basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY

FEBRUARY/MARCH 2011

MEMORANDUM

MARKS: 200

This memorandum consists of 12 pages.

QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

1.1 1.1.1 Reduction in CO_2 emissions reducing air pollution✓, reduction of noise pollution.✓ (2)

1.1.2 Is not using a finite source✓
Doesn't contribute to air pollution✓ (2)

1.2 One may be infected with HIV/AIDS by direct contact with the blood of an infected person and therefore any direct contact should be avoided ✓ ✓

The virus in aids that damages the human cell is living in the blood and therefore direct contact should be avoided

Avoid mouth to mouth respiration without proper protection
(Any relevant answer) (2)

1.3 Ability to identify opportunities.✓This creates the potential to develop a product/business/idea which can lead to economic growth. ✓
Ability to commercialise the solution in a form of services or technologies. ✓
This could lead to empowerment, employment and economic growth ✓
(Any relevant answer) (4)
[10]

QUESTION 2: TECHNOLOGICAL PROCESS

2.1 Internet✓
Magazines✓
Engineer/Mentor
Supplier (Any TWO relevant answers) (2)

2.2 **Criteria**
- Does the lock latch?✓
- Can the solenoid lock work on DC?✓
- Will a solenoid lock be used? ✓
- Is battery backup needed?
- Will the circuit run off mains supply?
- What is the range of the remote transmitter and receiver?
- How will the circuit be activated?
- Is there an indication system, light or buzzer?

(Any THREE relevant answers) (3)

2.3 **Design Specifications**

- The charger has to accept 220 V✓
- The battery voltage must be 12 volts✓
- The solenoid lock must be strong enough to hold the door back✓
- The indicator light housing must be waterproof
- The circuit must have lightning protection
- The wires must be insulated
- The circuit must have fused protection
- The indicator light must be red.
- The buzzer must sound at -82 dB
- When the door opens the buzzer must sound
- The circuit must be in a box

(Any THREE relevant answers) (3)

2.4
- The product is suited to store owners. ✓
- It is a unique product. ✓
- It is effective in securing store / shop access (It is more effective than a padlock)
- It is easily installed into existing structures.

(Any TWO relevant answers) (2)
[10]

QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 The type of work that will be done in an electrical technology workshop requires the correct lighting level because good visibility✓ is crucial in soldering work, making electrical connections and other electrical work.✓ (2)

3.2 The leads (connecting wires) supplying the motor-starter must be disconnected from the power source ✓ to prevent electrical shock ✓
(any other relevant and applicable answers) (2)

3.3 No adequate earth leakage protection. ✓ If there is no earth leakage protection earth faults may go undetected which may lead to electric shock. ✓
(any other relevant and applicable answers (2)

3.4 Working on live installations, ✓ any mistake may lead to a shock.✓ All installations must be isolated and made safe.
(any other relevant and applicable answers) (2)

3.5 Water is an electrical conductor. ✓ If it is used in fighting an electrical fire the fire fighter will be electrocuted. ✓ (2)
[10]

QUESTION 4: THREE-PHASE AC GENERATION

4.1 $V_L = \sqrt{3}V_{ph}$ ✓

$= \sqrt{3}x6350$ ✓

$= \underrightarrow{11\,000\,V}$ ✓ (3)

4.2 Apparent power is the power without considering the efficiency✓, losses✓ and power factor ✓ of the circuit. $S = VI$ (3)

4.3 Three-phase systems are more versatile, they can operate in both the star and delta mode. ✓
Load distribution and phase balancing are possible. (any other relevant and applicable answers) (1)

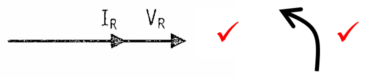
4.4 A balanced load is a load that draws the same current from each phase of a three-phase distribution system. ✓✓ **(any other relevant and applicable answers)** (2)

4.5 When connected in a circuit a wattmeter measures the power of the circuit at that instant in time. ✓ (1)
[10]

QUESTION 5: R, L AND C CIRCUITS

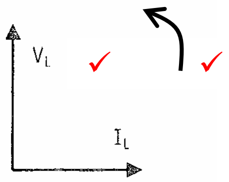
1 mark for the correct relation between V and I and 1 mark for direction of rotation

5.1 5.1.1



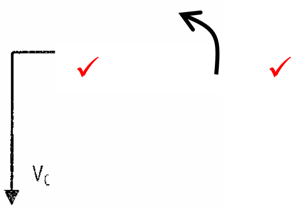
Direction of
Rotation (2)

