



basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY

NOVEMBER 2011

MEMORANDUM

MARKS: 200

This memorandum consists of 14 pages.

INSTRUCTIONS TO MARKERS

1. All questions with multiple answers imply that any relevant, acceptable answer should be considered.
2. Calculations:
 - 2.1 All calculations must show the formula(e).
 - 2.2 All answers must contain the correct unit to be considered.
 - 2.3 Alternative methods must be considered, provided that the same answer is obtained.
 - 2.4 Where an erroneous answer could be carried over to the next step, the first answer will be deemed incorrect. However, should the incorrect answer be carried over correctly, the marker has to re-calculate the values, using the incorrect answer from the first calculation. If correctly used, the learner should receive the full marks for subsequent calculations.
3. Phasor diagrams must show the direction of rotation.
4. The memorandum is only a guide with model answers. Alternative interpretations must be considered, and marked on merit. However, this principle should be applied consistently throughout the marking session at ALL marking centres.

QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

- 1.1 It causes radiation that is harmful to the environment ✓
It needs a vast amount of water for cooling. ✓
The area used to dispose nuclear waste need to be secured. ✓
It needs advanced technology and high safety measures
(Any three) (3)
- 1.2 Solar power. ✓
Wind power. ✓
Hydro-electrical power.
Geothermal
(Any two) (2)
- 1.3 High rate of absenteeism ✓
Low levels of production ✓
Loss of concentration ✓
High rate of accidents
Reduced skilled labour
High economical cost
(Any three) (3)
- 1.4 Financial management skills ✓
Be a creative thinker ✓
Hard worker
Determine a need and fulfil it
Identify a problem and solve it
Look for solutions
Focus on customers
Invest in sweat equity in your business
Planning skills
(Any two relevant answers) (2)

[10]**QUESTION 2: TECHNOLOGICAL PROCESS**

- 2.1 2.1.1 The process is the acceptance ✓ of the input AC signal and changing it to another voltage value via mutual induction. ✓ (2)
- 2.1.2 The output is the delivery ✓ of the processed input to a load. ✓ (2)

Note: If learners refer to the technological process – these answers should be assessed on merit.

For Example:

Process: The making Process – Put the winding with the fewer turns on the primary side and the winding with more turn on the secondary side.

Output – Test and Evaluate – Apply voltage to primary windings and measure the induced voltage on the secondary winding and confirm that this is a step-up transformer.

- 2.2 It is important to evaluate the electrical product because the evaluation will determine whether you have met ✓ the original criteria of the product ✓, i.e. correct operation, cost effective, marketable, etc. ✓ (3)
- 2.3 Internet ✓
Magazines ✓
Pamphlets ✓
Advertising
Competitions
Media
Marketing
Communication
(Any three) (3)
[10]

QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

- 3.1 Earth-leakage system ✓
Overload circuit breakers ✓
No-volt coil prevents automatic restarting after power interruption.
Fuses
Emergency stop switch
(Any two) (2)
- 3.2 Make sure that the panel is disconnected from the supply ✓ so that when working the panel is not live. ✓ (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. ✓ (2)
- 3.4 Beware wet areas and moisture ✓; water is a conductor which could lead to electric shock. ✓
Check for cracks on the casing of the tool; ✓ cracks may lead to contact with live conductors resulting in shock. ✓
The cable must be earthed or double insulated. This will prevent accidental shock.
(Answers must have a motivation/reason in order to receive two marks.) (4)
[10]

QUESTION 4: THREE-PHASE AC GENERATION

- 4.1 For high power generation the three-phase system is functional and efficient. ✓
The voltages between all phases (i.e. line voltages) are the same.
The direction of rotation of three-phase machines can be easily changed.
Transmission and distribution are fairly simple.
(Any one) (1)

$$\begin{aligned}
 4.2 \quad I_L &= \sqrt{3} I_{ph} \checkmark \\
 &= \sqrt{3} \times 300 \checkmark \\
 &= 519,62 \text{ A} \checkmark
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 4.3 \quad 4.3.1 \quad &\text{Star connection } I_L = I_{Ph} = 20 \text{ A} \\
 &V_L = \sqrt{3} V_{Ph} \checkmark \\
 &= \sqrt{3} \times 220 \checkmark \\
 &= 381,1 \text{ V} \checkmark
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 4.3.2 \quad P_T &= 3V_{PH} \times I_{PH} \text{Cos}\theta \checkmark \\
 &= 3 \times 220 \times 20 \times 0,867 \checkmark \\
 &= 11,49 \text{ kW} \checkmark
 \end{aligned}$$

