education

Department:
Education
REPUBLIC OF SOUTH AFRICA

NATIONAL
SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY

FEBRUARY/MARCH 2010

MEMORANDUM

MARKS: 200

This memorandum consists of 12 pages and 1 formula sheet.

QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

1.1

Maintenance:
Electrical Pumps and Compressors need constant care and maintenance.✓ Municipalities that do not budget for preventative maintenance will soon find themselves faced with broken equipment and no funding to repair items. ✓

Training:
Trained personel capable of maintaining pumps, compressors and UV lightsources will enable the plant to continue operation. ✓ Without proper human resources sewage plants will soon run out of working equipment due to the constant maintenance that is needed. ✓

Management:
If sewage plants are mis-managed, electrical technology personel, even though well trained, will not be supplied with the needed tools, funding, equipment and replacement parts needed to maintain sewage systems.

The learner may provide an answer quite different to the guidelinegiven above. This question is open to interpretation and any acceptable answer given by the learner, provided it refers to electrical technology in some way will be acceptable. (4)

1.2 Electrical Technology machines such as blood cleansing devices, blood pressure devices, heart rate monitors and breathing apparatus all contribute✓ to the care of patients with HIV and may be instrumental in prolonging life and comfort. ✓ (2)

1.3 Mobile phones, internet and e-mails ✓ have changed the way societies now communicate✓ as compared to letter writing, giving immediate contact. (2)

Electronic access has changed the method of security✓ at access points from finger printing to cards and therefore improving access control and safety. ✓ (2)

[10]

QUESTION 2: TECHNOLOGICAL PROCESS

2.1 Sibusiso's invention is not highly effective.✓ It will be easy to cirumvent and the trespasser will not be deterred, unless it is a mouse. ✓ (2)

2.2 No. ✓ Sibusiso's uncle did not give him good advice, seeing as the trespasser in Sibusiso's room is in all likelyhood not a rat, but a person. This advice caused Sibusiso to choose a solution not suited for the problem. ✓ It is also an expensive solution, which will set Sibusiso back financially. (2)

2.3 Follow the Design Process/Technological Process:

Identify the problem✓
Investigate the problem✓
Find possible solutions to the problem✓
Evaluate these solutions✓
Choose the best solution
Make / Build a solution
Test the solution
Re-evaluate the solution
If needed change the solution until the problem is solved (4)

(Although more points are listed than is needed. In essence the learner needs to show some idea of the Technological Process, which would be regarded as correct.)

2.4 Does the solution eliminate the problem? ✓
Is the solution cost effective? ✓
Is the solution of a difficulty level within the skills level of the person applying it?
Is the solution safe?
Does the solution have other possibilities?

(Any acceptable answer by the learner is allowed. Please assess this answer within context of the previous answers given.) (2)
[10]

QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 Make sure that the meter is connected in series in the circuit. ✓

Make sure the leads of the meter are connected into the correct sockets of the meter. ✓ (2)

3.2 Wear the correct eye protection✓

Make sure the tool rest is secure✓ (2)

3.3 Poor ventilation may lead to drowsiness✓ which could cause loss of concentration which may result in an accident. ✓ (2)

3.4 Working with mains on. ✓ (1)

Using faulty portable electrical equipment. ✓ (1)

3.5 Be carefull not to damage the conductor which may weaken it leading to a poor connections which will result in future problems. ✓✓ (2)

(To all the above answers there may be alternatives. It is up to the chief marker and internal moderator in the respective provinces to accept alternate answers for these questions.) **[10]**

QUESTION 4: THREE-PHASE AC GENERATION

4.1 Add power factor correcting capacitors in parallel with the load✓
Make use of synchronous motors.
Make use of an AVR to assist in correcting the P/F (1)

4.2 Three-phase alternators can be connected in parallel to obtain a combined supply. ✓
Three phase alternaters are more versatile as they may be connected in both star and delta✓
(Many answers but must be complete) (2)

4.3 A balanced load is a load in which the current drawn in each phase is the same or✓✓
The power distributed in each phase is the same. (2)

4.4 The motor will draw more current to deliver the same power✓✓ This will result in the motor running hotter than it should and the cost of running the motor will be high. (2)

4.5

$$S = \frac{P}{\cos\theta} \checkmark$$
$$= \frac{2.5}{0.85} \checkmark$$
$$= 2.94 kVA \checkmark$$

