education

Department:
Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY

NOVEMBER 2008

MEMORANDUM

This memorandum consists of 12 pages.

QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

1.1

- Find a need and fill it ✓
- Find a problem and solve it✓
- Look for possible solutions ✓
- Focus on your customers ✓
- Invest financially in your business (any four) (4)

1.2 1.2.1 In some areas, the land is contaminated with hazardous waste✓, to an extent that people cannot live on this land or travel over it. ✓ (2)

1.2.2 Water in some areas is unsafe to drink.✓ In some situations water is contaminated with oils or poisonous chemicals. ✓ (2)

1.2.3 During the use and application of technological processes the atmosphere can be polluted by factory emissions. ✓ (2)

[10]

QUESTION 2: TECHNOLOGICAL PROCESS

2.1 The Electrical System must adhere to the following criteria:

- The motor must be strong enough to handle the weight of the passenger as well as the weight of the device itself. ✓
- The motor must be able to rotate in both directions or change direction✓
- The device must have a braking system✓
- The device must contain limit switches✓
- The device must contain overcurrent protection✓
- The device must contain earth protection✓
- The device must incorporate an emergency stop
- The device must have a start and a stop button
- The wiring should not be exposed (any five acceptable answers) (5)

2.2

- Critical evaluation of a scenario develops the ability to identify problems in real life scenarios and it is a life skill. ✓
- Identifying solutions illustrates the ability to apply creative thinking and sometimes thinking ouside the box, a critical skill needed by engineers and designers in this modern everchanging society ✓
- Finding more information through research informs the decision-making process, enabling you to use knowledge and decide on the best possible solution for the problem ✓
- Simulations enable the development of practical skills✓
- Building a protoype/artefact confirms the design and highlights any further points that need development. It also illustrates how effectively the research and design was done. ✓ (any five acceptable answers) (5)

[10]

QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 Any unsafe acts
e.g. working on live installations✓ (1)

3.2 Any unsafe conditions
e.g. No CO_2 fire extinguishers
Exposed electrical conductors✓ (1)

3.3

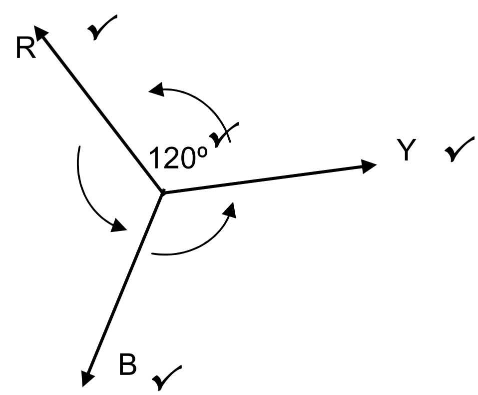
- Switch off the supply immediately.✓
- If you are unable to switch off the supply, pull or push the victim away from the point of shock using an insulated item. ✓
- Do not use your bare hands.✓
- Apply first-aid or get a trained person to do it. ✓ (4)

3.4 Any good housekeeping rules
e.g. Beware of wet areas and moisture, ✓
To avoid shock use electric tools only if the floor and surroundings are dry. ✓
Always disconnect the power from a tool when not in use. ✓
This will prevent any fault occurring when equipment is not in use i.e. a short circuit ✓ (4)
[10]

QUESTION 4: THREE-PHASE AC GENERATION

4.1 Connect power factor correcting capacitors in parallel with the motor✓ (1)

4.2



(4)

4.3 4.3.1

$$I_{Ph} = I_L \checkmark$$
$$= 8A \checkmark$$

(2)

4.3.2

$$V_{Ph} = \frac{V_L}{\sqrt{3}} \checkmark$$
$$= \frac{415}{\sqrt{3}} \checkmark$$
$$= 242\,V \checkmark$$

(3)

[10]

QUESTION 5: R, L AND C CIRCUITS

5.1 The reading on the ammeter will decrease✓ because at resonance the impedance is at a minimum. When the frequency is changed from the resonance frequency the impedance will increase. ✓

The meter labelled V_1 measures the voltage across the resistor. When the frequency is changed, the current flowing through the circuit will decrease,✓ which means the voltage drop across the resistor will decrease as well✓

