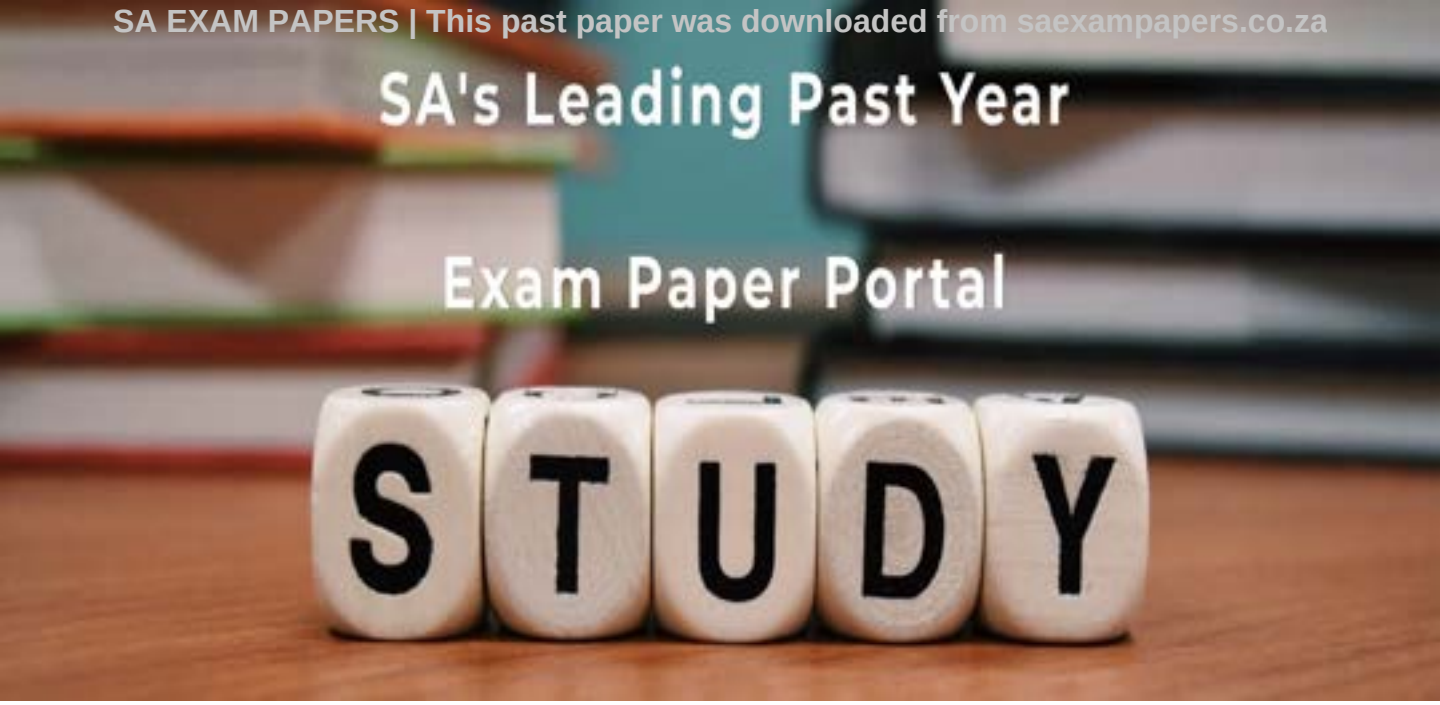


basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY: DIGITAL ELECTRONICS

NOVEMBER 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

1.1	B ✓	(1)
1.2	B ✓	(1)
1.3	C ✓	(1)
1.4	C ✓	(1)
1.5	B/C ✓	(1)
1.6	D ✓	(1)
1.7	B ✓	(1)
1.8	C ✓	(1)
1.9	A ✓	(1)
1.10	B ✓	(1)
1.11	C ✓	(1)
1.12	B ✓	(1)
1.13	A ✓	(1)
1.14	A ✓	(1)
1.15	C ✓	(1)

[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 Workplace means any premises or place where a person performs work ✓ in the course of employment.✓ (2)