OR

$$\begin{aligned}
 P_T &= \sqrt{3} V_L \times I_L \text{Cos}\theta \\
 &= \sqrt{3} \times 381,1 \times 20 \times 0,867 \\
 &= 11,49 \text{ kW}
 \end{aligned}$$

(3)
[10]

QUESTION 5: RLC CIRCUITS

5.1 The capacitive reactance will decrease. \checkmark (1)

5.2 The inductive reactance will decrease. \checkmark (1)

5.3 Impedance is the total opposition \checkmark offered to a flow of current in a RLC circuit \checkmark when the circuit is connected across an alternating-voltage supply and it is measured in Ohms. (2)

$$\begin{aligned}
 5.4 \quad 5.4.1 \quad X_C &= \frac{1}{2\pi FC} \checkmark \\
 &= \frac{1}{2\pi \times 50 \times 247 \times 10^{-6}} \checkmark \\
 &= 12,89 \Omega \checkmark
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 5.4.2 \quad X_L &= 2\pi FL \checkmark \\
 &= 2\pi \times 50 \times 0,17 \checkmark \\
 &= 53,41 \Omega \checkmark
 \end{aligned}
 \tag{3}$$

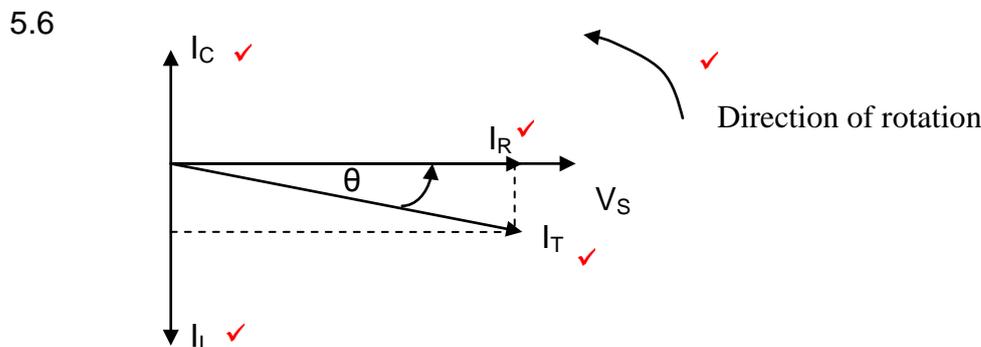
$$\begin{aligned}
 5.4.3 \quad Z &= \sqrt{R^2 + (X_L - X_C)^2} \checkmark \\
 &= \sqrt{100^2 + (53,41 - 12,89)^2} \checkmark \\
 &= 107,89 \Omega \checkmark
 \end{aligned}
 \tag{3}$$

5.5 5.5.1 $X_L = \frac{V}{I_L}$ ✓
 $= \frac{220}{6}$ ✓
 $= 36,67 \Omega$ ✓ (3)

5.5.2 $X_C = \frac{V}{I_C}$ ✓
 $= \frac{220}{4}$ ✓
 $= 55 \Omega$ ✓ (3)

5.5.3 $R = \frac{V}{I_R}$ ✓
 $= \frac{220}{8}$ ✓
 $= 27,5 \Omega$ ✓ (3)

5.5.4 $I_T = \sqrt{I_R^2 + (I_L - I_C)^2}$ ✓
 $= \sqrt{8^2 + (6 - 4)^2}$ ✓
 $= 8,25 A$ ✓ (3)



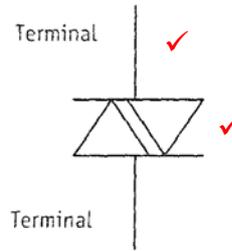
Phasor diagram must indicate direction of rotation. If not, subtract one mark. (5)
 Any five correct labels.

[30]

QUESTION 6: SWITCHING AND CONTROL CIRCUITS

- 6.1 6.1.1 1: Current (I)(Amps) ✓
 2: Voltage (Volts) ✓
 3: Breakover Voltage V_{Bo} ✓
 4: Holding Current I_H ✓ (4)

6.1.2



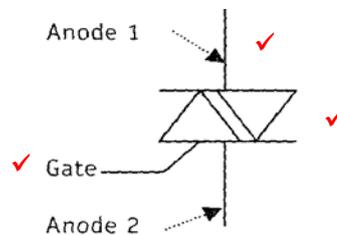
(One mark for symbol and one mark for labels)

(2)

- 6.1.3 A voltage of either polarity can be connected across either terminal; ✓ once the voltage rises above V_{BO} the DIAC will conduct/switch on. ✓ The DIAC is designed to break through at a V_{BO} of between 30 V and 50 V. ✓ It can conduct in both directions. ✓

(4)

6.2



(One mark for symbol, one mark for gate and one mark for anode 1 and 2)

(3)

- 6.3 A voltage must be applied across the two main terminals of the TRIAC ✓; the polarity of the voltage may be in either direction. ✓ It can now be triggered into conduction by either a positive or negative pulse on the gate ✓.

