basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY

NOVEMBER 2012

MEMORANDUM

MARKS: 200

This memorandum consists of 13 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 Substitution of values must be done correctly.

   2.3 All answers MUST contain the correct unit to be considered.

   2.4 Alternative methods must be considered, provided that the same answer is obtained.

   2.5 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. 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 1.1.1 Coal causes air pollution✓ which is harmful to the environment✓ as man, animal and plant life all rely on clean air for healthy living. (2)

1.1.2 Availability of coal✓
Economical✓
(Any acceptable answer) (2)

1.2 Need to be a hard worker.✓
Need to be a creative thinker.✓
Must have sound financial management skills.
Good communication skills; Personal drive and commitment; Good positive attitude and work ethic; Have the desire to succeed; Good marketing skills; Good time management skills; and be a good leader.
(Any TWO relevant competencies) (2)

1.3 The cellphone has given many people more access to a wide range of communication methods✓ which has allowed access to the business world. ✓
Education opportunities.
Cellphones allow access to the Internet, Facebook and Twitter; it is not only just a phone but a computer as well.
(Many possiblities) (2)

1.4 Equal access to employment to school leavers means that all learners leaving school should have had an education✓ that does not disadvantage them in any way that gives them access to economic independence. ✓
No restricted access to education or work opportunities
Affords the opportunity for the school leaver to work in related Electrical Technology fields.
(Alternative answers within the context of Electrical Technology) (2)
[**10]**

QUESTION 2: TECHNOLOGICAL PROCESS

2.1 Investigation✓
Designing✓
Making✓
Evaluation✓ (4)

2.2 To make the product according to the selected design✓ and to improve the product after evaluation. ✓ (2)

2.3 To identify possible improvements of the product. ✓
To collect data and information of the product. ✓
To conduct tests on the prototype. ✓
To check if specifications are met. ✓
To see if the prototype is suitable before the final product is made.
To check costing and other financial constraints.
(Any relevant answer) (4)
[10]

QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 Working on a live system with exposed conductors. ✓
Working with portable electric equipment that is not insulated correctly. ✓
Using electrical machines without using the required safety equipment or clothing. (2)
(Any valid answer)

3.2 Because water is a conductor of electricity✓ and will result in electric shock.✓ (2)

3.3 Power to the circuit must be switched off when connecting meter leads. ✓
Make sure that the leads are connected to the correct terminal or sockets of the meter. ✓
Make sure that the multimeter is connected in series when measuring current.
For safety, start with the highest scale of the multimeter.
(Any TWO) (2)

3.4 To prevent drowsiness✓ which could cause loss of concentration resulting in an accident. ✓
To remove vapour and smoke which are harmful to humans. (2)

3.5 To avoid electric shock.✓
Some sections of the circuit may be live. ✓
The power supply could have been switched on by mistake. (2)
[10]

QUESTION 4: THREE-PHASE AC GENERATION

4.1 Effective value✓ or rms value (1)

4.2 Apparent power is the product✓ of the supply voltage and the current✓ in an AC system. ✓

S = VI (3)

4.3 The active current is that component of current✓ which is in phase ✓with the supply voltage of an AC system. ✓ (3)

4.4 $I_L = \sqrt{3} I_{PH}$ ✓
$= \sqrt{3} \times 10$ ✓
$= \underline{17{,}32 A}$ ✓
(3)
[10]

QUESTION 5: RLC CIRCUITS

5.1 Capacitive reactance is the opposition✓ to the flow of current ✓ a capacitor offers when the capacitor is connected across an alternating voltage supply. ✓ (3)

5.2 When the frequency of the supply is increased, the inductive reactance will increase✓ thus increasing the impedance of the circuit✓. The increase in impedance will result in a decrease in current flowing through the circuit✓ thus reducing the brightness of the lamp. (3)

5.3 5.3.1

$$I_T = \sqrt{I_R^2 + (I_L - I_C)^2} \checkmark$$
$$= \sqrt{15^2 + (15-10)^2} \checkmark$$
$$= \underline{15.81A} \checkmark$$

(3)

5.3.2

$$X_L = \frac{V}{I_L} \checkmark$$
$$= \frac{240}{15} \checkmark$$
$$= \underline{16\Omega} \checkmark$$

(3)