Alternative Method

$$S = \sqrt{3} V_L I_L$$
$$= \sqrt{3} x 380 x 4.47$$
$$= 2.94 kVA$$

(To all the above answers there may be alternatives) (3)
[10]

QUESTION 5: RLC CIRCUITS

5.1 Connect an ammeter in series in✓ the circuit to measure the total current. Only adjust the frequency of the supply, ✓ when the reading of the ammeter is at maximum the circuit will be at resonance. ✓ (3)

5.2 The impedance will be at a minimum and the current will be at a maximum The voltage drop across the lamp will be at a maximum which will make the lamp brighter.✓ (3)

5.3 5.3.1 It represent a series circuit✓ because current is common to all the components and only one current value is shown. ✓✓ (3)

5.3.2
$$V_S = \sqrt{V_R^2 + (V_L - V_C)^2} \checkmark$$
$$= \sqrt{110^2 + (189 - 60)^2} \checkmark$$
$$= 169.53V \checkmark$$
(3)

5.3.3
$$Z = \frac{V_{sup\,ply}}{I} \checkmark$$
$$= \frac{169.53}{18} \checkmark$$
$$= 9.42\ \Omega \checkmark$$
(3)

5.3.4
$$X_L = \frac{V_L}{I} \checkmark$$
$$= \frac{189}{18} \checkmark$$
$$= 10.5\Omega \checkmark$$
(3)

5.4 5.4.1
$$I_R = \frac{V_R}{R} \checkmark$$
$$= \frac{240}{39} \checkmark$$
$$= 6.15\,A \checkmark$$
(3)

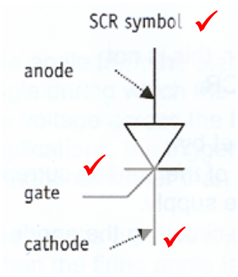
5.4.2
$$I_L = \frac{V}{X_L} \checkmark$$
$$= \frac{240}{75} \checkmark$$
$$= 3.2\,A \checkmark$$
(3)

5.4.3
$$I_C = \frac{V}{X_C} \checkmark$$
$$= \frac{240}{50} \checkmark$$
$$= 4.8A \checkmark$$
(3)

5.4.4
$$I_S = \sqrt{I_R^2 + (I_C - I_L)^2} \checkmark$$
$$= \sqrt{6.15^2 + (4.8 - 3.2)^2} \checkmark$$
$$= 6.35\,A \checkmark$$
(3)
[30]

QUESTION 6: SWITCHING AND CONTROL CIRCUITS

6.1



(3)

6.2 A SCR can be switched ON by;

Applying a positive trigger voltage to the gate when there is a positive potential on the anode. ✓
Rasing the foward biasing voltage across the SCR above V_{bo}✓ (2)

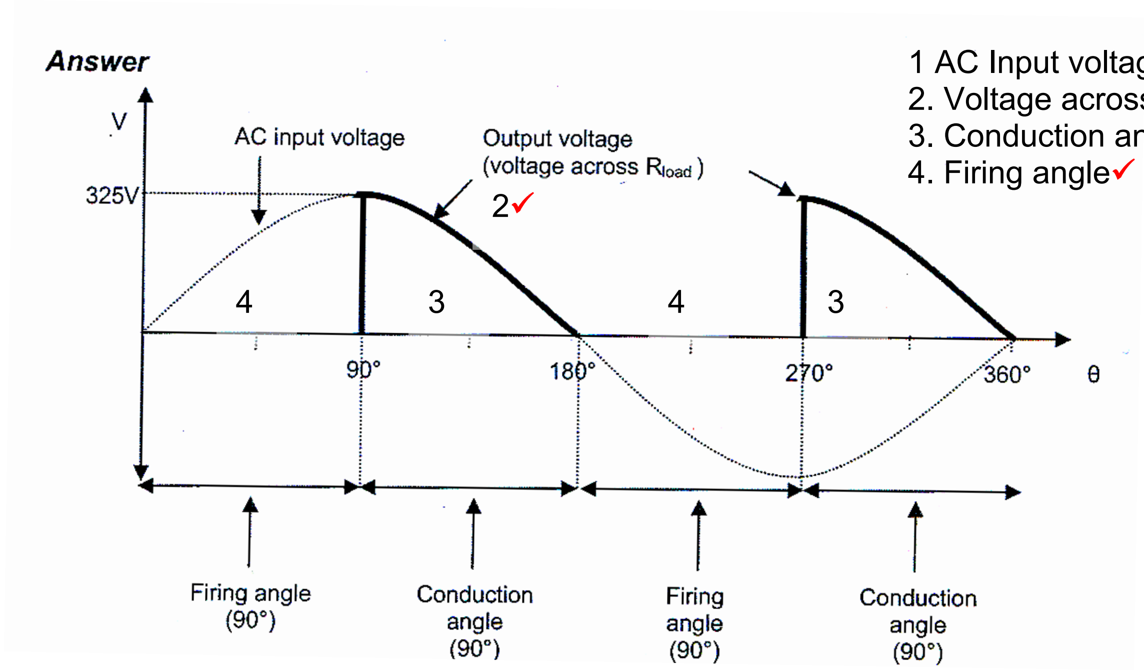
A SCR can be switched OFF by;