OR

A voltage must be applied across the two main terminals of the TRIAC; the polarity of the voltage may be in either direction. If the voltage is now increased to above V_{BO} of the TRIAC it will conduct.

(3)

- 6.4 6.4.1 The full 220 V. ✓

(1)

- 6.4.2 If R_2 is increased the time constant of the trigger circuit is increased ($t=RC$); ✓ this will prolong ✓ the time it takes for the capacitor to charge to the voltage that is equal to the break-over voltage of the diode, ✓ increasing the trigger angle (taking longer to trigger in each half cycle), thus lowering the temperature of the soldering iron ✓ as less time is allowed for current to flow through the iron. ✓

(5)

- 6.4.3 It can only conduct for the positive half cycle ✓ of an AC cycle. It can only conduct in one direction.

(1)

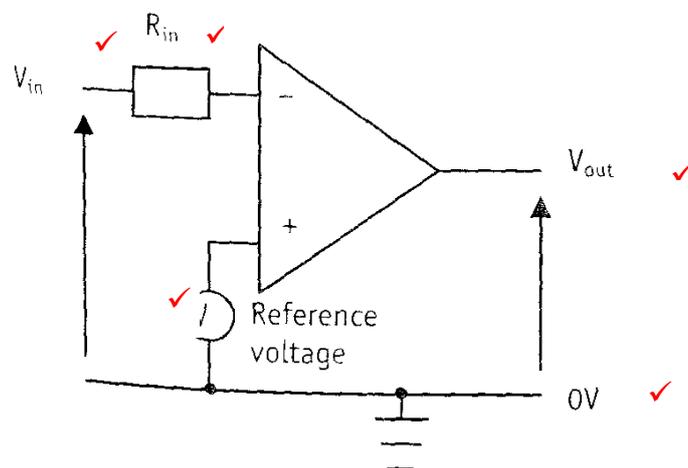
- 6.5 A bigger SCR ✓ can handle more current ✓ and resultant heat.

(2)

[25]

QUESTION 7: AMPLIFIERS

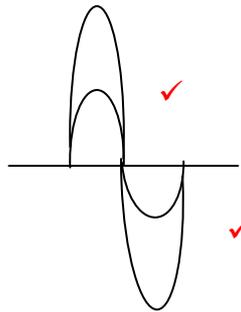
- 7.1 Linear amplifiers. ✓
Pulse amplifiers. ✓
Buffer circuits
Integrating or
Differentiating or
Summing amplifiers
(Any two) (2)
- 7.2 Current gain is very small ✓
It must be connected to a dual supply with -15 V to $+15\text{ V}$
Integrated circuit is complex
(Any one) (1)
- 7.3 Input draws no current. ✓
The voltage drop between the input terminals is zero. ✓
The open-loop voltage gain is infinite. ✓
Output impedance is zero.
Input impedance is infinite.
Frequency Response is infinite.
(Any three) (3)
- 7.4 Means that there is no feedback ✓ (neither negative nor positive) from the output ✓ back to the input ✓.
The gain of the circuit is at a maximum. (3)
- 7.5

**Op-amp as an inverting voltage comparator**

(5)

7.6 7.6.1 Non-inverting op-amp . ✓ (1)

7.6.2



INPUT/OUTPUT SIGNAL

(2)

7.6.3 Output signal ✓ is fed back to the inverting input ✓ through feedback resistor R_f . ✓

OR

Value of R_f determines the amount of gain fed back into the op-amp

(3)

7.6.4 If the resistance of R_f is increased V_{rf} will increase ✓ this is feedback on the inverting input of the op-amp ✓ reducing the overall gain of the circuit. ✓

(3)

7.6.5 R_{in} allows further control ✓ of the op-amp circuit gain. ✓
Setting R_{in} at a high value compared to R_f creates a voltage-follower circuit. ✓
 R_{in} sets a reference point for the inverting input.