2.2 Your right to fair labour practices. ✓
Your right to work reasonable hours. ✓
Your right to belong to a trade union.
Your right to earn a living wage.
Your right not to be discriminated against.
Your right to work in a safe environment. (2)

2.3 Poor ventilation reduces the correct amount of oxygen ✓ which might lead to drowsiness. ✓
NOTE: If reference is made to other effects that relates to poor ventilation like drowsiness, accidents etc. the answer will be accepted on merit. (2)

2.4
- To dismiss an employee without due process. ✓
- To reduce the rate of remuneration without due process. ✓
- Alter the terms of conditions of his/her employment to terms of conditions that is less favourable to him/herself.
- Harassment and verbal abuse.
- Alter position relative to other people.
- Treat employees unfair because of race.

NOTE: If a learner only mentions an infringement of rights only 1 mark will be awarded. Duplicate mentioning of rights will not be awarded (2)

2.5 Equipment may be damaged making it unsafe ✓ endangering the life of other users ✓ which might lead to an accident/injury. (2)
[10]

QUESTION 3: SWITCHING CIRCUITS

3.1 Negative feedback is when a portion of the output signal ✓ is fed back to the input, out of phase ✓ or subtracted from the input. (2)

3.2 3.2.1 Schmitt trigger ✓ (1)

3.2.2 Bistable multivibrator ✓ (1)

3.2.3 Monostable multivibrator ✓ (1)

3.3 3.3.1 R_2 is a pull-up resistor ✓
R_2 keeps the voltage on pin 2 high. (1)

3.3.2
- When S_2 is pressed it connects pin 2 to 0 V. ✓
- This low input triggers the circuit and the output goes high. ✓
- When output goes high LED_2 is forward biased and ON ✓
- while LED_1 is reversed biased and OFF. ✓ (4)

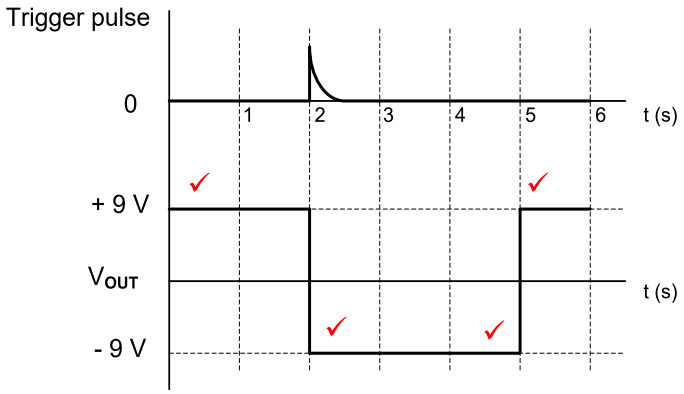
3.3.3 The circuit is reset by pressing S_1. ✓ This connects reset pin 4 to 0 V. ✓ (2)

3.4 3.4.1 0 V ✓ (1)

3.4.2 During its natural resting condition, the negative reference voltage keeps the potential on the inverting input negative ✓ ensuring that the output remains stable at $+V_{CC}$. ✓ (2)

3.4.3 When a positive trigger voltage greater than V_{REF} is applied to the inverting input its potential will be greater than the 0 V on the non-inverting input ✓ causing the output to saturate to $– V_{CC}$ ✓ where it will remain for the duration of the time constant determined by C_2 and R_2. ✓ (3)

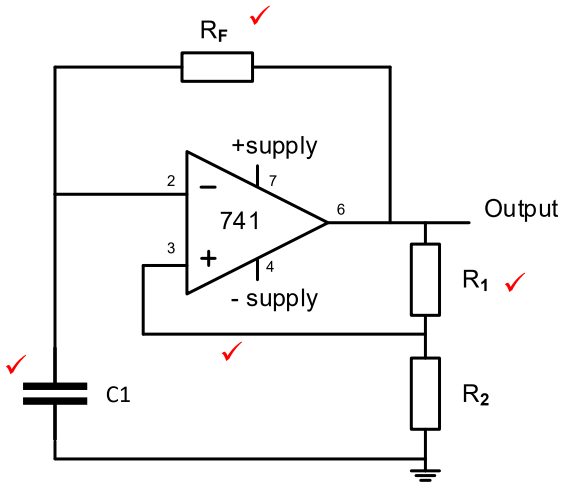
3.4.4



(4)

NOTE: 1 mark for starting the output at +9 V
1 mark for the output changing from +9 V to -9 V at trigger input
1 mark for the correct duration of the output state
1 mark for the return to +9 V
An inverted waveform will lose 1 mark for orientation.

