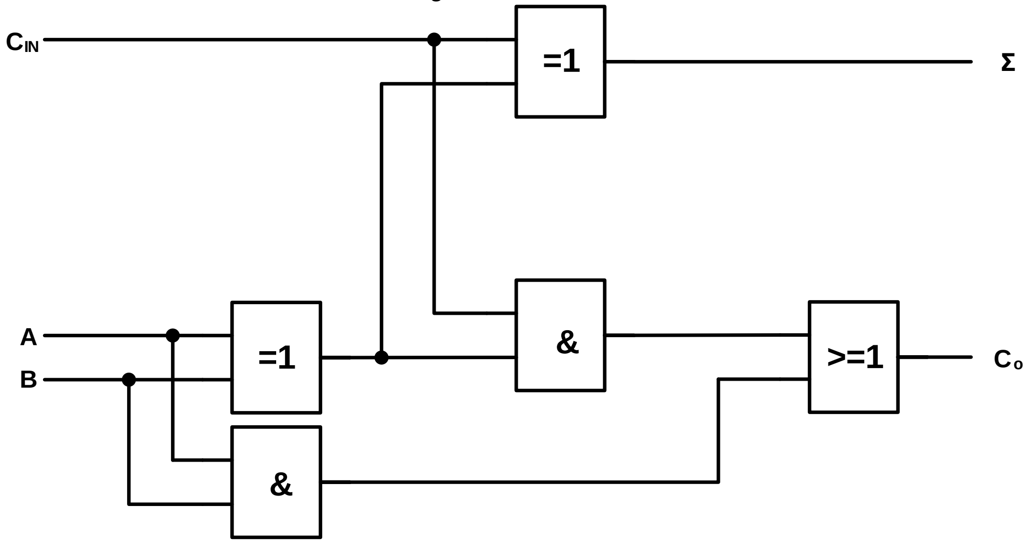
INPUTS			OUTPUTS	
C_i	A	B	Σ	C_o
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	**1**✓
1	0	0	1	0
1	0	1	0	**1**✓
1	1	0	0	**1**✓
1	1	1	**1**✓	**1**✓

(5)

5.2.2

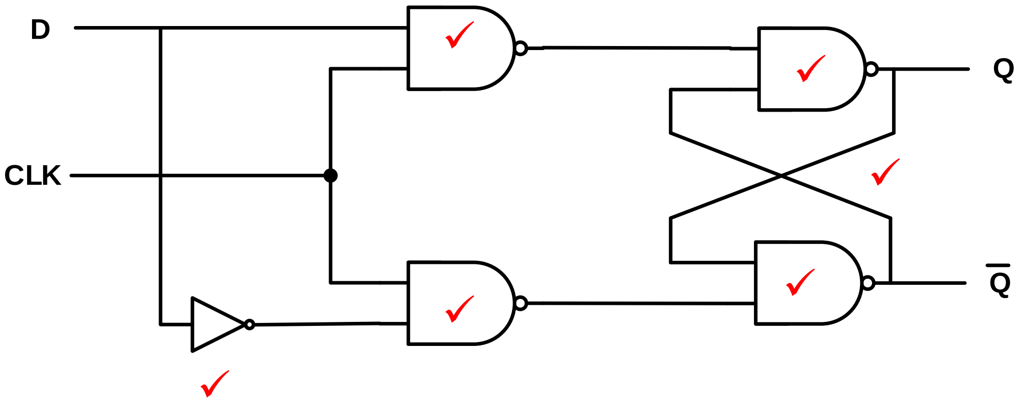


OR (6)

