Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2022

ELECTRICAL TECHNOLOGY: DIGITAL ELECTRONICS MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 13 pages.

INSTRUCTIONS TO 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.

   2.6 Markers should consider that candidates' answers may deviate slightly from the marking a guideline depending on how and where in the calculation rounding off was used.

3. These marking guidelines are only a guide with model answers.

4. 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	A ✓	(1)
1.2	B ✓	(1)
1.3	A ✓	(1)
1.4	D ✓	(1)
1.5	C ✓	(1)
1.6	C ✓	(1)
1.7	A ✓	(1)
1.8	D ✓	(1)
1.9	B ✓	(1)
1.10	C ✓	(1)
1.11	D ✓	(1)
1.12	A ✓	(1)
1.13	D ✓	(1)
1.14	B ✓	(1)
1.15	A ✓	(1)
		[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 An occurrence of catastrophic proportions, ✓resulting from the use of machinery, or activities at work. ✓ (2)

2.2 The learner does not know safe practices. ✓
The learner knows better but intentionally conducts the act. (1)

2.3 2.3.1 Running could cause you to trip or collide with another learner. ✓
This could result in you injuring yourself with nearby equipment or machinery. ✓ (2)

2.3.2 This could cause the outlet to exceed its rated current ✓ and could lead to short circuits, fires or damaged appliances. ✓ (2)

2.4 First, I would define all the various threats to safety in the workshop. ✓
Secondly, I would determine the extent of all the vulnerabilities in the workshop. ✓
Finally, I would devise countermeasures should a risk occur. ✓ (3)

[10]

QUESTION 3: SWITCHING CIRCUITS

3.1 3.1.1
- Two external inputs ✓
- Two stable states ✓ (2)

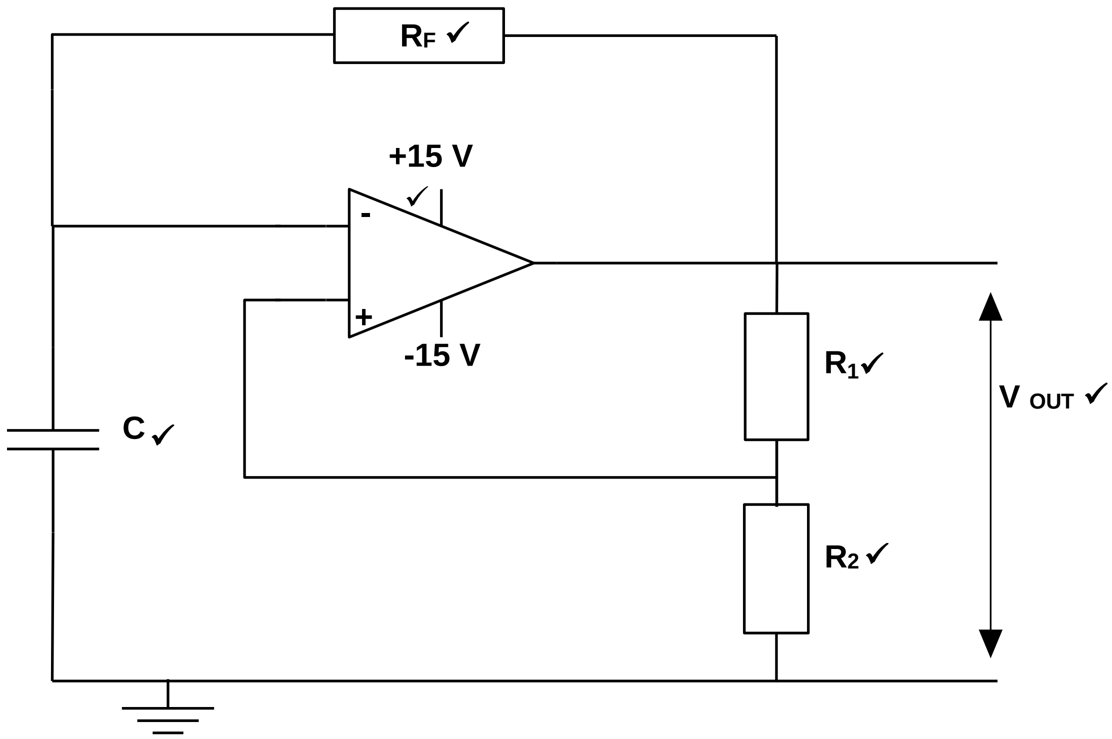
3.1.2 The LED will be destroyed. ✓ (1)