3.5 3.5.1



(4)

3.5.2 The output voltage of a 741 op amp astable multivibrator circuit constantly changes between + Vcc and -Vcc whereas the output of a 555 IC astable multivibrator circuit changes between +Vcc and 0 V. (2)

3.6 3.6.1 Variable resistor/Potentiometer R_2 (1)

3.6.2 Resistor R_1
Thermistor (2)

3.6.3 By adjusting variable resistor R_2 the new reference voltage at the inverting input will change. (2)

3.7 Clean up signals in radio receivers.
Eliminate noise caused by switch bounce in digital circuits.
Changing of sine waves into square or rectangular waves
Signal recovery after severe distortion. (2)

3.8 3.8.1 Variable resistor R_4 provides negative feedback that controls the gain of the circuit. (2)

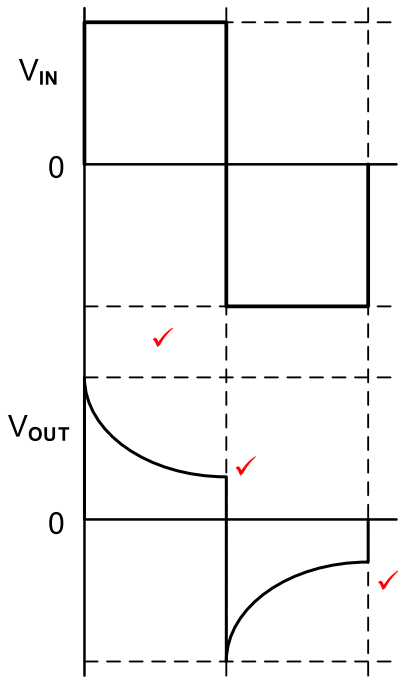
3.8.2
$$V_{OUT} = -\left(V_1\frac{R_F}{R_1} + V_2\frac{R_F}{R_2} + V_3\frac{R_F}{R_3}\right)$$
$$= -\left(0{,}5 \times \frac{72000}{10000} + 0{,}45 \times \frac{72000}{10000} + 0{,}3 \times \frac{72000}{10000}\right)$$
$$= -9\ V$$
(3)

3.8.3 When $R_F = R_1 = R_2 = R_3$. They cancel each other out in the formula giving $V_{OUT} = -(V_1+V_2+V_3)$.
When R_4 is set to 10 kΩ the overall circuit gain is 1. (1)

3.8.4 When R_4 is increased beyond 72 kΩ the gain of the amplifier increases driving it into saturation and causing distortion on the output. (2)

3.9 3.9.1 A passive differentiator primarily performs mathematical differentiation on an input signal, ✓ producing an output voltage proportional to the rate of change of the input voltage. ✓ (2)

3.9.2



NOTE: The wave shape must be correct before any marks are allocated.
1 mark for orientation
1 mark for each ½ cycle (3)

3.10 In an op-amp differentiator a capacitor is connected to the inverting input and resistor used in the feedback loop. ✓
In an op-amp integrator a resistor is connected to the inverting input with a capacitor in the feedback loop. ✓ (2)
[50]

QUESTION 4: SEMICONDUCTOR DEVICES

4.1 4.1.1 FIGURE A - output voltage will be positive/high. ✓
FIGURE B - output voltage will be negative/low. ✓ (2)

4.1.2 Small size ✓
Cheap ✓
Low power consumption
Highly stable
Highly reliable (2)

4.1.3 Common mode rejection ratio is the ability of an op-amp to suppress common mode signals. ✓
The common mode rejection ratio is the ratio between the output voltage to the common input voltage when the same signal is applied simultaneously to both inputs. (1)

4.2 4.2.1 Negative feedback. ✓ (1)

