education

Department:
Education
REPUBLIC OF SOUTH AFRICA

# NATIONAL SENIOR CERTIFICATE

## GRADE 12

## ELECTRICAL TECHNOLOGY

## FEBRUARY/MARCH 2009

## MEMORANDUM

**MARKS: 200**

**This memorandum consists of 12 pages.**

## QUESTION 1

1.1 TRANSPORTATION✓

The design of new cars changed the way we travelled over the years. ✓
The use of more electronic devices in cars improved safety and ergonomics of cars

COMMUNICATION✓
The design of mobile phones changed the way we communicated over the years. ✓
The use of electrical/electronic devices improved telecommunication.

TEXTILE/CLOTHING✓
The development of electrical automation at textile industries changed the design of clothes which changed the way we dress. ✓ (6)

Any related answer, particularly within electrical field.

1.2.1 Inclusivity: All capable people in the company with disabilities✓ and barriers should also be given the opportunity to work. The company should have✓ facilities for the physically disabled people to work, including where race, sexual orientation, religion, language and national origin must be taken into consideration. (2)

1.2.2 Gender: The company should provide the same opportunity for capable male and female staff in the work environment without any discrimination due to gender. That is, ladies should have the same opportunity of being promoted to higher positions. ✓✓ (2)

**[10]**

## QUESTION 2

2.1 Visit shops or exhibitions to examine existing products✓

Develop a questionnaire to gather more information✓

Interview people to investigate the problem✓

Visit media centres and utilising all forms of media. ✓

Visit industry to gather information✓ (5)

2.2 Design and construct a simple hand controlled lever device✓✓ that can be operated by a disabled child✓✓ who has lost the use his/her legs. ✓ (5)
NB: If reference is made to the control of current flow , the learner must be credited with full marks even if no mention is made of loss of limbs. **[10]**

## QUESTION 3

3.1 Suitable eye protection must be worn. ✓ (1)

3.2 This is to protect the operator from eye injury which could lead to blindness. ✓✓ (2)

3.3 No person may enter or remain in a workplace under the influence of drugs as he may place himself and other persons in danger while operating machinery. ✓ He may also cause damage to the machinery. ✓ (2)

3.4 Unsafe Acts

No horseplay in the workshop✓
No working on a machine which does not have correct guards✓ (2)

3.5 When using an electrical appliance, that has a conducting material, under faulty conditions, the user may be shocked. ✓ With the earth leakage unit any earth fault above 20 mA will operate the unit✓ removing the supply rendering the appliance safe✓ (3)
**[10]**

## QUESTION 4

4.1 Advantages

Three-phase supply systems are more versatile. They can be operated in star and delta ✓
When connected in star, both line and phase voltages are obtainable which allows both three-phase and single-phase utilization ✓ (2)

4.2 A wattmeter measures the power consumed at an instant in time by a circuit. ✓
A kilowattmeter measures the power consumed over a period of time (energy). ✓ (2)

4.3 Delta connection

$$V_L = V_{ph}$$
$$I_L = \sqrt{3} I_{ph}$$

$$I_L = 5A$$
$$V_L = 380V$$
$$P.F. = 0.9$$

4.3.1

$$I_{ph} = \frac{I_L}{\sqrt{3}} \checkmark$$
$$= \frac{5}{\sqrt{3}} \checkmark$$
$$= 2.89A \checkmark$$

(3)

4.3.2

$$P = \sqrt{3}V_L I_L \cos\theta \checkmark$$
$$= \sqrt{3}x380x5x0.9 \checkmark$$
$$= 2.962\,kW \checkmark$$

(3)

**[10]**

## QUESTION 5

5.1.1 Inductive reactance ✓ (1)

5.1.2 Impedance ✓ (1)

5.1.3 Capacitive reactance ✓ (1)

5.2.1

$$X_L = 2\pi fl \checkmark$$
$$= 2\pi x50x0.015 \checkmark$$
$$= 4.71\Omega \checkmark$$

(3)