3.1.3 The current flowing through the LED will not be limited. ✓ This will cause the LED to draw more current than what it is able to handle. ✓ (2)

3.1.4 Pressing the SET button will pull Pin 2 ‘low’ ✓ and cause the IC output to switch to ‘high’. ✓ As Pin 6 is deliberately held ‘low’ the IC cannot reset itself thus staying ‘high’. ✓ (3)

3.1.5 These resistors are known as ‘pull up’ resistors. ✓ When both SET and RESET buttons are open, the pull up resistors keep the voltage on the input high. ✓ (2)

3.2



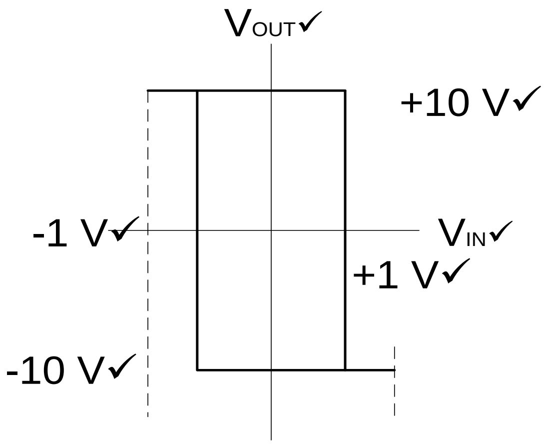
(6)

3.3 The feedback resistor is connected from the output ✓ of the op amp to the inverting input. ✓
This allows a part of the output to flow back to the inverting input. ✓ (3)

3.4 It is used to eliminate switch bounce. ✓ (1)

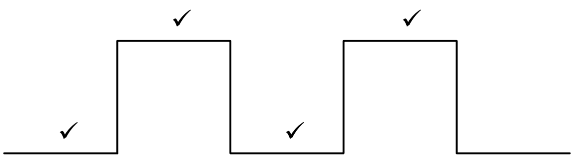
3.5
- A light dependent resistor (LDR) and a 100 kΩ resistor is connected in series. This forms a voltage divider. ✓
- The voltage divider feeds the non-inverting input of the op-amp. ✓
- The inverting input is fed by a 100 kΩ variable resistor. ✓
- Less light on the LDR the resistance rises and in turn the voltage on the non-inverting also rises. ✓
- When the voltage level increases to a level higher than the level set by the variable resistor, op amp output will go high immediately. ✓
- This will switch the transistor on, and the alarm will be energised. ✓ (6)

3.6



(6)

3.7



(4)

3.8 3.8.1 A summing amplifier is used to add two or more different input signals ✓ to create one amplified output signal. ✓ (2)

3.8.2

$$V_{OUT} = -(V_1 + V_2 + V_3) \checkmark$$
$$= -(0,5 + 1,2 + 0,9) \checkmark$$
$$= -2,6\ V \checkmark$$

OR

$$V_{OUT} = -\left(V_1 \frac{R_F}{R_1} + V_2 \frac{R_F}{R_2} + V_3 \frac{R_F}{R_3}\right) V \checkmark$$
$$V_{OUT} = -(0,5 \frac{20\ 000}{20\ 000} + 1,2 \frac{20\ 000}{20\ 000} + 0,9 \frac{20\ 000}{20\ 000}\ V \checkmark$$
$$V_{OUT} = -2,6\ V \checkmark$$
(3)