4.2.2
$$A_V = -\frac{R_F}{R_{IN}} \quad ✓$$
$$= -\frac{47\,00}{470} \quad ✓$$
$$= -10 \quad ✓$$
(3)

4.2.3
$$V_{out} = A_V \times V_{IN} \quad ✓$$
$$= -10 \times 2 \times 10^{-3} \quad ✓$$
$$= -0{,}02V \quad ✓$$
$$= -20\,mV$$

OR

$$V_{OUT} = V_{IN} \times \left(-\frac{R_f}{R_{IN}}\right)$$
$$V_{OUT} = 0{,}002 \times \left(-\frac{4700}{470}\right)$$
$$V_{OUT} = -0{,}02\,V$$
(3)

4.2.4 The output voltage will be able to swing above ✓ and below ✓ the zero levels. (2)

4.3 4.3.1 Controlling the positioning of a servo device. ✓
Temperature measurement.
Timers in oven temperature control.
Oscillator as motor speed control. (1)

4.3.2 The NPN transistor (T_1) will only turn on when output $\bar{Q}$ from the flip-flop goes high. ✓ (1)

4.3.3 When the inverting terminal voltage is higher, the comparator's output will be low ✓ (1)

4.3.4 It divides the supply voltage into three equal values. ✓
The resistors act as voltage dividers. (1)

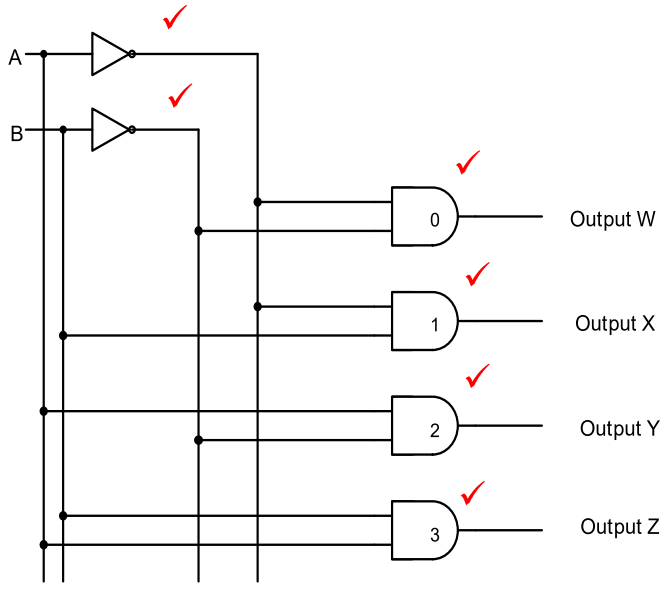
4.3.5 The 555 IC will be triggered ✓ and the output voltage at Pin 3 rises near to the supply voltage ✓
NOTE: Due to the error in the schematic of the 555 IC, the following response will be accepted:
When pin 2 falls below ⅓V_{CC}, the output of comparator C_2 will be low, if R of the flip-flop is high, the circuit will be reset, if R is low, the circuit will stay in its previous state. (2)
[20]

QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

5.1 5.1.1 Both grids A and B will only allow light waves that passes in a vertical plane ✓ therefore allowing vertical light waves to pass from point A to point B because the gridlines are in a vertical position. ✓
Grid C will allow only vertical light waves to pass through, ✓ because the gridlines are in a vertical position. Grid D will block the vertical light waves because the gridlines are in a horizontal position. ✓ (4)