Reducing the current through the SCR below the level of the holding current I_H✓
Removing or reversing the voltage across the SCR. ✓ (2)

6.3 The AC input is supplied to the RC network consisting of R_1 R_2 and C via the lamp. ✓
During the positive half cycle C will charge to a positive voltage via the resistors. ✓
After a time period dertermined by the time constant✓ the voltage across C will reach the break over voltage of the diac✓ which trigger the gate of the triac switching it on✓.
This will also occur in the negative half cycle.C will charge to a negative voltage again switching on the triac via the diac. ✓
By adjusting R_2,the time constant $T=(R_1+R_2)C$ ✓is either increased or decreased,resulting in the control of the duration which power is applied to the lamp✓.Therefore the brightness of the lamp. ✓ (9)

6.4 Low✓ (1)

6.5 6.5.1



1 AC Input voltage✓
2. Voltage across lamp✓
3. Conduction angle✓
4. Firing angle✓

(5)

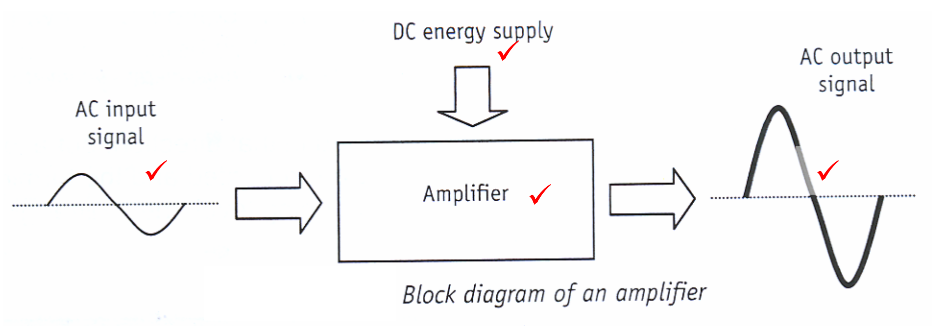
6.5.2 Half brightness, ✓as the conduction angle is 180^0✓ which is half of 360^0 therfore half power. ✓ (3)

[25]

QUESTION 7: AMPLIFIERS

7.1 Class A✓ (1)
Class B✓ (1)
Class C✓ (1)

7.2

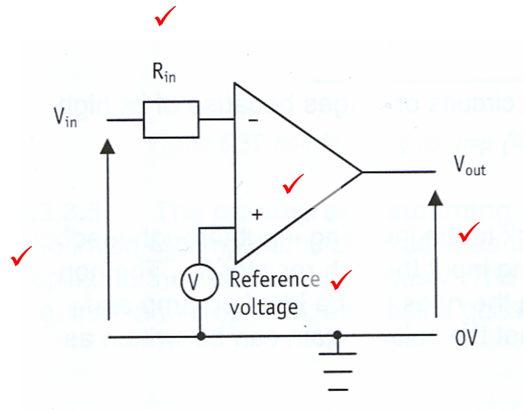


Block diagram of an amplifier

(4)

7.3 7.3.1 Increase stability of the overall gain✓
Less distortion✓
Wider bandwidth
The input and output impedances can be altered to almost any desired values
(Any two) (2)

7.3.2



(5)