3.8.3

$$V_{OUT} = -\left(V_1 \frac{R_F}{R_1} + V_2 \frac{R_F}{R_2} + V_3 \frac{R_F}{R_3}\right) V \checkmark$$
$$V_{OUT} = -(0,5 \frac{40\ 000}{5\ 000} + 1,2 \frac{40\ 000}{10\ 000} + 0,9 \frac{40\ 000}{20\ 000}\ V \checkmark$$
$$V_{OUT} = -10,6\ V \checkmark$$
(3)

3.8.4 $V_{OUT} = -\left(V_1 \frac{R_F}{R_1} + V_2 \frac{R_F}{R_2} + V_3 \frac{R_F}{R_3}\right) V$ ✓

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

$R_F = \frac{-10,4}{\frac{0,5}{20\,000} + \frac{1,2}{20\,000} + \frac{0,9}{20\,000}}$ ✓

$R_F = 80\ k\Omega$ ✓

OR

$A_V = -\frac{R_F}{R_{IN}}$

$R_F = A_V \times R_{IN} \Omega$

$R_F = 4 \times 20\,000\ \Omega$

$R_F = 80\,000\ \Omega$

$R_F = 80\ k\Omega$ (3)

3.8.5 $A_V = -\left(\frac{V_{OUT}}{V_{IN}}\right)$

$= -\left(\frac{V_{OUT}}{V_1 + V_2 + V_3}\right)$ ✓

$= -\left(\frac{5,2}{0,5 + 1,2 + 0,9}\right)$ ✓

$= -2$ ✓ (3)

[50]

QUESTION 4: SEMICONDUCTOR DEVICES

4.1
- Infinite gain ✓
- Infinite input impedance ✓
- Zero output impedance ✓
- Infinite Bandwidth ✓
- Infinite common mode rejection ratio
- Unconditional stability (Any 4 x 1) (4)

4.2 4.2.1

$$A_V = 1 + \frac{R_F}{R_{IN}} \checkmark$$
$$A_V = 1 + \frac{50\,000}{10\,000} \checkmark$$
$$A_V = 6 \checkmark$$
(3)

4.2.2

$$V_{OUT} = V_{IN} \times \left(1 + \frac{R_F}{R_{IN}}\right) V \checkmark$$
$$V_{OUT} = 1{,}5 \times \left(1 + \frac{50\,000}{10\,000}\right) V \checkmark$$
$$V_{OUT} = 9\ V \checkmark$$
(3)

4.2.3 If the value of the feedback resistor is decreased the gain of the amplifier will decrease ✓ causing the output voltage to decrease. ✓ (2)

4.3 4.3.1 This pin sets the voltage at which the 555 IC will trigger. It is used to maintain ✓ the voltage across the timing capacitor ✓ which is discharged through pin 7. ✓ (3)

4.3.2 The 555 IC can operate from power supply voltages of between +5 V ✓ and +18 V. ✓ (2)

4.3.3 In this mode the 555 timer is astable ('free running'), therefore its output will continuously toggle between HIGH and LOW ✓ thus generating a continuous train of square-wave pulses. ✓ (2)

4.3.4 The pin closest to the dot. ✓
The pin to the left of the notch. (Any 1 x 1) (1)

[20]

QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

5.1
- Liquid crystal display (LCD) ✓
- Light emitting diode (LED) ✓ (2)

5.2 Current sinking ✓ digital output ✓ (2)

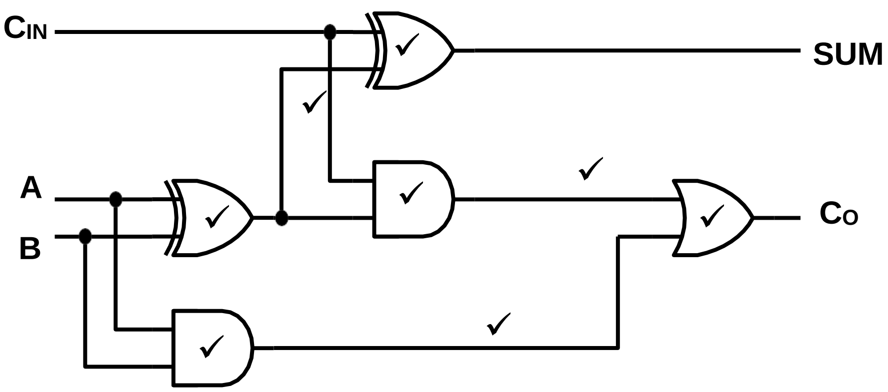
5.3 5.3.1 Decoder ✓ (1)

