Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2013

ELECTRICAL TECHNOLOGY MEMORANDUM

MARKS: 200

This memorandum consists of 11 pages.

QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

1.1
- Marketing ✓
- Communication ✓
- Presentation ✓
- Financial literacy
- Costing of materials, etc. (Any 3) (3)

1.2 Make sure that you do not come into contact with blood. ✓ (1)

1.3 1.3.1 Air
During the use and application of technological processes the atmosphere can be polluted by factory emissions. ✓✓ (2)

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

1.3.3 Land
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)

[10]

QUESTION 2: TECHNOLOGICAL PROCESS

2.1 Poor sound quality of the radio ✓✓ (2)

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. ✓✓
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. ✓✓ (5)

2.3
- Observation: this includes analysing the product in order to understand its design, and jotting down notes about the product. ✓
- Interviews: this is about finding out from the target audience, whether the product satisfy their needs. ✓
- Questionnaires survey: to find out how many in the target audience are satisfied with the product. ✓ (3)

[10]

QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1
- Make sure you are standing firmly. ✓
- Make sure you remove the chuck key from the chuck after loosening or tightening the bit. ✓ (2)

3.2
- 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)

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

3.4
- Horseplay in the workshop. ✓
- Working on a machine which does not have correct guards. ✓
- Working with the mains on (Any 2) (2)

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

[10]

QUESTION 4: THREE-PHASE AC GENERATION

4.1 Add power factor correcting capacitors in parallel with the load. ✓ (1)

4.2 The power distributed in each phase is the same. ✓✓ (2)

4.3
- 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)

4.4 $S = \frac{P}{Cos\theta}$ ✓= $\frac{2500}{0,85}$ ✓ = 2,94 kW ✓ (3)

4.5 $V_{ph} = \frac{V_L}{\sqrt{3}}$ = $\frac{380}{\sqrt{3}}$ ✓ = 219,4 V ✓ (2)

[10]

QUESTION 5: R, L AND C CIRCUITS

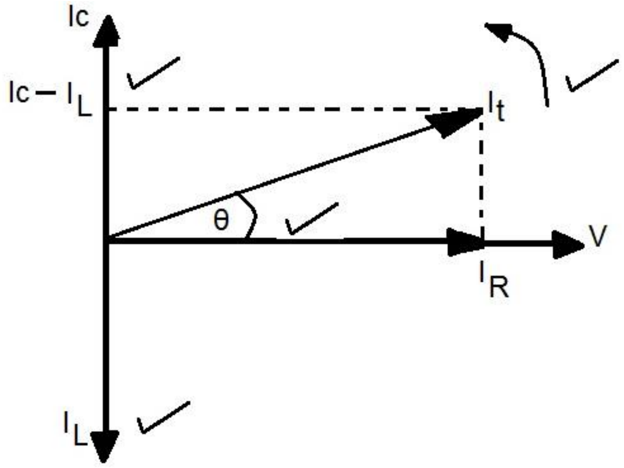
5.1 5.1.1 $I_c = \frac{V}{X_c}$ ✓ = $\frac{220}{21,22}$ ✓ = 10,37 A ✓ (3)

5.1.2 $I_L = \frac{V}{X_L}$ ✓ = $\frac{220}{37,7}$ ✓ = 5,83 A ✓ (3)

5.1.3 $I = \frac{V_R}{R}$ ✓ = $\frac{220}{20}$ ✓ = 11 A ✓ (3)

5.1.4 $I_T = \sqrt{IR^2 + (I_C - I_L)^2}$ ✓= $\sqrt{11^2 + (10,37 - 5,83)^2}$ ✓= 11,9 A ✓ (3)

5.1.5



(4)

5.2 5.2.1 $X_L = 2\pi fL$ ✓ $= 2.\pi.50.140.10^{-3}$ ✓ = 43,98 Ω ✓ (3)