(2)

[25]

QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 The function of a transformer is to step-up or to step-down ✓ an alternating voltage. ✓

OR

The function of a transformer is to isolate two circuits electrically from each other.

(2)

8.2 Copper losses. ✓

Iron losses.

Stray losses.

Dielectric. (Any one)

(1)

8.3 $V_{L1} = 11\text{kV} = 11000\text{ V}$

$I_{P1} = 450\text{ A}$

8.3.1

$$\begin{aligned}
 V_{ph(s)} &= \frac{V_{Ph(P)} \times N_S}{N_P} \quad \checkmark \\
 &= \frac{11000 \times 1}{50} \quad \checkmark \\
 &= 220 \text{ V} \quad \checkmark
 \end{aligned}
 \tag{3}$$

8.3.2

$$\begin{aligned}
 V_{L(S)} &= \sqrt{3} V_{Ph(S)} \quad \checkmark \\
 &= \sqrt{3} \times 220 \quad \checkmark \\
 &= 380 \text{ V} \quad \checkmark
 \end{aligned}
 \tag{3}$$

8.3.3

$$\begin{aligned}
 I_{Ph(P)} &= \frac{I_{Ph(S)} \times N_S}{N_P} \quad \checkmark \\
 &= \frac{450 \times 1}{50} \quad \checkmark \\
 &= 9 \text{ A} \quad \checkmark
 \end{aligned}
 \tag{3}$$

8.3.4

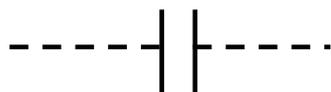
$$\begin{aligned}
 I_{L(P)} &= \sqrt{3} I_{Ph} \quad \checkmark \\
 &= \sqrt{3} \times 9 \quad \checkmark \\
 &= 15,59 \text{ A} \quad \checkmark
 \end{aligned}
 \tag{3}$$

[15]**QUESTION 9: LOGIC CONCEPTS AND PLCs**9.1 Programmable Logic Controller. \checkmark (1)

9.2 Input terminals \checkmark
 Output terminals \checkmark
 Memory \checkmark
 CPU \checkmark
 Screen, PSU etc. (4)

9.3 A series of instructions \checkmark written in a language \checkmark that a PLC can recognise and interpret into an output. \checkmark (3)
OR

That is language used to program PLCs.

9.4 9.4.1 \checkmark 

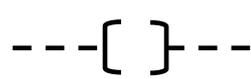
(1)

9.4.2



(1)

9.4.3



(1)

- 9.5 Economical. ✓
- Simplified design. ✓
- Quick delivery. ✓
- Compact and standardised.
- Improved reliability.
- Reduced maintenance.
- (Any three)

(3)

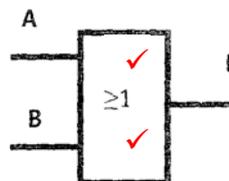
- 9.6 User interface (On the PLC Unit – Screen & Buttons) ✓
- Computer or laptop with interface cable ✓
- Handheld programming device ✓

(3)

- 9.7 Ladder logic (LL). ✓
- Instruction list (IL). ✓
- Logic block diagram (LBD). ✓
- Function Block Diagram (FBD)
- Structured Text
- Sequential Flow / Function Chart
- (Any Three)

(3)

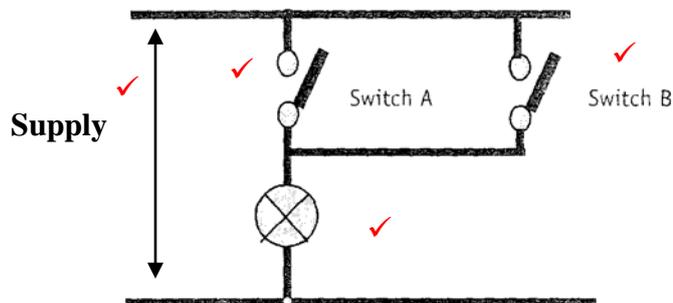
9.8 9.8.1



OR-GATE SYMBOL
American Symbols Accepted.