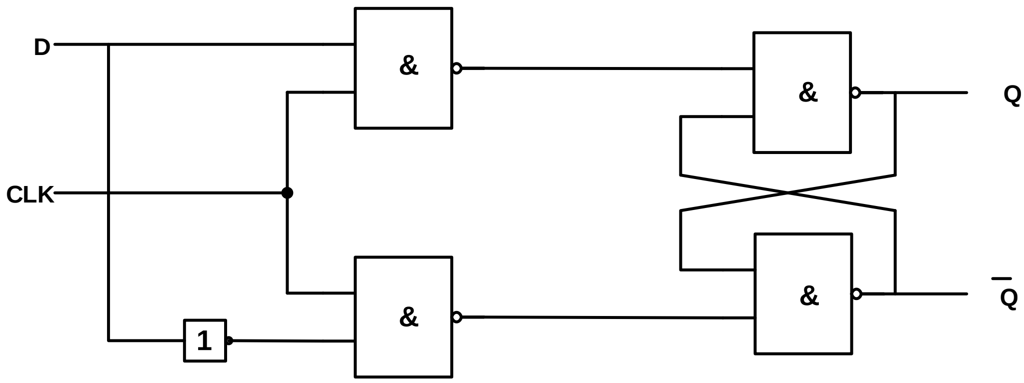

CIN
=1
Σ
A
B
=1
&
>=1
Co
&

5.3 An asynchronous device is one that is free running, ✓ with its operation not relying on the additional input of an input clock pulse. ✓ (2)

5.4 5.4.1



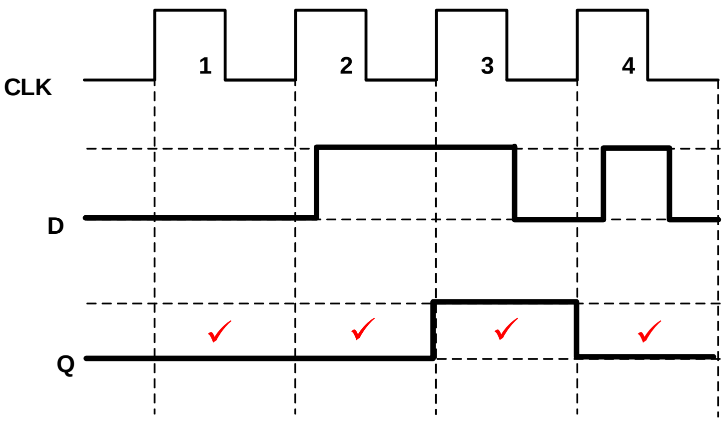
OR



(6)

5.4.2 Shift registers ✓
Storage registers ✓ (2)

5.4.3

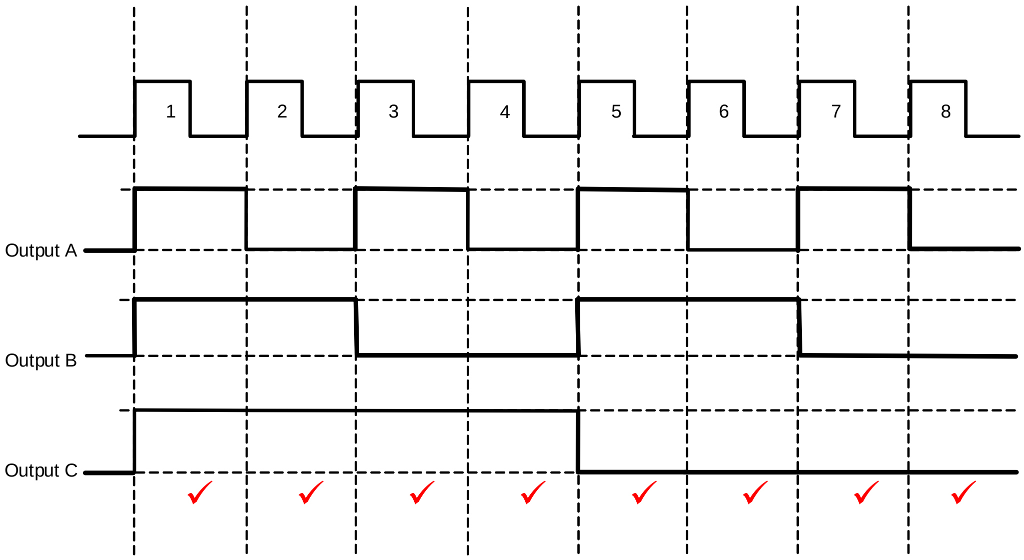


(4)