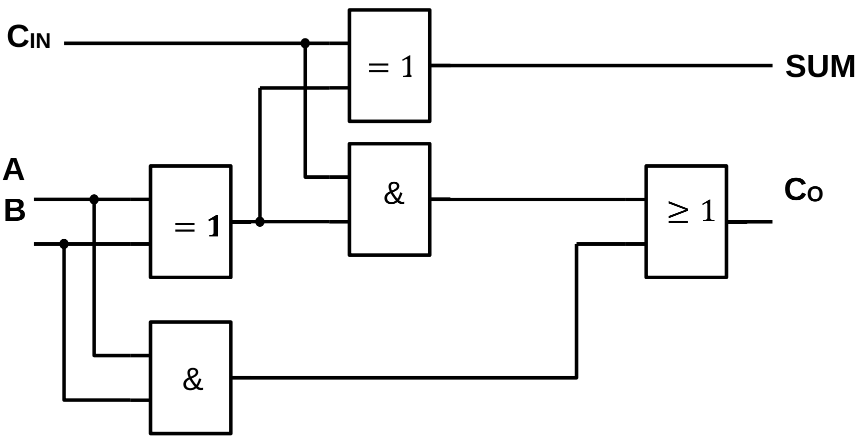
5.3.2

INPUTS		OUTPUTS			
A	**B**	**0**	**1**	**2**	**3**
0	0	1	0	0	0
0	1	0	1	**0**✓	0
1	0	0	0	1	**0** ✓
1	1	0	0	0	**1** ✓

(3)

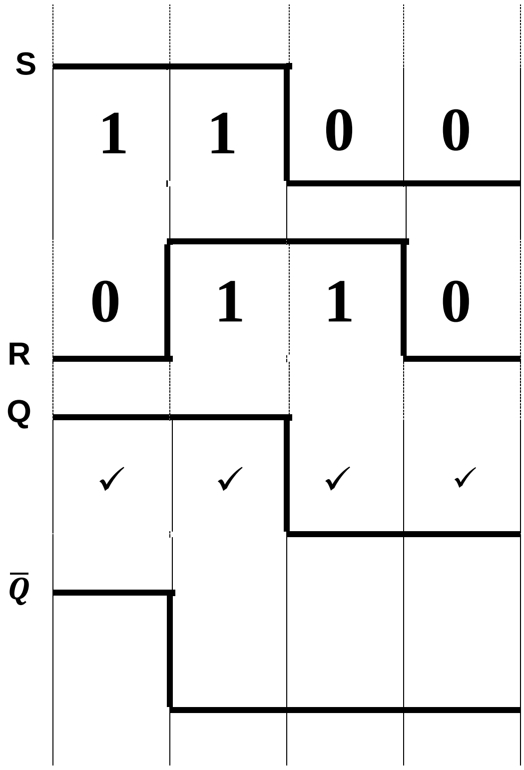
5.4





(8)

5.5



(4)

5.6 5.6.1 D-Type Latch ✓
D Flip-Flop (1)

5.6.2 In this circuit the R input has been replaced by the compliment (inversion) of the S input. ✓ The S input has been renamed to D input. ✓ If the clock input is low, the D-Latch will not respond to an input signal. ✓ Once the clock input goes high the output will follow the D input. As the second input is always the inverse of the D input there will thus never be an illegal state. ✓ (4)

5.6.3
- Shift Registers ✓
- Storage Registers ✓ (2)