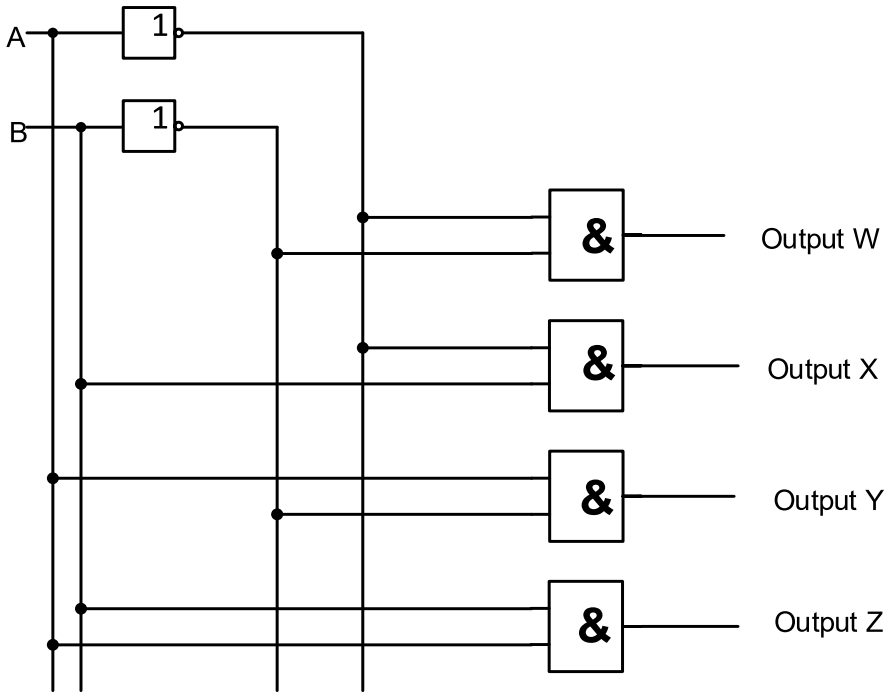
5.1.2 Each pixel in the matrix is controlled by its own thin film transistor ✓ that turns the energising voltage on or off. ✓
The transistor array requires careful control for them to turn their pixels on and off ✓ at the correct times to create a picture.
By energising different pixels by means of a transistor, the pixels will become visible and the combined visible pixels will form a coherent number or letter. (3)

5.2 5.2.1



(6)

OR

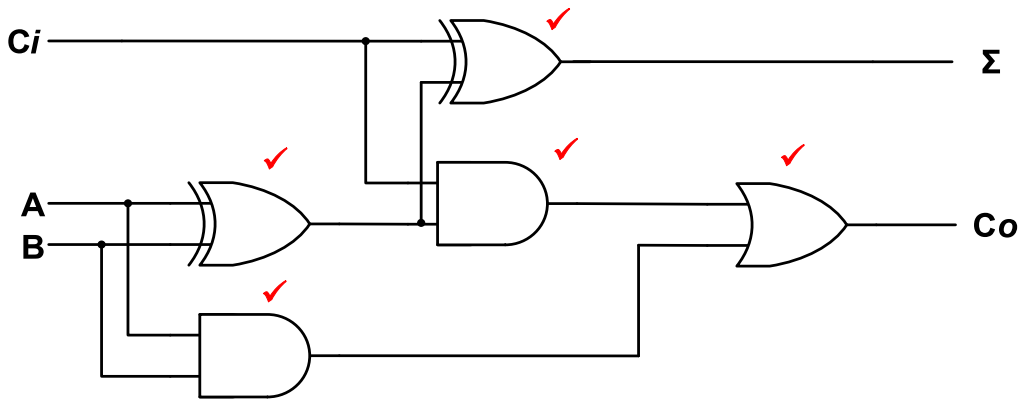


5.2.2

Inputs		Outputs			
A	B	W	X	Y	Z
1	0			1 ✓	
1	1				1 ✓
0	0	1 ✓			
0	1		1 ✓		

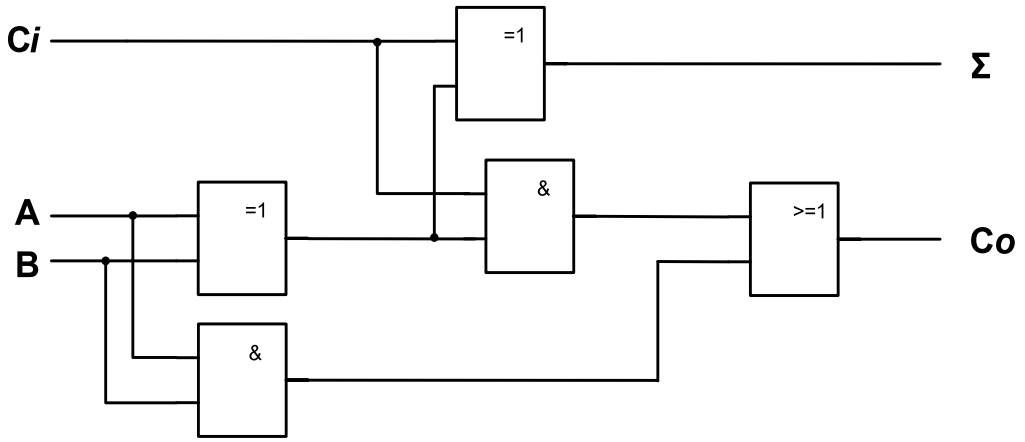
(4)