5.2.2

$$X_C = \frac{1}{2\pi fC} \checkmark$$
$$= \frac{1}{2\pi x50x147x10^{-6}} \checkmark$$
$$= 21.65\Omega \checkmark$$

(3)

5.2.3

$$Z = \sqrt{R^2 + (X_C - X_L)^2} \checkmark$$
$$= \sqrt{20^2 + (21.65 - 4.71)^2} \checkmark$$
$$= 26.21\Omega \checkmark$$

(3)

5.2.4

$$I = \frac{V}{Z} \checkmark$$
$$= \frac{220}{26.21} \checkmark$$
$$= 8.39A \checkmark$$

(3)

5.2.5

$$V_R = IR$$
$$= 8.39x20$$
$$= 167.80V$$

(3)

5.3.1

$$I_T = \sqrt{I_R^2 + (I_L - I_C)^2}$$
$$= \sqrt{12^2 + (10-7)^2}$$
$$= 12.37A$$

(3)

5.3.2

$$Z = \frac{V}{I}$$
$$= \frac{220}{12.37}$$
$$= 17.78\Omega$$

(3)

5.3.3

$$C = \frac{1}{2\pi f X_C}$$

$$\boxed{\begin{aligned} but X_C &= \frac{V}{I_C} \\ &= \frac{220}{7} \\ &= 31.43\Omega \end{aligned}}$$

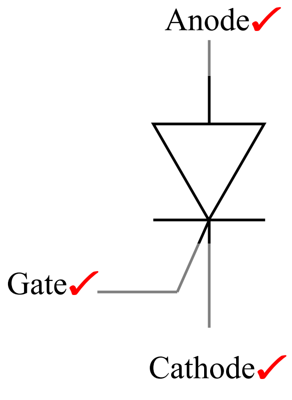
$$\therefore C = \frac{1}{2\pi x 50 x 31.43}$$
$$= 101.28\,\mu F$$

(6)

**[30]**

## QUESTION 6

6.1



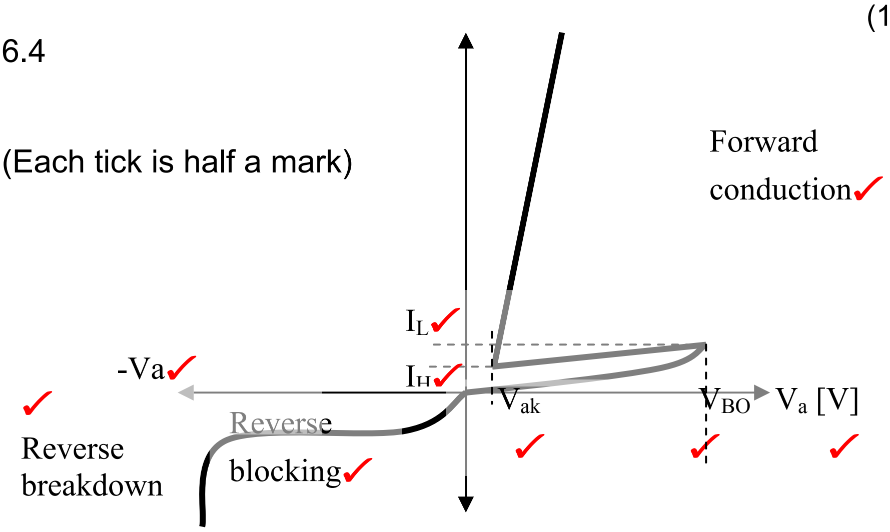

(3)

6.2 To conduct the anode must be positive and the cathode negative✓
The outer junctions are now forward biased✓
A positive trigger signal must be applied to the gate to forward bias the gate junction. All three junctions will be forward biased at this moment and the SCR will start conducting✓
The SCR can now be switched off by reducing the current below the holding current threshold. ✓
If the supply voltage is removed or if the polarity of the supply is changed, it will also switch off. ✓ (5)