5.1.2



(2)

5.1.3



(2)

5.2 5.2.1 $I_R = \frac{Vs}{R}$ ✓

$= \frac{240}{80}$ ✓

$= \underrightarrow{3\,A}$ ✓ (3)

5.2.2
$$X_L = 2\pi fL \checkmark$$
$$= 2x\pi x50x0.4 \checkmark$$
$$= 125{,}66\ \Omega \checkmark$$
(3)

5.2.3
$$I_L = \frac{Vs}{X_L} \checkmark$$
$$\therefore I_L = \frac{240}{125.66} \checkmark$$
$$= 1{,}91\ A \checkmark$$
(3)

5.2.4
$$X_C = \frac{1}{2\pi fC} \checkmark$$
$$= \frac{1}{2\pi x50x47x10^{-6}} \checkmark$$
$$= 67{,}72\ \Omega \checkmark$$
(3)

5.2.5
$$I_C = \frac{Vs}{X_C} \checkmark$$
$$= \frac{240}{67.72}$$
$$= 3{,}54\ A \checkmark$$
(3)

5.2.6
$$I_S = \sqrt{I_R^2 + (I_C - I_L)^2} \checkmark$$
$$= \sqrt{3^2 + (3.54 - 1.91)^2} \checkmark$$
$$= 3{,}41\ A \checkmark$$
(3)

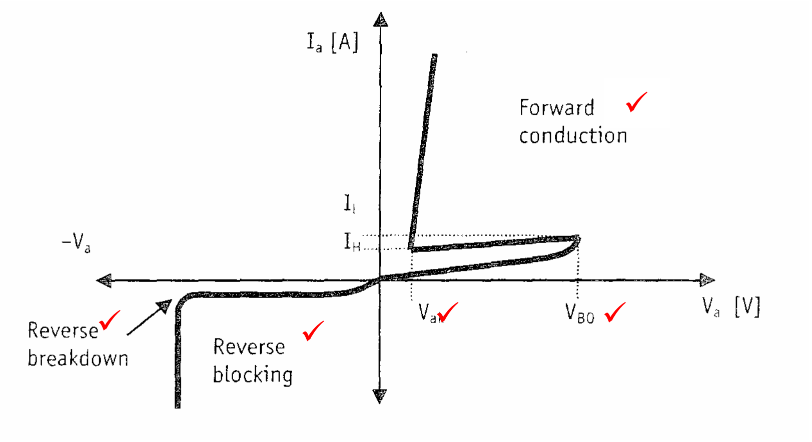
5.2.7
$$Z = \frac{V_S}{I_S} \checkmark$$
$$= \frac{240}{3.41} \checkmark$$
$$= 70{,}38\ \Omega \checkmark$$
(3)

5.3 The value of the capacitive reactance will decrease✓ because capacitive reactance is inversely proportional✓ to the frequency of the supply✓ (3)

[30]

QUESTION 6: SWITCHING AND CONTROL CIRCUITS

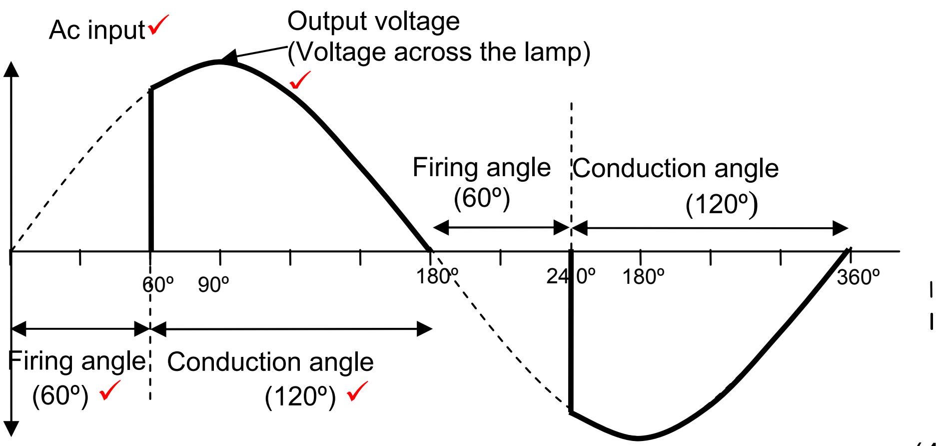
6.1



(5)