(2)

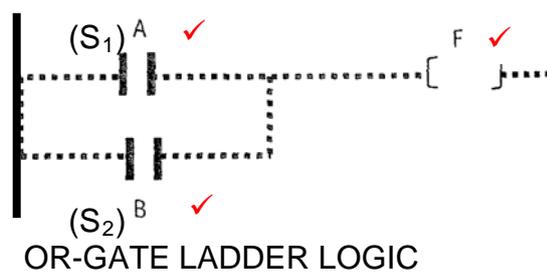
9.8.2



OR-GATE CIRCUIT

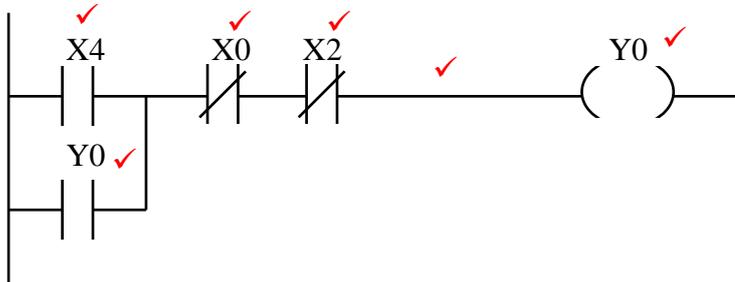
(4)

9.8.3



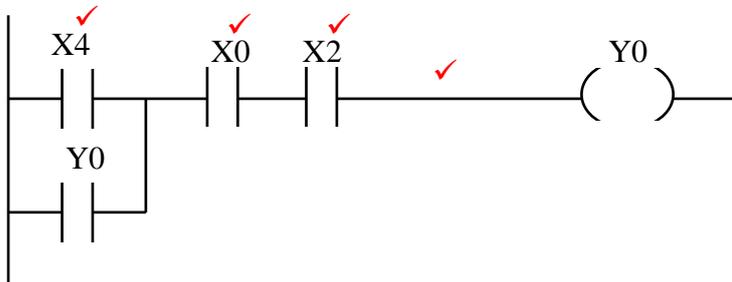
(3)

9.9



(6)

Alternatively learners could opt not to invert the input X0 and X2 as NC switches will be used.

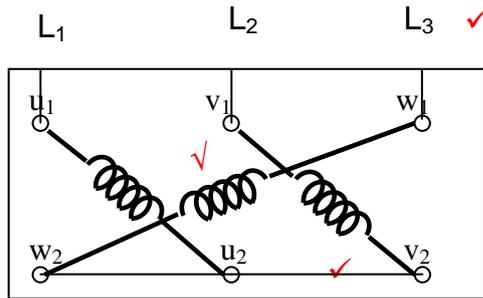


[35]

QUESTION 10: THREE-PHASE MOTORS AND CONTROL

- 10.1 10.1.1 Insulation resistance tester or Megger. ✓ (1)
- 10.1.2 It is important to do the test because if the reading is not correct, it could indicate a fault ✓ which could lead to an electric shock, ✓ which could lead to further risk of injury to the operator. ✓
The motor could be damaged due to a short circuit. (3)
- 10.1.3 The expected reading should be very high ✓, in the order of mega ohms. This would indicate no electrical contact between the windings ✓ which would lead to fault conditions. A low reading would indicate an electrical short between the windings. ✓ (3)

10.1.4



One mark for coils
One mark for supply lines
One mark for neutral

(3)

10.2

10.2.1

$$P = \sqrt{3} \times V_L \times I_L \times \cos \phi$$

$$I_L = P / \sqrt{3} \times V_L \times \cos \phi$$

$$= 15\,000 / \sqrt{3} \times 380 \times 0,9$$

$$= 25,32 \text{ A}$$

(3)

10.2.2

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

$$= \frac{15000}{0,9}$$

$$= 16,67 \text{ kVA}$$

OR

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

$$= \sqrt{3} \times 380 \times 25,32$$

$$= 16,67 \text{ kVA}$$

(3)

10.2.3

$$I_{ph} = I_L / \sqrt{3}$$

$$= 25,32 / \sqrt{3}$$

$$= 14,62 \text{ A}$$

(3)

10.3

To reduce the voltage at start-up. This in turn reduces the starting current.

Reduced starting current leads to fewer nuisance tripping problems at start or to less heat build-up and decreases the chance of burn-out of the motor.

(3)

10.4

Stator.
Rotor.
End plates.
Fan.
Terminal box.
Bearings.
(Any three)

(3)

- 10.5 Supply-voltage drop. ✓
Loss of a supply phase.
Insulation faults. ✓
Overloading the motor.
Insufficient cooling
(Any two) (2)
- 10.6 The stator windings are spaced 120° apart. ✓ (1)
- 10.7 The purpose of using a starter to start a three-phase motor is to safely control the motor, ✓ protect electrical equipment and the user of the motor. ✓ (2)
- [30]**
- TOTAL: 200**