5.2.2 $X_C = \frac{1}{2\pi fL}$ ✓ $= \frac{1}{2\pi.50.49.10^{-6}}$ ✓ = 64,96 Ω ✓ (3)

5.2.3 $Z = \sqrt{R^2 + (X_C - X_L)^2}$ ✓ $= \sqrt{20^2 + (64{,}96 - 43{,}98)^2}$ ✓ = 45,17 Ω ✓ (3)

5.2.4 $I_t = \frac{V}{Z}$ ✓ $= \frac{240}{45{,}17}$ ✓ = 4,87 ✓ (3)

5.3 5.3.1 Inductive reactance ✓ (1)

5.3.2 Capacitive reactance ✓ (1)

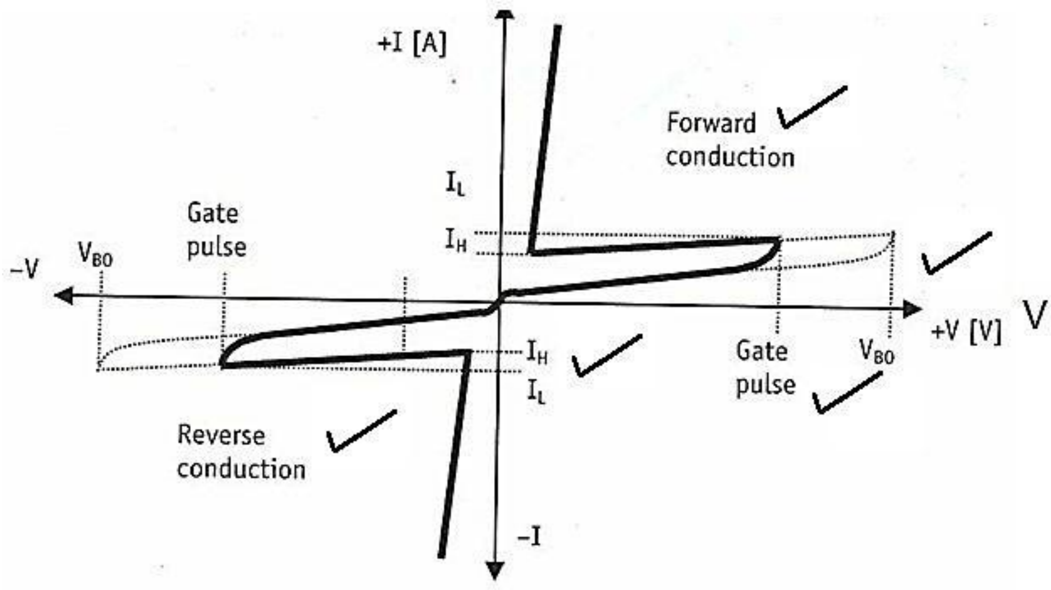
[30]

QUESTION 6: SWITCHING AND CONTROL CIRCUITS

6.1 <u>Functional operation of a DIAC</u>

If a rising voltage is applied to a DIAC it acts like an open switch. ✓ When the DIAC's trigger voltage is reached, the internal resistance of the DIAC breaks down✓ allowing the DIAC to conduct. It operates in both directions. ✓ When the current falls below the holding current, it switches off. A DIAC switches on at the same time in both directions. ✓. (4)

6.2



(5)

6.3 <u>SCR is switched on and switched off</u>.

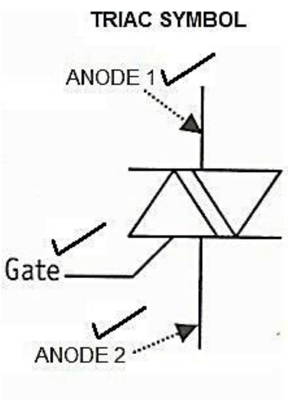
Switched on.