6.2 To conduct the anode must be positive relative to the cathode. ✓ Under this condition when a positive pulse is applied to the gate ✓of the SCR it will begin to conduct. Once conduction has started the gate signal loses control of the SCR. From the characteristic curve we see that in reverse bias the SCR does not conduct. ✓ If it is forward bias, ✓ and not triggered, it will block the current until forward breakdown voltage V_{bo} is reached. ✓ At this point it will begin to conduct. It will stop conducting if the current through the SCR is reduced below the level of the holding current, or the voltage across the SCR is removed or reversed. ✓ (6)

6.3 6.3.1



(4)

6.3.2 If R_2 is decreased the time constant of the trigger circuit is decreased.✓ This will reduce the time it takes for the voltage across the capacitor to reach the break over voltage of the DIAC, thus decreasing ✓ the trigger angle increasing the brightness of the lamp. ✓ (3)

6.3.3 R_1 limits the current in the trigger circuit to protect the DIAC when R_2 is set at its minimum. ✓ (1)

6.3.4 Yes the TRIAC would turn on. ✓ ✓It would not be triggered on by the trigger network. ✓ When the supply voltage which is also connected across the TRIAC reaches the break over voltage V_{BO} of the DIAC it will turn on.✓ (4)

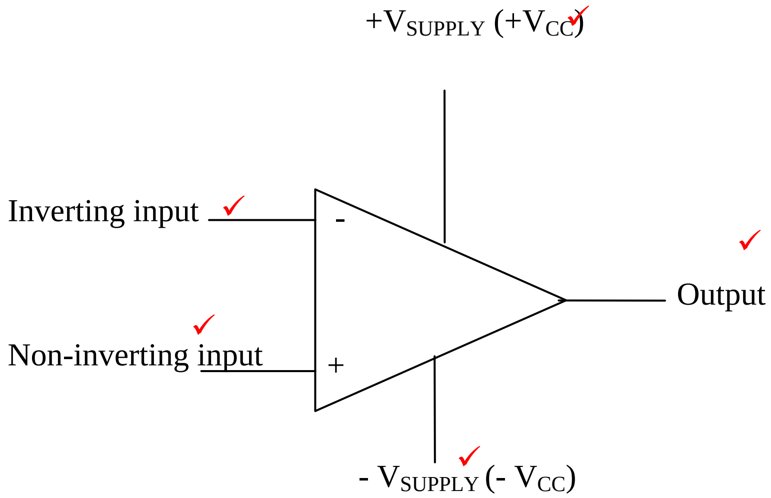
6.4 The current rating and the voltage rating of the TRIAC✓combined with the duty cycle of the TRIAC. ✓ (2)

[25]

QUESTION 7: AMPLIFIERS

7.1 Input impedance is infinite ✓ (Current on input terminal is very small) -
Open loop voltage gain is infinite✓ Voltage Drop between input terminals are zero
Unconditional stability✓ –It is stable (3)

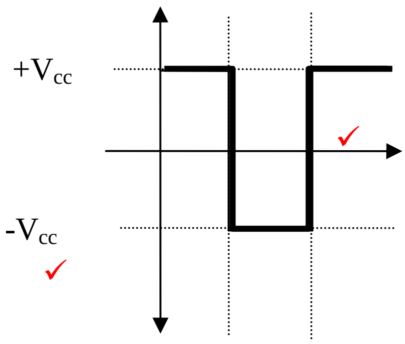
7.2



(5)

7.3 7.3.1 The op-amp as a voltage✓ comparator✓ (2)

7.3.2



(2)

7.3.3 The comparator is used in power supplies ✓ to compare the output voltage with the input voltage ✓ and is used to stabilize the power supply ✓ (3)

7.3.4 The input signal ✓is compared to the R_{ref} ✓Voltage input in the inverting mode✓, the output will be maximum, but out of phase with the difference in input. ✓ (4)

7.4 Improving the amplifiers stability, ✓
Increasing the amplifiers bandwidth, ✓
Enhancing the amplifiers input and output impedances and✓
Reducing or suppressing the noise produced within the amplifier.
(Any other relevant and applicable answers) (3)

7.5 Negative feedback is 180° out of phase with the input signal. ✓When the input goes positive the feedback signal will go negative✓ diminishing the gain ✓of the amplifier due to a smaller resulting input signal. (3)
[25]

QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 Copper losses✓
Iron losses✓
Stray losses
Dielectric losses