5.5 Data enters the register one bit at a time ✓ and leaves the register one bit at a time in a serial manner. ✓ (2)

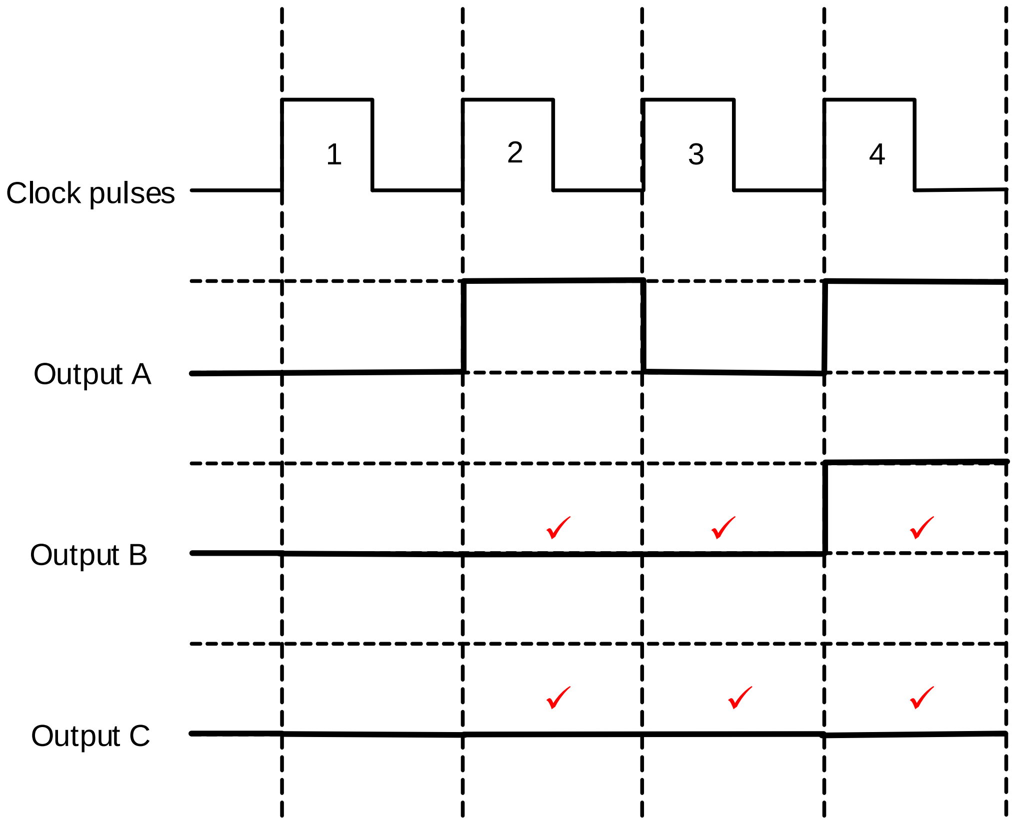
5.6 5.6.1 Synchronous Down counter ✓
Down counter
Synchronous counter (1)

5.6.2



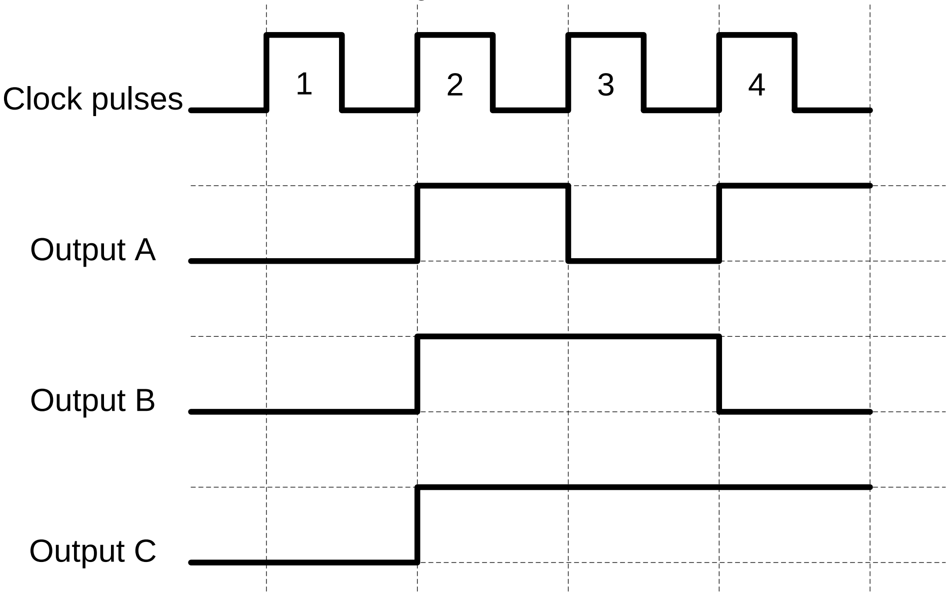
NOTE: 1 mark for each correctly drawn output per clock pulse = 8 (8)