5.7 5.7.1
- The Q output of each flip-flop serves as an output sensing point. ✓
- If sensed together, these three points produce a binary code ✓ of the circuit's count sequence ✓ and this converts directly into the decimal equivalent. ✓
- J and K inputs of all three flip-flops are connected to a permanent high to ensure the sensing together. ✓
- The clock pulse fed into the first flip-flop will be transferred to the next flip-flop via the $\bar{Q}$ output. ✓
- Due to the clock pulse for the next flip-flop been fed from the $\bar{Q}$ output of the previous flip-flop, there will be a delay in the output pulses. ✓
- This is called propagation delay. ✓ (8)

5.7.2 These are called asynchronous as they are not triggered at the same time ✓ therefore, the outputs will not change at the same time. ✓ (2)

5.7.3 1 + 2 + 4 = 7 ✓✓✓ (3)

5.7.4 The $\bar{Q}$ output of the first flip-flop ✓ feeds the clock pulse input of the next flip-flop. ✓ (2)

5.8 5.8.1 A – Serial data in ✓
B – Clock ✓ (2)

5.8.2 The bits are loaded into the register one bit at a time ✓ usually from the left, ✓ moving the data from one flip-flop to the next flip flop ✓ for every clock pulse. ✓ This register will require 4 clock pulses to shift four bits in and 4 clock pulses to shift four bits out of the register. ✓

For example, a four-bit number such as 1111 will need four clock pulses to be loaded into the register and another four clock pulses for the number to move out in a serial manner. (5)

5.9 Combinational logic circuits use AND, OR and NOT gates (logic gates) ✓ as their basic elements.
Sequential logic circuits rely on the flip-flop ✓ as its basic building elements (2)

5.10 Serial-in: Parallel-out shift register (SIPO) ✓
Parallel-in: Serial-out shift Register (PISO) ✓
Parallel-in: Parallel-out shift Register (PIPO) (2)

5.11 Truncated counter will stop ✓ before reaching its maximum count. ✓ (2)
[55]

QUESTION 6: MICROCONTROLLERS

6.1 6.1.1 Microcontroller ✓ (1)

6.1.2 RAM (Random Access memory) ✓ (1)

6.1.3 Read Only Memory ✓ (1)

6.1.4 This is a fast, temporary memory that allows information to be stored ✓ and retrieved by the system as it operates. ✓ (2)

6.2 6.2.1 Discrete logic consists of a single processor ✓ with many separate logic chips. ✓ (2)

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

6.3 6.3.1
- Memory Address Register (MAR) ✓
- Memory Data Register (MDR)
- Current Instruction Register (CIR)
- Program counter (Any 1 x 1) (1)

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

6.4 6.4.1 It is used to pass information, data and instructions ✓ between the respective parts of the microcontroller ✓ as well as to communicate with the outside world through input and output ports. ✓ (3)

6.4.2
- Control bus ✓
- Data bus ✓
- Address bus ✓ (3)

6.4.3
- Supports a higher data transfer rate. ✓
- The sender and the receiver use the same clock pulse. ✓ (2)

6.4.4
- Requires more communication lines. ✓
- Requires more space. ✓
- Requires larger connections. (2)

6.5 6.5.1 -200 V = 1 ✓
200 mV = 0 ✓ (2)

6.5.2
- To connect the following to the main frame:
- Point of sale terminals ✓
- Metering instruments ✓
- Large special automated machines ✓ (3)