Any two (2)

8.2 Yes✓. The primary circuit is complete✓ and will have a supply connected across it. ✓ Therefore current will flow ✓ and it will be dependant upon the impedance of the primary circuit and the supply voltage. (4)

8.3 8.3.1

$$V_{ph(s)} = \frac{V_{ph(p)} N_s}{N_p} \checkmark$$

$$= \frac{11000\,x1}{46} \checkmark$$

$$= \underline{240\ V} \checkmark$$

(3)

8.3.2

$$P = \sqrt{3} V_{1L} I_{1L} \cos\theta \quad \checkmark$$

$$= \sqrt{3} x 11000 x 6 x 0.84 \checkmark$$

$$= \underline{96{,}02\ kW} \quad \checkmark$$

(3)

8.3.3

$$I_{ph(p)} = \frac{I_{L(p)}}{\sqrt{3}} \quad \checkmark$$

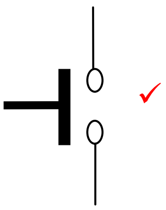
$$= \frac{6}{\sqrt{3}} \quad \checkmark$$

$$= \underline{3{,}46\ A} \quad \checkmark$$

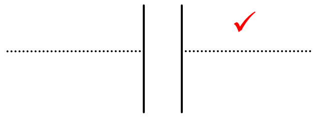
(3)
[15]

QUESTION 9: LOGIC CONCEPTS AND PLC'S

9.1 9.1.1

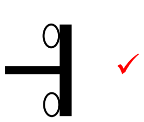


Circuit diagram

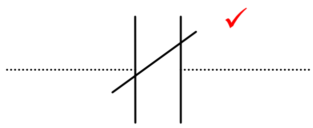


Ladder diagram (2)

9.1.2

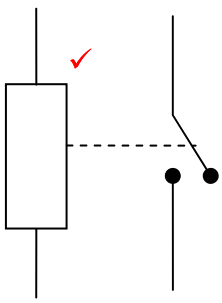


Circuit diagram

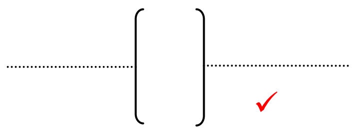


Ladder diagram (2)

9.1.3



Circuit diagram

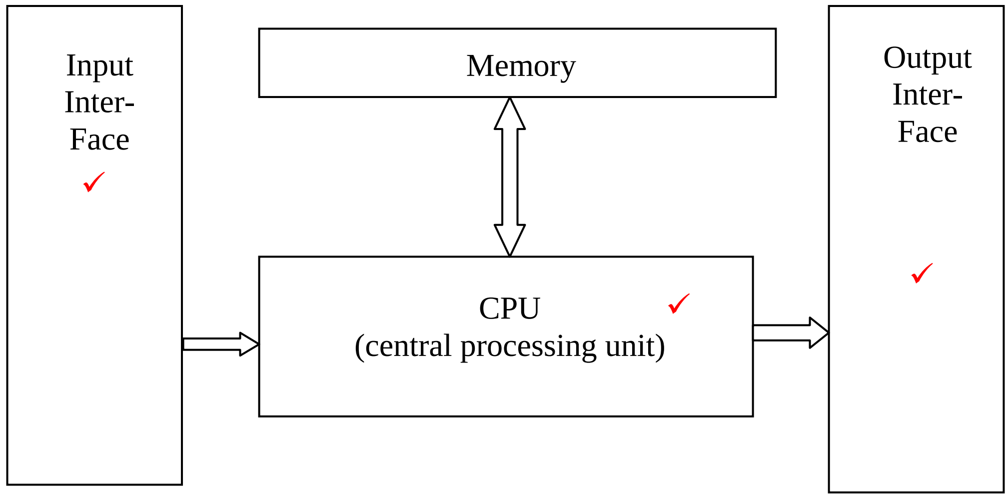


Ladder diagram (2)

9.2 Economical. ✓ For a control panel with more than ten relays, a PLC is cheaper.
Simplified design. ✓ The design effort is simpler due to fewer components and easy sequence planning.
Quick delivery. Installation time is reduced due to fewer components, flexible specification changes and simplified wiring. ✓
Compact and standardised. They are much more compact than relay box.
Mass production is possible by repeat use of programs.
Improved reliability. ✓
Relay and timer problems are reduced.
Reduced maintenance. Fewer components are subject to wear and units have built-in diagnostic functions.