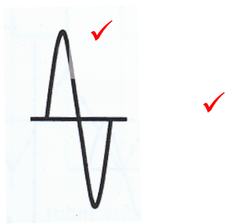
7.4 Overall loop gain of the system must be equal to unity (1) ✓. With a gain of less than unity the oscillations will die away ✓. With a gain of more than unity the output will perpetually increase. (2)

A frequency determing network ✓ must be used to ensure that the frequency of oscillation is correct. ✓ (Any two) (2)

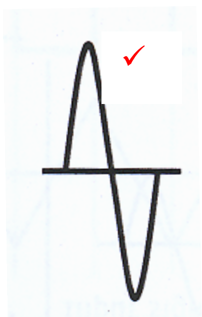
7.5

7.5.1 Non inverting amplifier✓ (1)

7.5.2



Input



Output

(3)

7.6

$$F_r = \frac{1}{2\pi\sqrt{LC}} ✓$$

$$= \frac{1}{2\pi\sqrt{(10x10^{-3})(220x10^{-6})}} ✓$$

$$= 107.302 Hz ✓$$

(3)

[25]

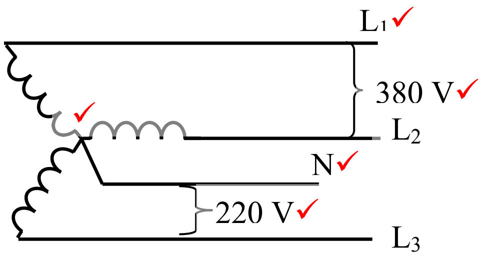
QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 8.1.1 Low to high voltage applications✓ (1)

8.1.2 High to low voltage applications✓ (1)

8.1.3 Transmission system✓
Low to high voltage applications (1)

8.2 8.2.1



(5)

8.2.2

$$P_{in} = \sqrt{3} V_L I_L \cos\theta \checkmark$$

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

$$= \frac{500000}{\sqrt{3} x 380 x 0.85} \checkmark$$

$$= 893.73\,A \checkmark$$

(4)

8.2.3

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$$

$$T.R = \frac{V_{1ph}}{V_{2ph}} \checkmark$$

$$= \frac{11000}{220} \checkmark$$

$$= 50:1 \checkmark$$

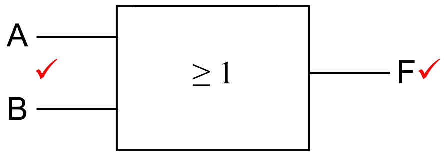
(3)
[15]

QUESTION 9: LOGIC CONCEPTS AND PLC'S

9.1.1 **Mains** - Supplies Mains power to the PLC from the distribution grid. ✓
Power Supply – Converts Mains Power to 24 V DC for most PLC's✓
The CPU – After programming the CPU stores the list of instructions and carries out instructions in accordance with the programming of the PLC✓
Inputs – Input ports connected to certain input devices. This is where environmental information is fed into the PLC. ✓
Outputs – The outputs are where the PLC feeds back into the environment and outputs are switched on and of in line with the instruction sets given to the PLC. ✓ (5)

9.1.2 Inputs : Switches, push buttons, contacts✓✓ (2)
Outputs: relay coils, solenoids valves ✓✓ (2)

9.2.1



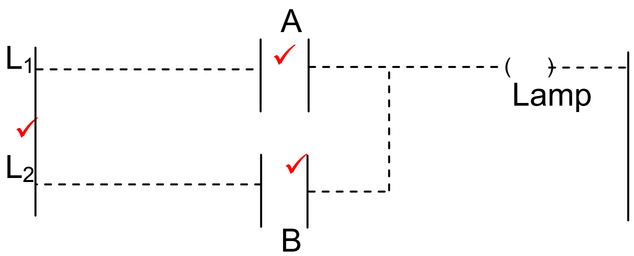
(2)

9.2.2

A	B	C	
0	0	0	✓
0	1	1	✓
1	0	1	✓
1	1	1	✓

(4)

9.2.3



(3)

9.3 $X = (\overline{A \cdot B})(C + D)$ ✓✓✓ (3)