6.5.3 Simplex data 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)

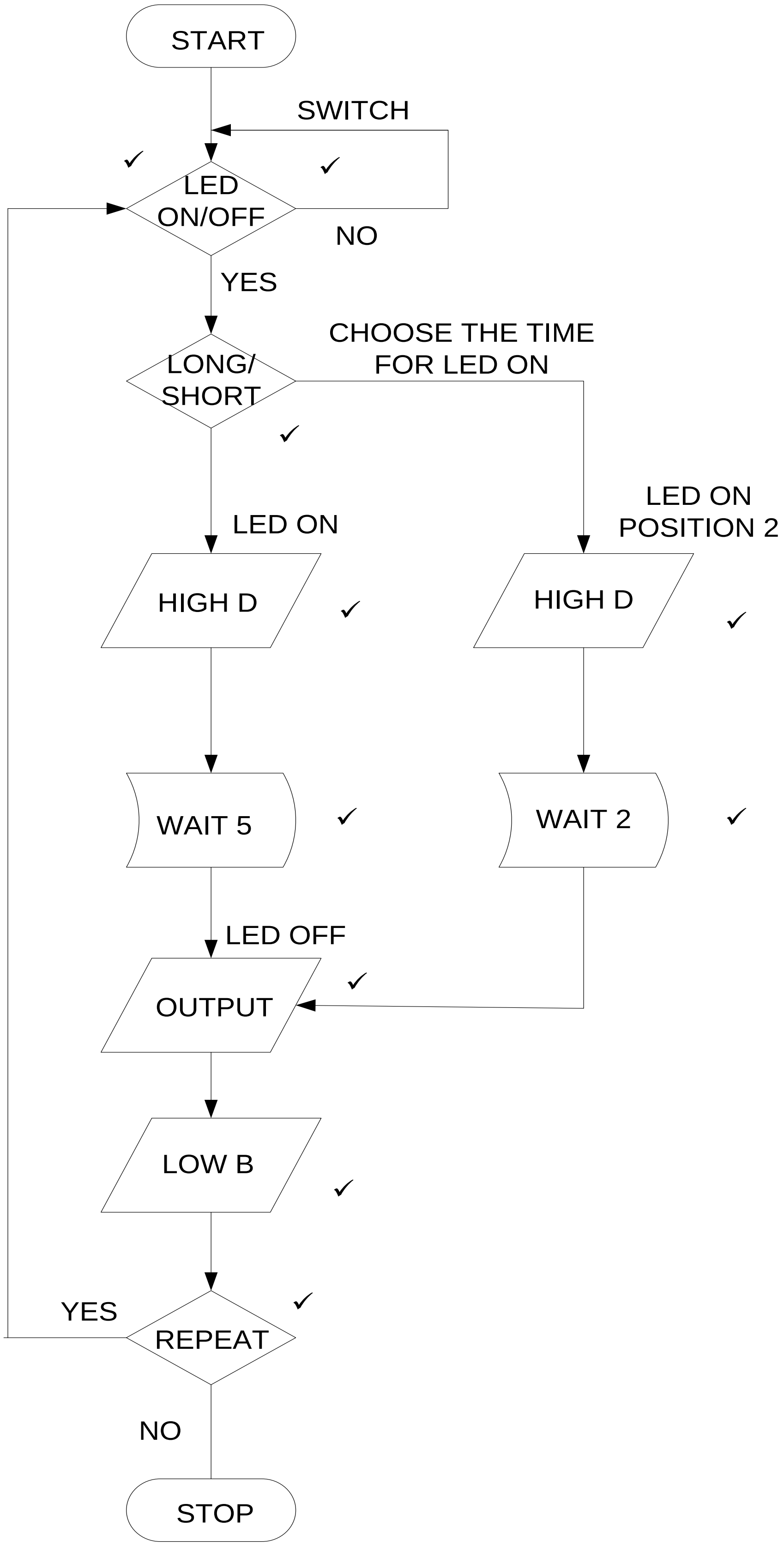
6.6 6.6.1 An algorithm is a detailed step by step set of instructions ✓ to complete a task, ✓ where a program is a sequence of instructions ✓ that tell a computer how to complete a task. ✓ (4)

6.6.2 Looping allows for a task ✓ to be repeated over and over. ✓ (2)

6.7 6.7.1 This symbol indicates the decision point ✓ between two paths in a flow chart. ✓ (2)

6.7.2 A terminator symbol will be used in the start or end of a flow chart. ✓ (1)

6.8



(10)
[50]

TOTAL: 200