5.3.3

$$L = \frac{X_L}{2\pi f} \checkmark$$
$$= \frac{16}{2x\pi x50} \checkmark$$
$$= 51mH$$
$$= \underline{51\times10^{-3}H} \checkmark$$

(3)

5.4 5.4.1

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

(3)

5.4.2

$$Z = \sqrt{R^2 + X_C^2} \checkmark$$
$$= \sqrt{30^2 + 21.65^2} \checkmark$$
$$= \underline{37\Omega} \checkmark$$

(3)

5.4.3
$$I = \frac{V}{Z} \checkmark$$
$$= \frac{240}{37} \checkmark$$
$$= \underline{\rightarrow 6.49\,A} \checkmark$$
(3)

5.4.4
$$\theta = \tan^{-1}\frac{X_C}{R} \checkmark$$
$$= \tan^{-1}\frac{21.65}{30} \checkmark$$
$$= \underline{\rightarrow 35.82°} \checkmark$$

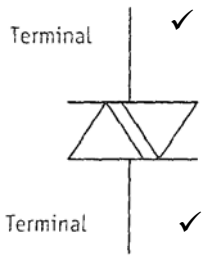
OR

$$\theta = \cos^{-1}\frac{R}{Z}$$
$$= \cos^{-1}\frac{30}{37}$$
$$= \underline{\rightarrow 35.82^\circ}$$
(3)

5.5 If the capacitance of the capacitor is increased the capacitive reactance of the capacitor will decrease✓. The voltage across the capacitor will decrease✓ which will result in an increase of the voltage across the resistor. ✓
(3)
[30]

QUESTION 6: SWITCHING AND CONTROL CIRCUITS

6.1

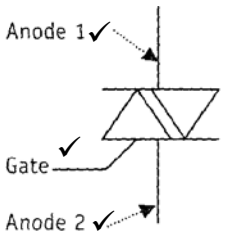


✓ ✓
(2)

6.2 6.2.1 The TRIAC may be used in the following applications:

Motor speed control ✓
Lamp dimming
Temperature control
Triacs are used in switching circuits.
(Any ONE application) (1)

6.2.2



(ONE mark for correct symbol with no or incorrect labelling) (3)

6.2.3 At both points labelled 'gate pulse' the TRIAC will be triggered into conduction✓ if there is an appropriate voltage across the terminals of the TRIAC. ✓ (2)

6.2.4 When the voltage across the TRIAC reaches V_{BO} the TRIAC will begin to conduct✓ without the gate being triggered. ✓ (2)

6.2.5 I_H is the holding current of the TRIAC, this is the minimum current that must flow to keep the TRIAC conducting✓ if the current through the TRIAC falls below I_H the TRIAC will switch off. ✓ (2)

6.2.6 When the TRIAC begins to conduct, the internal resistance of the TRIAC decreases✓ therefore the voltage across the TRIAC will decrease.✓ (2)

6.2.7 It conducts in both directions. ✓ (1)

6.3 6.3.1 1 – Anode✓
2 – Cathode✓
3 – Gate✓ (3)

6.3.2 R_1 acts as a current limiting resistor.✓ In the event that R_2 is decreased to zero,✓ a short circuit is prevented. ✓ (3)

6.3.3 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) ✓ thus reducing the brightness of the lamp✓ as less time is allowed for current to flow through the lamp. (4)

[25]

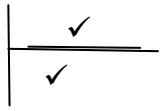
QUESTION 7: AMPLIFIERS

7.1 7.1.1 1 – Non-inverting input ✓
2 – Inverting input ✓
3 – Output ✓ (3)

7.1.2 4 and 5 are the terminals to the dual DC supply✓ that supplies power to the op amp. ✓ (2)

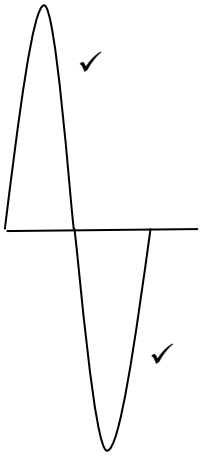
7.2 The concept of feedback is to sample the voltage at the output terminal✓ and to feed it back into one of the input terminals. ✓ (2)

7.3 7.3.1



(2)