9.4

$(A + B) \cdot (A + C) = A + BC$

$AA + AC + AB + BC$ ✓

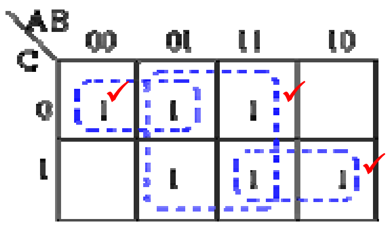
$A + AC + AB + BC$ ✓

$A(1 + C + B) + BC$ ✓

$A + BC = A + BC$ ✓

(4)

9.5 $Z = f(A,B,C) = \bar{A}\bar{B}\bar{C} + \bar{A}B + AB\bar{C} + AC$
✓ ✓ ✓



(6)

9.6 Synchronous counter✓ : all the clock pulse inputs are connected to one another. ✓ (2)

Asynchronous counter✓: the output of the lower order flip-flop is connected to the clock input of the next order flip-flop✓ (2)
[35]

QUESTION 10: THREE-PHASE MOTORS AND CONTROL

10.1 The casing of a motor is made from a conducting material,earthing it will activate protection under fault conditions ✓preventing electric shock. ✓ (2)

10.2 Swop any two phases of the motor conections. ✓✓ (2)

10.3 10.3.1 When the N\O start is depressed the main contactor,the timer contactor and the star contactor are all energised✓ supplying the motor which is now connected in the star mode with power. ✓
The timer contactor now begins to time through. ✓
Once timed through to a preset time the N\C timer contacts open de-energising the star contactor. ✓
The N\O timer contacts close energising the delta contactor.This now conects the motor in delta. ✓
The N\C star and delta contacts provide interlocking to prevent both contactors been energised at the same time (5)

10.3.2 A star-delta starter is used to reduce✓ the starting current of a motor at start✓.
At start a motor draws 4 to 5 times full load current✓.
At start the motor is connected in star.The phase voltage is reduced by $\sqrt{3}$. ✓
This reduces the phase current by $\sqrt{3}$ reducing the starting current✓. (5)

10.3.3 The overload switch opens under over current conditions✓ protecting the motor. ✓ (2)

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

10.5 An AC supply is connected to the stator winding,which sets up currents in the stator winding. ✓
Due to the phase difference of the currents a rotating magnetic is set up in and around the stator. ✓
The rotating magnetic field sweeps across the rotor conductors,cutting the conductors, inducing an emf across them (Faradys law) ✓ this in turn sets up currents in the rotor. ✓
The currents produce a rotating magnetic field in the rotor. ✓
A force is excerted between the two magnetic fields. ✓
This results in a torque on the rotor and the rotor rotates. (6)

10.6 10.6.1

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

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

$$= \frac{5000}{\sqrt{3}x380x0.8}$$

$$= 9.5A \checkmark$$

(3)

10.6.2

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

$$= \frac{9.5}{\sqrt{3}} \checkmark$$

$$= 5.48A \checkmark$$

(3)
[30]

TOTAL: 200

FORMULA SHEET

RLC

$$X_L = 2\pi\pi F$$

$$X_C = \frac{1}{2\pi\pi F}$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$I_T = \sqrt{I_R^2 + \left(I_C - I_L\right)^2}$$

$$V_T = \sqrt{V_R^2 + \left(V_C - V_L\right)^2}$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$Q = \frac{X_L}{R} = \frac{V_L}{V_R}$$

$$Cos\theta = \frac{I_R}{I_T}$$

$$Cos\theta = \frac{R}{Z}$$

Amplifiers

$$Av = \frac{R_f}{R_{in}} + 1$$

$$\beta = \frac{I_c}{I_b}$$

$$I_b = I_e - I_c$$

$$P_G = 10log\frac{P_0}{P_i}$$

Alternating Current, Transformers and Motors

Single Φ

$$P = VIcos\theta$$

$$S = VI$$

$$Q = VIsin\theta$$

Three Φ

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

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

$$Q = \sqrt{3}\ V_L I_L sin\theta$$

$$I_L = \sqrt{3} I_{PH}\ for\ \Delta$$

$$V_L = V_{Ph}\ for\ \Delta$$

$$V_L = \sqrt{3}\ V_{Ph}\ for\ Y$$

$$I_L = I_{Ph}\ for\ Y$$

$$f = \frac{1}{T}$$

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$$

$$\eta = \frac{P_O}{P_I}$$

$$f_r = \frac{1}{2\pi\sqrt{(6RC)}}$$

END