V_2 will increase✓ because inductive reactance is proportional to the frequency. As the frequency increases, the inductive reactance will also increase thus increasing the voltage drop across the inductor✓

V_3 will decrease✓ because capacitive reactance is inversely proportional to the frequency. As the frequency increases, the capacitive reactance will also decrease thus decreasing the voltage drop across the capacitor. ✓ (8)

5.2 5.2.1

$$I_R = \frac{V}{R} \checkmark$$
$$= \frac{240}{50} \checkmark$$
$$= 4.8\,A \checkmark$$

(3)

$$I_L = \frac{V}{2\pi fL} \checkmark$$
$$= \frac{240}{2x\pi x50x0.15} \checkmark$$
$$= 5.1\,A \checkmark$$

(3)

$$I_C = 2\pi fCV \checkmark$$
$$= 2x\pi x50x47x10^{-6}x240 \checkmark$$
$$= 3.54\,A \checkmark$$

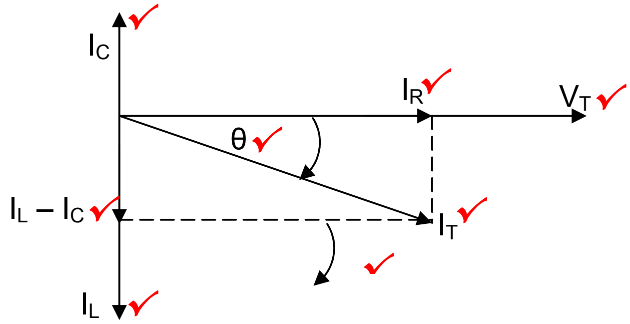
(3)

5.2.2

$$I_T = \sqrt{I_R^2 + (I_L - I_C)^2} \checkmark$$
$$= \sqrt{4.8^2 + (5.1 - 3.4)^2} \checkmark$$
$$= 5.1A \checkmark$$

(3)

5.3



(7)

5.4 XC = XL ∴ Z = R

$$I = \frac{V}{Z} \checkmark$$
$$= \frac{240}{3} \checkmark$$
$$= 8A \checkmark$$

(3)
[30]

QUESTION 6: SWITCHING AND CONTROL CIRCUITS

6.1

- The RC circuit provides the triggering signal for the SCR.✓
- R_1 limits the current✓ to protect the diode when the variable resistor is at a minimum. ✓
- When there is a positive potential on the anode of the gate, the SCR is in a state ready for conduction. ✓
- When the voltage across the capacitor reached the triggering voltage it triggered the gate of the SCR✓ and switches the SCR on and it conducts, supplying the load with power. ✓
- The RC time constant determines the time it takes for the capacitor to reach the triggering voltage. ✓
- The capacitor charges through R_1 and R_2. This time can be shortened or lengthened by adjusting the variable resistor R_2. T = RC✓
- The firing angle can be adjusted between 0 and 180º,✓ therefore controlling the brightness of the lamp. ✓

(10)

6.2 A voltage of either polarity could be applied across the main terminals of the TRIAC.✓ The TRIAC is now in a condition and ready to conduct.✓ When a gate pulse of either potential is applied to the gate, ✓ the gate triggers the TRIAC into conduction. ✓ If the TRIAC is not triggered, it will still switch on at its break over voltage. V_{BO} ✓ (5)

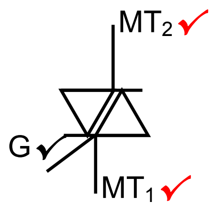
6.3 The TRIAC will switch off under the following conditions:

- The voltage across the TRIAC goes through zero. ✓
- The current through the TRIAC must fall below the holding current for it to be turned off. ✓ (2)

6.4

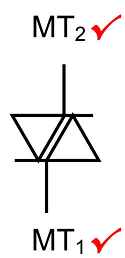
- A TRIAC conducts in both directions, the SCR in only one. ✓
- A TRIAC can be triggered by a positive or a negative gate pulse, the SCR only a positive pulse✓
- A TRIAC can be controlled by 360º, the SCR only a 180º✓ (3)

6.5 6.5.1



(3)

6.5.2



(2)
[25]