5.3

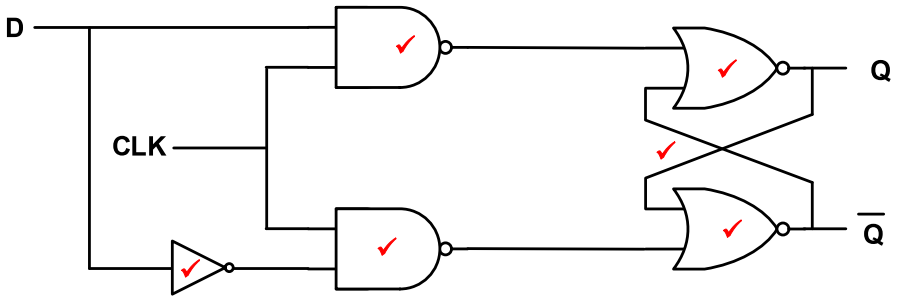


(5)

OR

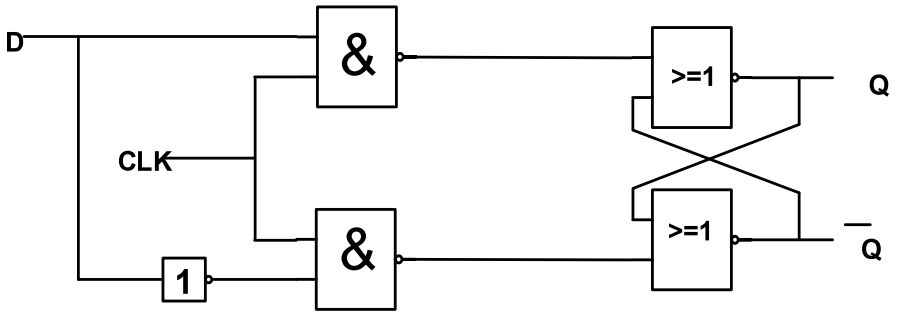


5.4 5.4.1



(6)

OR



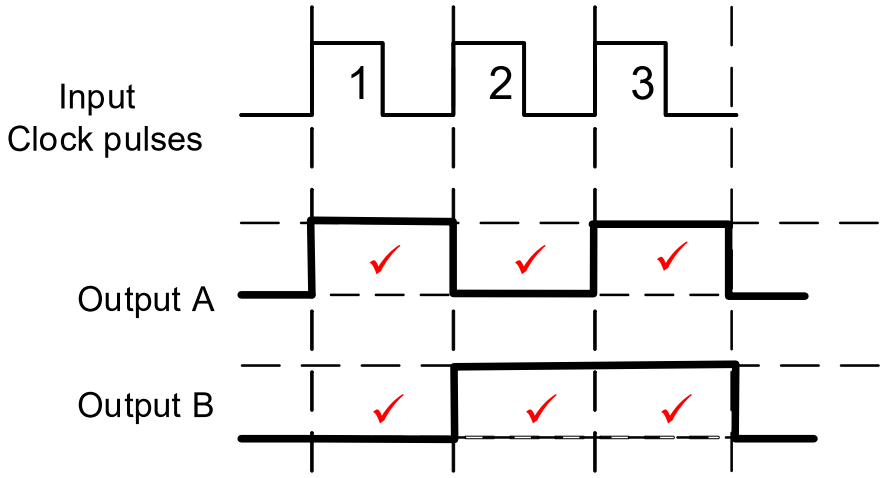
NOTE: 1 mark for each correctly placed gate = 5
1 mark for latch = 1
If a candidate draws the circuit with NAND gates only, full marks will be awarded.