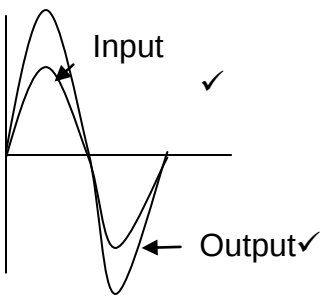
7.3.2



(2)

7.4 7.4.1 Non-inverting op amp✓ (1)

7.4.2



(ONE mark showing phase and ONE mark showing increased amplitude) (2)

7.4.3 $A_V = \frac{R_f}{R_{in}}$

The voltage gain of the circuit will decrease✓ as R_{IN} increases, ✓ because A_V is inversely proportional to R_{IN}. ✓

(ONE mark if only the formula is given) (3)

7.4.4 The input and output waveforms will be in phase. ✓
The input and output amplitudes will be the same. ✓ (2)

7.5 The frequency of the wave form remains unchanged. ✓ (1)

7.6 This will reduce the loading effect on the previous circuit. ✓ In so doing, no current will be drawn✓ from that circuit. Therefore, the voltage appearing ✓at its output terminals✓ will be passed on to the op amp with little or no loss. ✓

OR

When the input impedance of a circuit is high, the current it draws from the preceding circuit is minimal. As a result, the voltage drop is reduced and the input circuit loading is reduced. Circuit loading is when the current exceeds the delivery capacity and as a result the output voltage reduces to zero. (5)
[25]

QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 Insufficient ventilation✓
Short circuit
Overloading
Insufficient cooling substance (Any ONE) (1)

8.2 Electric circuit✓
Magnetic circuit✓ (2)

8.3 To create a three-phase four-wire system✓ so that a transformer can supply both single-phase✓ and three-phase. ✓(To distribute power to both domestic and industrial installations.) (3)

8.4 8.4.1

$$V_{L(s)} = \sqrt{3}V_{Ph(s)}$$

$$\therefore V_{Ph(s)} = \frac{V_{L(s)}}{\sqrt{3}} \quad ✓$$

$$= \frac{415}{\sqrt{3}} \quad ✓$$

$$= \underline{239.6\ V} \quad ✓$$

(3)

8.4.2 $S = \sqrt{3} V_{L(p)} \ I_{L(p)}$

$\therefore \ I_{L(p)} = \frac{S}{\sqrt{3} V_{L(p)}}$ ✓

$= \frac{240000}{\sqrt{3}\ x 11000}$ ✓

$= \underline{12.59\ A}$ ✓ (3)

8.4.3 $P_O = \sqrt{3} V_{L(p)} I_{L(p)} \cos\theta$ ✓

$= \sqrt{3} \times 11000 \times 12.59 \times 0.85$ ✓

$= \underline{203{,}89\ \text{kW}}$ ✓ (3)

[15]

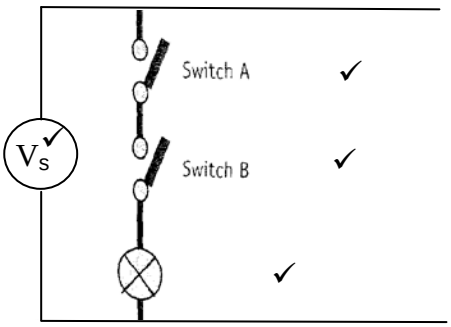
QUESTION 9: LOGIC CONCEPTS AND PLCs

9.1 9.1.1 This provides the power at a specific voltage ✓ to operate the PLC. ✓ (2)

9.1.2 This is the device that is programmed externally✓ to provide the necessary control of the plant (relays, motors, etc.).✓ (2)

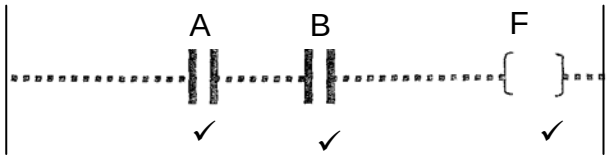
9.1.3 These modules are the interface✓ between the PLC and the plant equipment. ✓ (2)

9.2 9.2.1



(4)

9.2.2



(3)

9.3 9.3.1 R-S Flip-Flop latch✓
Bistable-multivibrator (1)