5.7

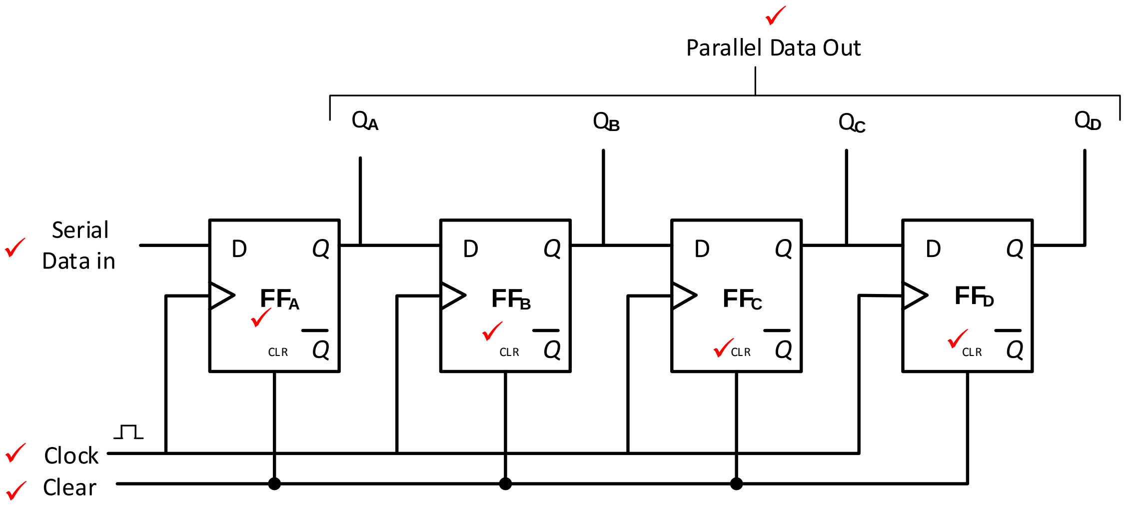


(6)

OR



5.8



NOTE: 1 mark for each correctly labelled input = 3
1 mark for correctly labelled output = 1
1 mark for each correctly placed flip flop = 4

(8)
[55]

QUESTION 6: MICROCONTROLLERS

6.1
- They perform arithmetic and logic operations that make use of data on the chip in the form of the ROM programme. ✓
- It is this data that the microprocessor moves in sequential order from the ROM into the CPU to be processed, ✓one-instruction-at-a-time, all controlled by an on-board clock. ✓
- As the process moves through its set sequence, data is often moved into and out of the RAM for short-term storage. ✓
- When the sequence has ended, the CPU sends its final result to the I/O ports to be communicated out to the 'real world' and to control appliances. ✓ (5)

6.2 6.2.1 A = Data from memory ✓
B = Address for reading/writing data ✓
C = Central Processing Unit (CPU) ✓
D = Program counter ✓ (4)

6.2.2
- The operating cycle of a CPU follows a 'fetch-decode-execute' cycle. ✓
- first it fetches instructions and data from memory. ✓
- it then decodes the instructions which are written in binary code, ✓
- then it executes the instruction ✓ before starting the cycle all over again.

NOTE: If a candidate used the diagram only, 2 marks will be awarded. (4)

6.3 6.3.1 The Memory Address Register (MAR) stores the address of the next instruction ✓ to be executed by the processor. (1)

6.3.2 The Programme counter (PC) contains the address and status of the next instruction for processing and also informs the processor what the next instruction is, that needs executing. ✓ It keeps a count of the number of instructions that have been executed, ✓ adding one instruction each time. ✓ (3)

6.4 The CACHE memory is a 'short term memory that stores instructions and addresses ✓ that are more often used ✓, which saves time for the CPU. (2)

6.5 6.5.1 A = Sender/Transmitter ✓
B = Receiver ✓ (2)