5.4.2

CLK	D	Q	$\overline{Q}$
0	0	Latch	Latch
0	1	Latch	Latch
1	0	0 ✓	1 ✓
1	1	1 ✓	0 ✓

(4)

5.5



(6)

5.6 Pulse triggered allows the circuit to change state ✓ during the 'high' period of a clock pulse. ✓

Edge triggered is where the flip-flop changes state at the rising edge ✓ or falling edge ✓of the waveform. (4)

5.7 5.7.1 A frequency divider is a counter that divides the input frequency of each preceding stage, ✓ resulting in a ripple effect of successive stages dividing the frequency of the chain of flip-flops. ✓ (2)

5.7.2 A decade counter is a binary counter designed to count from 0000 (decimal 0) to 1001 (decimal 9) ✓ and resets ✓ itself back to 0000 (decimal 0) (2)

5.8 5.8.1 Parallel - In: Serial-out ✓shift register (1)

5.8.2 A = 4-bit Parallel Data Input✓
B = Serial Data Output ✓ (2)

5.8.3 All four bits of the data are introduced to the register at the same time, ✓ but once stored, ✓the data is shifted out one bit at a time ✓ controlled by the clock input cycle. (3)

5.8.4 Four ✓ (1)

5.8.5 It enables parallel data to be converted into serial data. ✓
It is able to mix a number of input lines together into a single serial stream of data. ✓ (2)

[55]

QUESTION 6: MICROCONTROLLERS

6.1 A microcontroller is a computer presented in a single integrated circuit ✓ which is dedicated to perform a task/s ✓ and execute one specific application.✓

OR

A microcontroller is an independent device, a computer on a chip that can perform a limited range of functions without needing to rely on other chips or devices. (3)

6.2 6.2.1 A = Memory✓ (RAM & ROM)
B = Accumulator✓ (2)

6.2.2 The control unit manages the process of moving data ✓ into and out of the memory ✓ and carry out program instructions one at a time ✓ in an ordered sequence.✓ (4)

6.2.3 The function of the ALU is to carry out calculations ✓ and do a comparison on the data. ✓ (2)

6.3 Discrete logic consists of a single processor with many separate logic chips.✓

OR

Discrete logic is a term that refers to logic circuits that consists of many separate logic components.

Integrated logic consists of the entire processor on a single chip. ✓ (2)

6.4 The accumulator stores data ✓ that is needed as part of any arithmetic operation. ✓ (2)

6.5 6.5.1 The function of the system bus is to pass information, data and instructions ✓ between the respective parts of the microcontroller ✓ by using interconnecting 'tracks' ✓ as well as to communicate with the 'outside world' through the control bus, data bus and the address bus. ✓ (4)

6.5.2 Synchronous communication supports a higher data transfer rate.✓
The sender and the receiver use the same clock pulse. ✓
The same clock pulse is used to send and receive data. (2)

6.5.3 Requires more communication lines to transfer data. ✓
Requires more space. ✓
Requires larger connections. (2)

6.6 Half duplex communication is where the two devices take turns in communicating, ✓ one after the other. ✓
Full-duplex communication is where the two devices can both transmit and receive ✓ at the same time. ✓ (4)

6.7 6.7.1 Serial data line ✓ (1)