- A positive potential must be applied to the anode terminal. The SCR will now be in a state ready to conduct. ✓
- When the correct positive potential is applied to the gate the SCR will begin to conduct. ✓

Switched off.

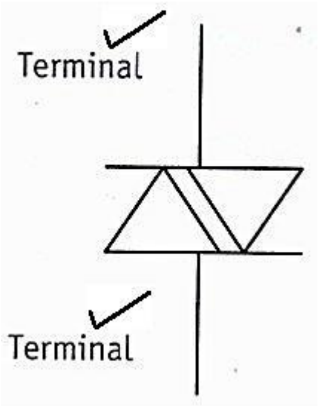
- The current flowing through the SCR must be reduced below the holding value. ✓
- Remove or reverse the potential across the SCR. ✓ (4)

6.4 6.4.1 <u>TRIAC</u>



(3)

6.4.2 DIAC



(2)

6.5 When the triggering circuit has no capacitor in it, ✓the triggering signal will not be delayed by a time constant. ✓When the voltage level at the gate reaches the triggering level, the SCR will be fired. ✓Because the sinusoidal supply reaches its maximum at 90°, any value after 90° that could trigger the SCR has already occurred before 90°.✓ (4)

6.6
- The advantage of the TRIAC and SCR in power control is that they have low power loss for the amount of power that is controlled. ✓
- Current control is also smooth, fast and accurate. ✓
- They conduct in both directions. ✓ (3)

[25]

QUESTION 7: SWITCHING AND CONTROL CIRCUITS

7.1
- Open loop voltage gain AV = 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 4) (4)

7.2 A differential amplifier consists of two identical sections each having input terminals. Two output terminals or a single output terminal common to both amplifiers is provided. Ground is common to both sections. The differential amplifier only amplifies the difference in signal between the two input signals. This amplified signal is represented on the output/outputs. ✓✓ (2)

7.3 **Positive Feedback**

When the output of a circuit is fed back to the input of the same circuit in phase with the input signal, the resultant will be ever increasing output. The result could be distortion or overloading of the circuit. ✓

Example: When the microphone of an audio amplifier is held close to the speaker positive feedback causes the amplifier to "whistle" causing great discomfort to the human ear. ✓

Negative feedback

When the output of a circuit is fed back to the input of the same circuit out of phase with the input, the result is that the output signal becomes smaller and may even disappear. ✓

Example: Negative feedback is utilised in amplifiers to obtain volume control and gain control such as is used in the oscilloscope. ✓ (4)

7.4 7.4.1 Non inverting amplifier mode ✓ (1)

7.4.2 This would not be a good audio amplifier because the output waveform is not an exact replica of the input waveform. ✓ The wave has been distorted slightly. ✓ (2)

7.4.3 $A_v = \frac{R_f}{R_{in}} + 1 = \frac{100\ 000}{10\ 000} + 1$ ✓ = 11 ✓ (2)

7.4.4
- By increasing the value of R_f upward, the amount of gain achieved by the circuit is increased. This is deduced from the formula used to calculate the total gain of the circuit. ✓✓
- Alternatively the value if R_i could be adjusted, where a small adjustment in R1 will result in a high change in gain of the circuit. ✓ (3)

7.5 Negative feedback advantages:
- Improved bandwidth ✓
- Less distortion ✓
- Less noise ✓ (3)

7.6 $F_O = \frac{1}{2\pi RC}$ ✓

$= \frac{1}{2\pi(R1+R2)(C1+C2)}$

$= \frac{1}{2\pi(100000+10000)(100p+50n)}$ ✓

= 28,9 Hz ✓ (3)

7.7 Potential divider base biasing ✓ (1)

[25]

QUESTION 8: THREE-PHASE TRANSFORMERS

8.1
- Making the transformer core long and narrow ✓
- Rearranging the primary and secondary windings ✓ (2)

8.2 8.2.1 Secondary phase voltage

$V = \frac{V_L}{\sqrt{3}}$ ✓ = $\frac{380}{\sqrt{3}}$ ✓ = 219,4 V ✓ (2)