QUESTION 7: AMPLIFIERS

7.1

- Open loop voltage gain A_V = infinite✓
- Input impedance Z_{IN} = infinite✓
- Output impedance Z_{OUT} = zero✓
- Bandwidth = infinite✓
- Unconditional stability
- Differential inputs i.e. two inputs
- Infinite common rejection (any four) (4)

7.2 When the gain = 10 A_V = 10

$$A_V = 1 + \frac{R_{F1}}{R_{IN}} \checkmark$$

$$R_{F1} = R_{IN}(A_V - 1) \checkmark$$

$$= 1000(10 - 1) \checkmark$$

$$R_{F1} = 9\ k\Omega \checkmark$$ (4)

When the gain is = 90 A_V =90

$$\therefore A_V = 1 + \frac{R_{F2}}{R_{IN}} \checkmark$$

$$= R_{IN}(A_V - 1) \checkmark$$

$$= 1000(90 - 1) \checkmark$$

$$R_{F1} = 89\ k\Omega \checkmark$$ (4)

7.3

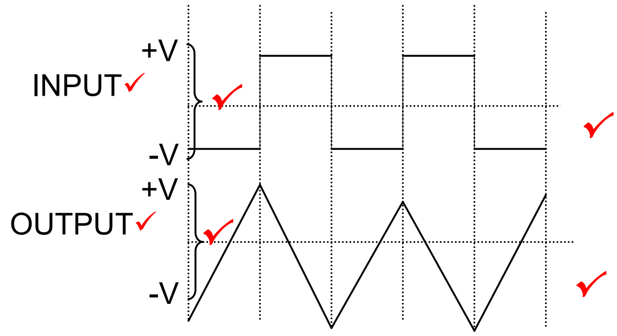
$$A_V = \frac{R_F}{R_{IN}} + 1 \checkmark$$

$$= \frac{56 \times 10^3}{2 \times 10^3} + 1 \checkmark$$

$$= 29 \checkmark$$ (3)

7.4 (a) = - 2 V✓
(b) = 0 V✓
(c) = 4 V✓ (3)

7.5 Integrator circuit✓



(7)
[25]

QUESTION 8: THREE -PHASE TRANSFORMERS

8.1 Star-delta✓
Delta-star✓
Star-star
Delta-delta (Any two) (2)

8.2 8.2.1 The causes of heat may be:
Insufficient ventilation ✓
Loose connections✓
Constant overloading (Any two) (2)

8.2.2 If the cause is insufficient ventilation the problem may be solved by cooling the transformer using air cooling method, oil cooling or water cooling method✓

If the cause is overloading, a transformer with a higher kVA rating should be used✓

If the cause is due to loose connection, the connection should be fixed
(Any two) (2)

8.3 8.3.1

$$V_{ph} = \frac{V_L}{\sqrt{3}} \checkmark$$
$$= \frac{415}{\sqrt{3}} \checkmark$$
$$= 239.6\,V \checkmark$$
(3)

8.3.2

$$S = \sqrt{3}V_L I_L$$

$$I_L = \frac{S}{\sqrt{3}V_L}$$ ✓

$$= \frac{24000}{\sqrt{3} \times 11000}$$ ✓

$$= 1.26\,A$$ ✓

✓✓✓ (3)

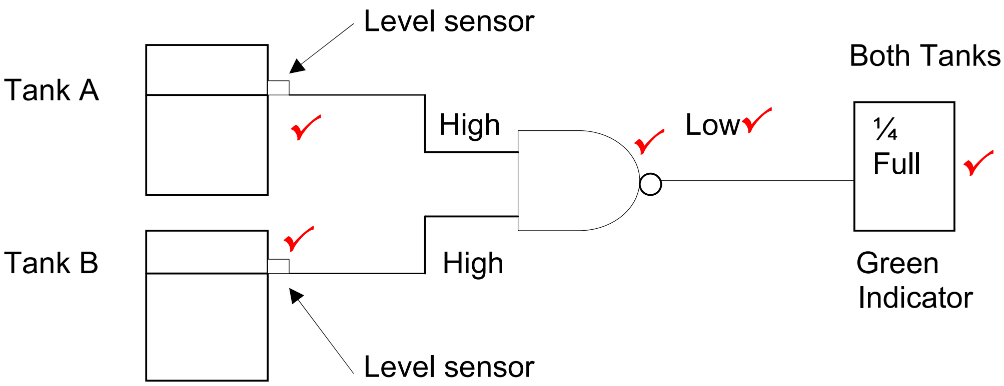
8.3.3

P = S cos Θ
= 24000 x 0.85
= 20400 W

(3)
[15]