6.7.2 Pull-up resistors, connected to a +5 V supply, are necessary for the lines (SCL and SDA) ✓ to go high. ✓ (2)

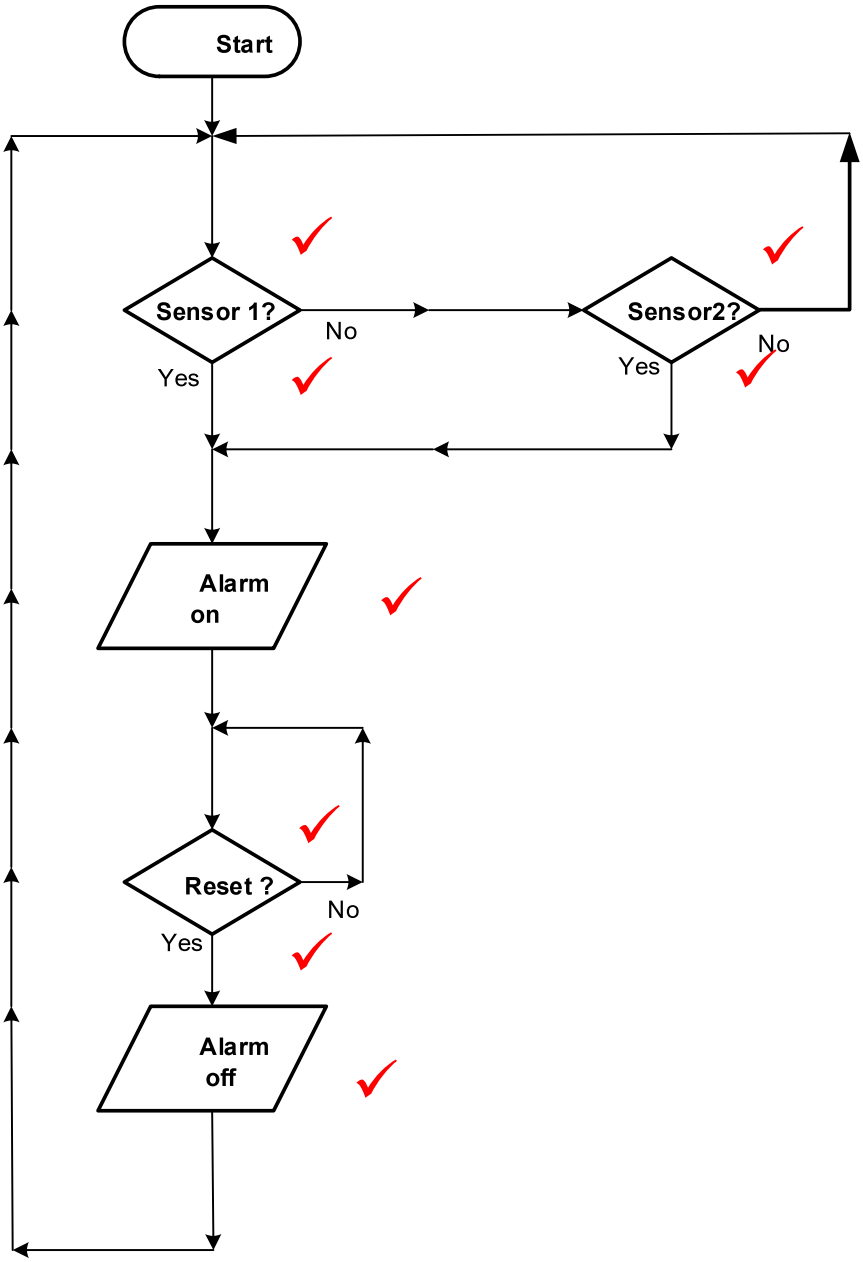
6.7.3 I^2C has slower speed ✓
I^2C draws more power than SPI ✓
I^2C can be locked up by one device that fails to release the communication bus. (2)

6.7.4
- The master issues a start sequence on the I^2C bus to the slave to transfer data. ✓
- This data will be transferred in sequence of 8 bits (byte) through the serial data line starting with the MSB to the LSB ✓
- The serial clock line will then pulse high and low during the data transfer process ✓
- For every 8 bits transferred, the device receiving the data sends back a low acknowledgement bit as an indication that it is ready to receive the next 8 bits (byte). ✓
- If the device receiving the data sends back a high acknowledgement bit, which is an indication that the device cannot accept any further data, ✓ then the master will terminate any further instruction to the slave by sending a stop bit. ✓ (6)

6.8 6.8.1 A program is a sequence of instructions ✓ that informs a computer how to perform a task. ✓ (2)

6.8.2 A flow diagram is a visual representation of steps and decisions ✓ needed to perform and complete a process. ✓ (2)

6.9



NOTE: 1 mark for each correct labelled symbol = 5
1 mark for each correctly placed Yes/No = 3

(8)
[50]

TOTAL: 200