8.2.2 Primary line voltage

$I_p = \frac{S}{\sqrt{3}\,V_L}$ ✓ = $\frac{30\,000}{\sqrt{3}\ 380}$ ✓ = 45,58 V ✓ (3)

8.2.3 Power delivered

$P_o = \sqrt{3}\,V_L\,I_L\,cos\theta$ ✓= $\sqrt{3}\,.\,380\,.\,45{,}58\,.\,0{,}85$ ✓ = 25,5 kW ✓ (4)

8.3
- Stray ✓
- Dielectric ✓
- Iron ✓
- Eddy current ✓ (4)

[15]

QUESTION 9: LOGIC CONCEPTS AND PLCs

9.1
- A PLC (i.e. Programmable Logic Controller) is a device that was invented to replace the necessary sequential relay circuits for machine control. ✓
- The PLC works by looking at its inputs and depending upon their state, turning on/off its outputs. ✓ The user enters a program, usually via software, that gives the desired results. (2)

9.2
- A hard wired system such as a star delta starter is wired to perform a certain duty. The system is specialised for that particular use and to alter it means to replace and rewire the system. ✓✓
- In a PLC system or soft wired system, relays are wired to the PLC. All the control aspects such as timers, lockouts, etc. are controlled by the PLC. Changing the system now to accommodate a change in manufacturing needs or process adaptations is as easy as changing the programming that controls the relay sets. ✓✓ (4)

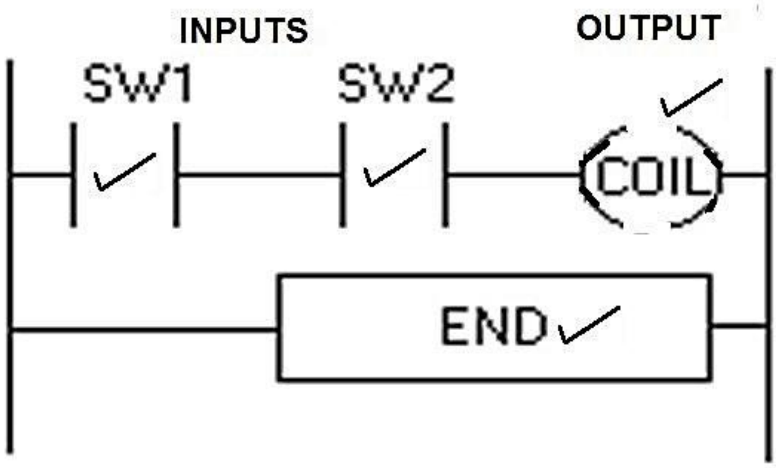
9.3 9.3.1 A PLC works by continually ***scanning*** a program. ✓ We can think of this scan cycle as consisting of 3 important steps. There are typically more than 3 but we can focus on the important parts and not worry about the others. Typically the others are checking the system and updating the current internal counter and timer values. ✓ (2)

9.3.2 Step 1: **CHECK INPUT STATUS** ✓ – First the PLC takes a look at each input to determine if it is on or off. In other words, is the sensor connected to the first input on? How about the second input? How about the third ... It records this data into its memory to be used during the next step. ✓

Step 2: **EXECUTE PROGRAM** ✓ – Next the PLC executes your program one instruction at a time. Maybe your program said that if the first input was on then it should turn on the first output. Since it already knows which inputs are on/off from the previous step it will be able to decide whether the first output should be turned on based on the state of the first input. It will store the execution results for use later during the next step. ✓

Step 3: **UPDATE OUTPUT STATUS**✓ – Finally the PLC updates the status of the outputs. It updates the outputs based on which inputs were on during the first step and the results of executing your program during the second step. Based on the example in step 2 it would now turn on the first output because the first input was on and your program said to turn on the first output when this condition is true. After the third step the PLC goes back to step one and repeats the steps continuously. One scan time is defined as the time it takes to execute the 3 steps listed above. ✓ (6)