6.3 An AC input is applied to the circuit consisting of R1, R2 and C via the lamp.
During the positive half cycle C will change to a positive voltage via the resistors.✓
After a period, determined by the time constant of C multiplied by the value of R1 + R2 the voltage over the capacitor reaches the value at which the DIAC triggers. This is usually around 30 V. The result is that the gate of the TRIAC is triggered and the TRIAC switches on✓✓
The TRIAC will now stay on for the remainder of the positive cycle, whether or not a signal is applied to the gate of the TRIAC. ✓✓
When the TRIAC switches on the internal resistance decreases rapidly causing C to discharge through it and simultaneously current flows through the TRIAC switching on the lamp✓✓
The TRIAC will remain switched on up to the end of the positive cycle, when it will switch off due to lack of current holding it switched on when the input goes through zero✓
During the negative half cycle C will be charged in the opposite direction (negative) and the whole process repeats itself✓, with the polarity being negative in this instance. The DIAC is able to switch to exactly the same voltage value in both directions thus allowing for the negative gate pulse to be applied to the TRIAC which in turn also conducts in both directions thus enabling it to regulate AC. ✓
By adjusting the value of R2 the time constant T=(R1+R2)xC is adjusted. This in return regulates the time the TRIAC is switched on during each half cycle. ✓ The longer the TRIAC stays switched on, the brighter the lamp will light up and vice versa. ✓
(12)

6.4

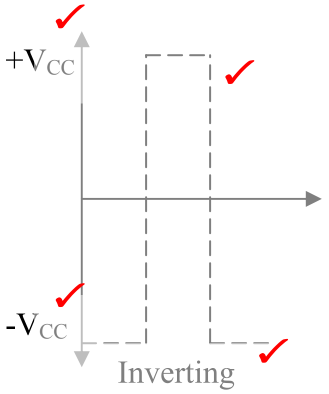
(Each tick is half a mark)




(5)
**[25]**

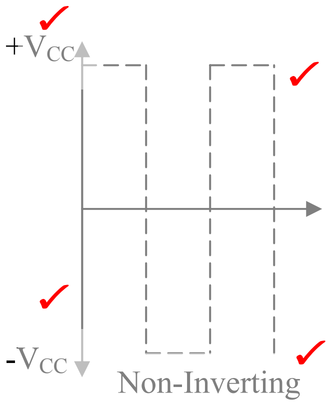
## QUESTION 7

7.1.1




(4)

7.1.2




(4)

7.2.1

$$Each\ RC = 60° \quad \therefore 3x60° = 180°$$
$$Output\ of\ Op\ Amp = 180°$$
$$Total = 180° + 180°$$
$$= 360°$$

(3)

7.2.2

$$f_r = \frac{1}{2\pi(6RC)^{1/2}} \quad R = 1k\Omega \quad C = 100\ pF$$
$$= \frac{1}{2\pi x(6x1x10^3 x100x10^{-12})^{1/2}}$$
$$= 205.57Hz$$

(3)

7.3 Any change at the output is added to the input signal and amplified to compensate for energy losses of a particular signal in the circuit. (4)

7.4 Must have a DC power source.
The circuit must operate within its parameters (must be configured as an amplifier).
It must be biased correctly to operate in the active region, to produce the wanted output signal. (Limit too high currents and temperatures) (3)

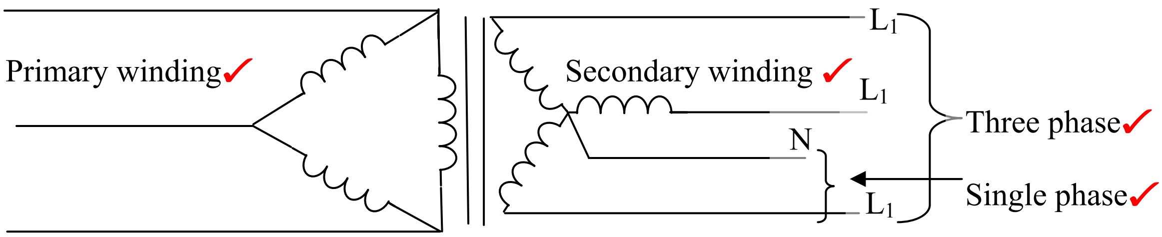
7.5 Active region (Amplification) ✓
Cut-off region (Hard Off) ✓
Saturation point (Hard On) ✓ (3)