QUESTION 9: LOGIC CONCEPTS AND PLC'S

9.1



(5)

9.2

- B = Low ✓
- C = High ✓
- D = Low ✓
- E = High ✓
- F = Low ✓

(5)

9.3 SET and RESET latch (Memory) ✓

Input		Output	
S	R	Q	$\overline{Q}$
0	0	No change	
0	1	0	1 ✓
1	0	1	0 ✓
1	1	Invalid ✓	

(4)

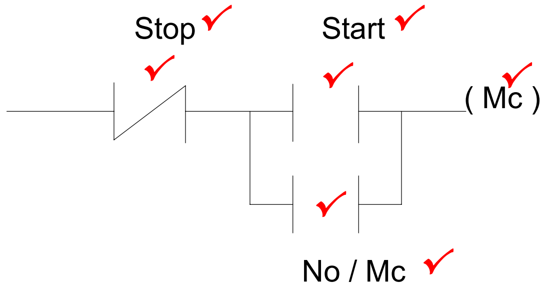
9.4 Z $= (\overline{ABC})(\overline{DEF})$ ✓✓

$= (\overline{A} + \overline{B} + \overline{C})(\overline{D} + \overline{E} + \overline{F})$ ✓✓ (4)

9.5

$(a + b)(\bar{c} \cdot d) = s$ (5)

9.6



(7)

9.7

- Fewer parts
- Less complex wiring
- Easier to implement
- More features
- More information
- More versatile, the function of the installation can be adjusted without changing the wiring (any five) (5)

[35]

QUESTION 10: THREE-PHASE MOTORS AND CONTROL

10.1 10.1.1 A star-delta starter is used to reduce the starting current✓ of a motor at start to reduce unnecessary tripping.✓ (2)

10.1.2

- At start the motor is connected in a star mode. ✓
- The voltage across each phase will be reduced. $V_{Ph} = V_L / \sqrt{3}$ ✓
- This reduction in phase voltage will reduce the current in each phase. ✓
- As the motor speeds up and approaches full speed the starter automatically changes over into the delta mode. ✓
- The full line voltage is now applied to each phase. $V_L = V_{Ph}$ ✓
- With the increase voltage across each phase there is an increase in current in each phase. ✓ (6)

10.2 In its operation it must swap✓ the connection of any two phases. ✓ (2)

10.3 Normally open contacts are contacts that have no connection between them in the de-energised state✓ and do have contact between them in the energised state. That is when the coil of the contactor is energised or de-energised. ✓ (2)

10.4 An overload unit in a motor starter protects the motor in event of an over current situation. ✓
The overload unit also makes provision for temporary over current during the starting process of a motor✓ when a large current is drawn to prevent unnecessary tripping✓ (3)

10.5 The I^2R✓ heat losses in the stator and rotor of the motor due to the resistance of the winding.

Iron losses✓, eddy current and hysteresis losses in iron core due to magnetic fields

Mechanical losses like friction between moving parts such as bearings and wind resistance of the cooling fan (3)

10.6

- A three phase voltage supply is connected across the stator windings. ✓
- This sets up three phase currents, ✓ which create a rotating magnetic field in and around the stator winding. ✓
- This rotating magnetic field sweeps across the rotor conductors inducing an emf across them.✓
- This sets up a current system in the rotor conductors✓ creating a rotating magnetic field in and around the rotor. ✓
- The two rotating magnetic fields interact and a force is exerted between them causing the rotor to rotate.✓ (7)

10.7 Mechanical (any two correct answers)

- Is the cooling fan intact and turning freely but mounted securely on the motor shaft✓
- Does the frame have any cracks✓

Electrical (any three correct answers)

- Is the frame of the motor earthed✓
- Have the insulation test been performed on the stator and are they above 1 MΩ✓
- Are all the windings of the coils fully conductive (Continuity Test)✓ (5)

[30]

TOTAL: 200