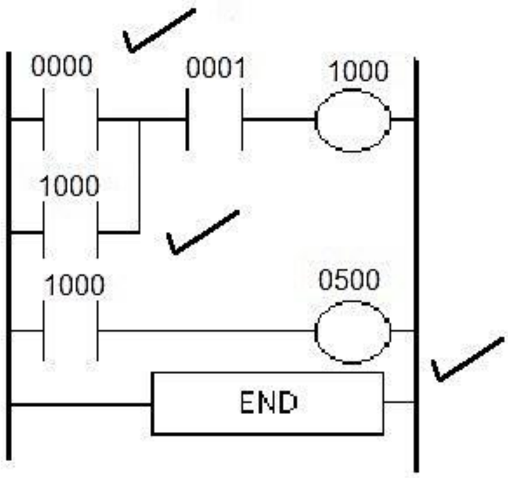
9.4 9.4.1



(4)

9.5 9.5.1 A.B + AB = X will only partly satisfy ✓the problem. An added memory component is needed to fully satisfy the problem. ✓
A = High Level Sensor
B = Low level Sensor
X = Motor (2)

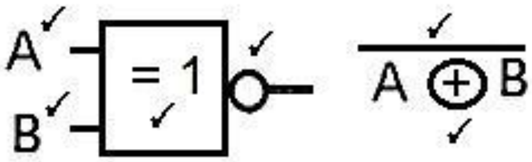
9.5.2



0000 – Low Level Sensor ✓
0001 – High Level Sensor ✓
1000 – Retaining Relay ✓
0500 – Motor ✓ (7)

9.5.3 Addresses are assigned to inputs and outputs, for the PLC device to correctly identify the assigned inputs and to its programmed function. ✓✓ (2)

9.6 9.6.1



(6)
[35]

QUESTION 10: THREE-PHASE MOTORS AND CONTROL

10.1 10.1.1 Line current and phase current

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

$I_L = \frac{P}{\sqrt{3}V_L\, Cos\theta}$ ✓ $= \frac{8\ 000}{\sqrt{3}\ .\ 380\ .\ 0{,}8}$ ✓ = 15,19 A ✓

$I_{ph} = \frac{I_L}{\sqrt{3}} = \frac{15{,}19}{\sqrt{3}}$ ✓ = 8,77 A ✓ (5)

10.1.2 Input in kVA

$S = \sqrt{3}\, V_L\, I_L$ ✓ $= \sqrt{3}\,.\,380\,.\,15{,}19$ ✓ = 9,997 kVA✓ (3)

10.2 To reduce the voltage at start-up. ✓ This in turn reduces the starting current. ✓ Reduced starting current leads to less heat build-up and decreased chance of burn out. ✓ (3)

10.3 No-volt protection prevents a motor from restarting after a power failure. ✓ The operator needs to re-engage the start switch in order to restart the motor. ✓ This protects both the operator and the equipment. ✓ (3)

10.4 A normally closed contact is closed in a de-energised state and opens in an energised state. ✓✓ (2)

10.5 Earthing the enclosure of the motor will keep it at earth potential, ✓ thus preventing it from becoming live / hot and placing the life of the operator in danger. ✓ This precautionary measure ensures the safety of the worker. ✓ (3)

10.6 By swapping the connections to any two phases of the three supply lines to the stator. ✓✓ (2)

10.7 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. ✓ (6)

10.8 Mechanical (Any 1 correct answer)

- Is the cooling fan intact and turning freely but mounted securely on the motor shaft? ✓

Electrical (Any 2 correct answers)

- Is the frame of the motor earthed? ✓
- Has the insulation test been performed on the stator and are the readings above 1 MΩ? ✓ (3)

[30]

TOTAL: 200