7.6 Fixed based biasing, current feedback✓
Potential divider base biasing (Any one) (1)
**[25]**

## QUESTION 8

8.1 For insulation purposes ✓
For cooling purposes ✓ (2)

8.2




(4)

8.3.1

$$\frac{V_{1ph}}{V_{2ph}} = \frac{N_1}{N_2}$$

$$V_{2ph} = \frac{V_{1ph} N_2}{N_1} \quad ✓$$

$$= \frac{11000x1}{45} \quad ✓$$

$$= 244.44V \quad ✓$$

(3)

8.3.2

$$V_{2L} = \sqrt{3}V_{2ph} \quad ✓$$

$$= \sqrt{3}x244.44 \quad ✓$$

$$= 423.38V \quad ✓$$

(3)

8.4

$$P_o = VA \times Cos\theta \quad ✓$$

$$= 250000x0.8 \quad ✓$$

$$= 200\, kW \quad ✓$$

(3)

**[15]**

## QUESTION 9

9.1 1 Power supply✓

2 C.P.U. ✓

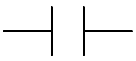
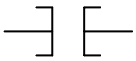
3 Input modules✓

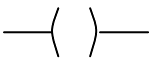
4 Output modules✓ (4)

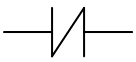
9.2 Ladder Logic✓

Statement language / Instruction Sets✓

Graphical format✓ (3)

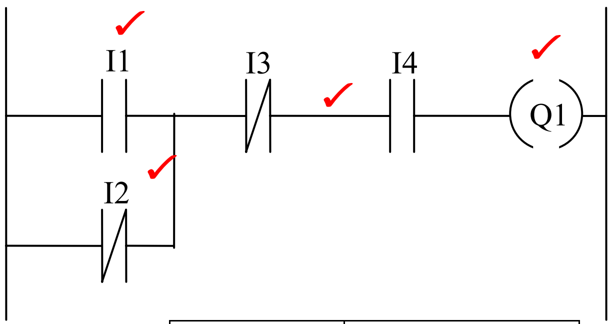
9.3.1  ✓ or  (1)

9.3.2  ✓ (1)

9.3.3  ✓✓ or  (1)

✓

9.4




| Descriptor | Logic Diagram |
|---|---|
| **A** | **I1** |
| **B** | **I2** |
| **C** | **I3** |
| **D** | **I4** |
| **F** | **Q1** |

(4)

9.5.1

$$F = \overline{\left(\overline{A+B+C}\right).\left(A+B+C\right)}$$

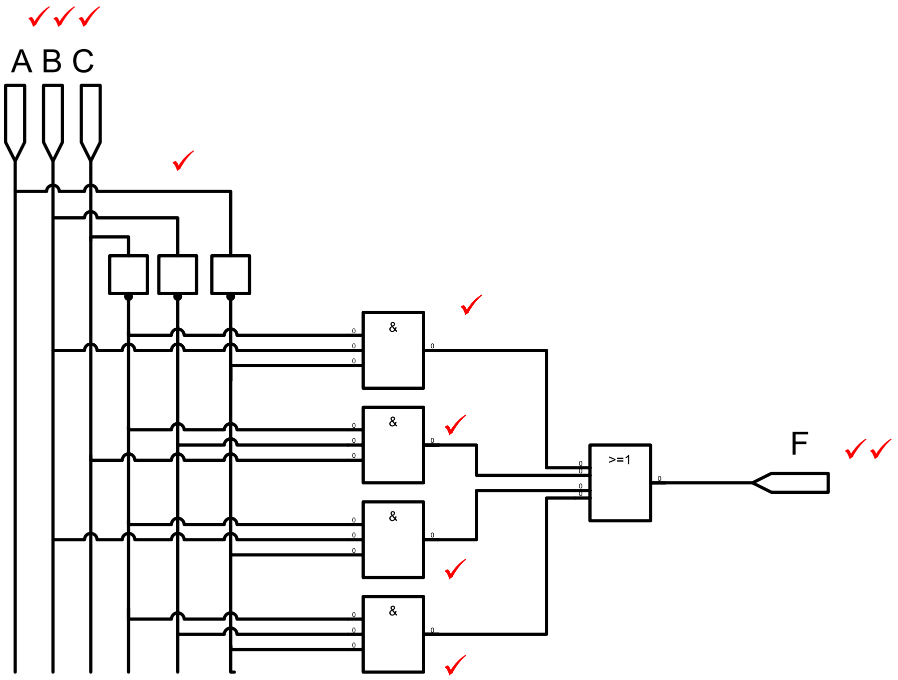
(2)