(Any other relevant and applicable answers) (4)

9.3



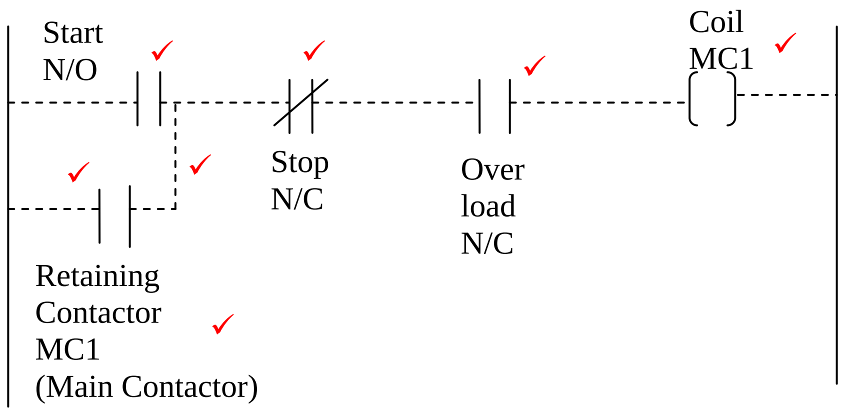
(3)

9.4 9.4.1 Real-time clocks ✓and timers ✓ [T] can be used on ovens, fans and cooling devices ✓ (3)

9.4.2 Adders ✓and sub tractors ✓ [C] can be used to fill packets, count products and items. ✓ (3)

9.4.3 Used for internal operations✓ [M], markers can be used to make the programming ✓of the PLC easier. ✓ (3)

9.5



(Descriptions have been added for clarity purposes only)

(7)

9.6 PLCs are used to automate machinery in assembly lines✓ and were developed as a substitute for large relay panels,✓ no rewiring is needed✓ when the sequence is changed. ✓ (4)

9.7 The internal memory of the PLC stores the instruction sets/programming ✓ for the CPU to access when operating. ✓ (Any acceptable answer) (2)

[35]

QUESTION 10: THREE-PHASE MOTORS AND CONTROL

10.1 10.1.1 Make sure the rotor of the machine rotates freely (any other relevant and applicable answers) (1)

10.1.2 Have the motor tests been carried out and are the insulation values above 1MΩ. ✓(any other relevant and applicable answers) (1)

10.2 10.2.1

$$P_i = \sqrt{3} V_L I_L \cos\theta$$

$$I_L = \frac{P_i}{\sqrt{3} V_L \cos\theta} \checkmark$$

$$= \frac{12000}{\sqrt{3} \, x \, 400 \, x \, 0.8} \checkmark$$

$$= \underline{21.65 \, A} \checkmark$$

(3)

10.2.2

$$S = \frac{P}{\cos\theta} \checkmark$$

$$= \frac{12000}{0.8} \checkmark$$

$$= \underline{15 \, kVA} \checkmark$$

(3)

10.3 Lagging power factor. ✓
A motor consists of coils ✓which have a inductive reactance causing opposition to the flow of current which causes the current to lag the voltage. ✓ (3)

10.4 10.4.1 The current drawn by the motor will decrease. ✓
$P_{OUT} = \sqrt{3}.V.I.Cos\varnothing$
P_{OUT} remains constant V_L remains constant. Therefore I_L must decrease✓ (3)

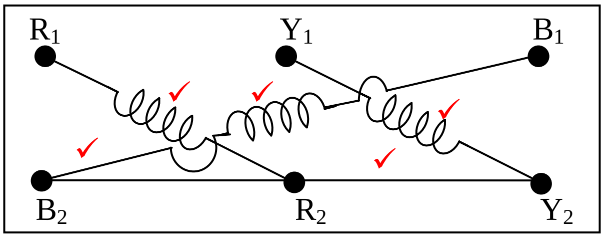
10.4.2 The output power of the motor would remain the same✓ as the motor is designed to deliver a specific power.✓ (2)

10.5
1. Overload relay✓
2. Delta contactor✓
3. Star contactor✓
4. Three- phase supply✓ (4)

10.6 The overload relay is designed to protect the motor✓ and motor wiring under over current fault conditions. ✓ It will open and remove power from the motor. ✓ (3)

10.7 The starter is used to limit ✓ the starting current✓ of squirrel cage✓ induction motors (3)

10.8



(5)
[30]

TOTAL: 200