6.5.2
- At point A the byte of data must be converted into a string of serial bits ✓ using a parallel-in – serial-out shift register. ✓
- The byte of data (8 bits) is then transmitted over a single data line.✓
- At point B the serial-in-parallel-out shift register ✓ receives the serial data bit-by-bit ✓and packs it into a 8-bit byte. ✓ (6)

6.6
- Useful for communicating serial data. ✓
- Easy and low-cost serial interface connection between two computer systems. ✓
- The industrial standard for asynchronous data communication interfaces.
- Reliable for high-speed serial communication.
- Uses far fewer wires than parallel communications.
- Enables long distance communications. (2)

6.7 6.7.1 SDA (Serial data line) ✓ (1)

6.7.2 I^2C has slower speed. ✓
I^2C draws more power. ✓
I^2C can be locked up by one device that fails to release the communication bus. (2)

6.7.3 The pull up resistors Rp enable the I^2C lines to go high .✓ (1)

6.7.4
- The master drives the SCL clock line. ✓ and initiates a transfer of data over the I^2C bus✓
- The slaves respond to the master when instructed. ✓One master can instruct many slaves. (3)

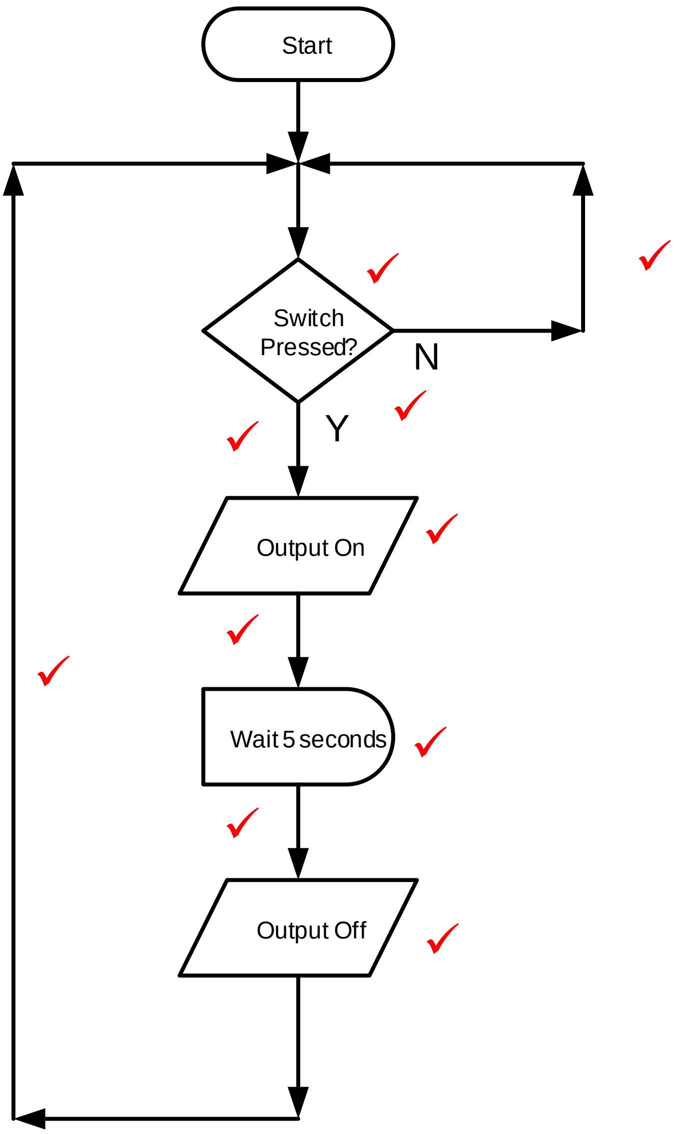
6.8 An algorithm is a detailed step-by-step sequence of instructions ✓ that are followed to complete a task. ✓

OR

An algorithm is a process that is followed in problem-solving operations or calculations.

A program is a sequence of instructions ✓ that tells a computer how to do a task.✓ (4)

6.9



NOTE: 1 mark for each correctly labelled symbol = 4
1 mark for each correctly placed flow line = 5
1 mark for each correctly placed YES/NO = 1 (10)

[50]

TOTAL: 200