9.5.2

$$F = \overline{\left(\overline{A+B+C}\right).\left(A+B+C\right)}$$
$$= \overline{\overline{\left(A+B+C\right)}} + \overline{\left(A+B+C\right)}$$
$$= \left(A+B+C\right) + \left(\overline{A}.\overline{B}.\overline{C}\right)$$

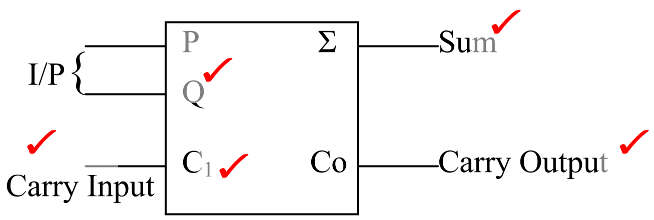
(4)

9.6




(10)

9.7




(5)

**[35]**

## QUESTION 10

10.1 The function of a star-delta starter is to reduce the starting current ✓ drawn by the motor at start by $\sqrt{3}$ of full load current. ✓ (2)

10.2 At start the motor is connected in the star mode. ✓

This ensures that the voltage across each phase of the winding is reduced. ✓

In star Vph =VL/√3. ✓ This reduction of the phase voltage results in a reduction of phase current. ✓ This in turn results in a reduction of current drawn by the supply. ✓ (5)

10.3 A three-phase voltage supply is connected across the stator windings, this sets up a three-phase alternating current system in the windings✓✓

A rotating magnetic field is created due to the flow of the 3-phase current each at an angle of 120º out of phase with each other. ✓

The rotating magnetic field sweeps across the squirrel cage of the motor and an EMF is induced in the rotor, causing current to flow in the squirrel cage. ✓

The induced current in the squirrel cage generates a magnetic field which interacts with the rotating field from the stator. ✓

The magnetic field tries to conform and as a result the rotor is turned due to the force exerted on it. ✓

The two magnetic fields interact and as soon as the rotor field tends to reach the synchronous speed, the induced current is reduced and the rotor speed lags behind the rotating magnetic field. This lag is known as motor slip and cannot be overcome unless the rotor field is energised additionally with a DC current, converting it to a synchronous motor. ✓✓ (8)

10.4 The function of an emergency stop button is to immediately interrupt the supply to a machine✓ to ensure the safety of the operator and machine. ✓

It must be located so that the operator can access it with the use of his hands. ✓ (3)

10.5 Normally open contacts are contacts that are open in the de-energised state✓ and close in the energised state. ✓ (2)

10.6 Three-phase motor

Star-delta

$P_0 = 6.5\,kW$

$V_L = 380\,V$

$\eta \ = 95\%$

$P.F = 0.85$

10.6.1

$$P_i = \frac{P_{out}}{\eta} \checkmark$$

$$= \frac{6.5}{0.95} \checkmark$$

$$= 6.84\,kW \checkmark$$

(3)

$$S = \frac{P_i}{P.F} \checkmark$$

$$= \frac{6.84}{0.85} \checkmark$$

$$= 8\,kVA \checkmark$$

(3)

10.6.2

$$Q = S.\sin\theta \checkmark \qquad \theta = \cos^{-1} 0.85$$

$$= 8x\sin 31.79 \checkmark \qquad = 31.79°$$

$$= 4.21\,kVA_r \checkmark$$

(4)

**[30]**

**TOTAL: 200**