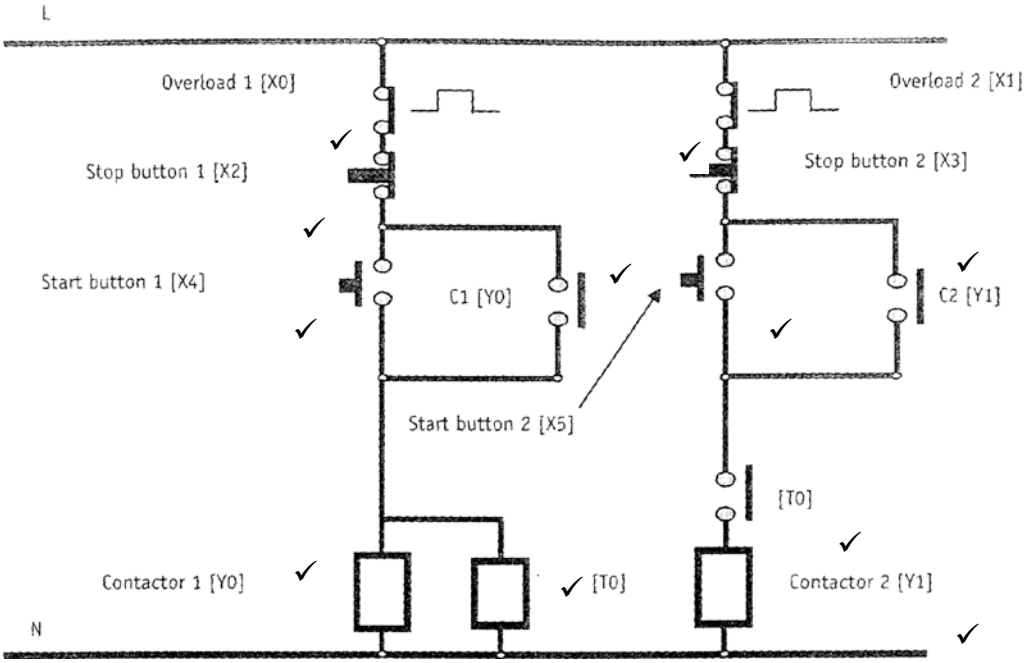
9.3.2 1 – Set ✓
2 – Reset✓
3 – Q ✓
4 – $\overline{Q}$ ✓ (4)

9.3.3 Memory device ✓ (1)

9.3.4 3 – 0✓
4 – 1✓ (2)

9.4 Simplified✓
Economical ✓
Quick delivery ✓
Compact
Changes to circuit design more easy to effect
Improved reliability
Reduced maintenance
(Any THREE) (3)

9.5



(11)
[35]

QUESTION 10: THREE-PHASE MOTORS AND CONTROL

10.1 By reversing the connections of any two of the three supply lines to the stator. ✓ (1)

10.2 To check if the frame is earthed. ✓
To see if all electrical connections are fastened and insulated.✓
To verify if the correct voltage is used.
(Any acceptable answer) (2)

10.3 Minimum of 0,5 M Ω✓. (Very high resistance) (1)

10.4 To limit the starting✓ current of a squirrel cage motor at start.✓ (2)

10.5 To protect electrical equipment from✓ damage during faulty operating conditions and protecting the operator of the equipment. ✓ (2)

10.6 10.6.1

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

$$V_{ph} = \frac{V_L}{\sqrt{3}} \quad ✓$$

$$= \frac{415}{\sqrt{3}} \quad ✓$$

$$\underrightarrow{= 239.60\,V} \quad ✓$$

(3)

10.6.2

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

$$I_L = \frac{P_i}{\sqrt{3}V_L \cos\theta} \quad ✓$$

$$= \frac{9\,000}{\sqrt{3}\,x415\,x0.9} \quad ✓$$

$$\underrightarrow{= 13.91A} \quad ✓$$

(3)

10.6.3

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

$$= \sqrt{3} \times 415 \times 13{,}9 \quad ✓$$

$$\underrightarrow{= 10kVA} \quad ✓$$

OR

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

$$= \frac{9000}{0.9}$$

$$\underrightarrow{= 10kVA}$$

(3)

10.7 It is important that a motor has an information plate because the plate contains crucial information about the motor, for example:
Current rating✓
Power factor✓
Phase✓
Power output (3)

10.8 The advantage of the three-phase induction motor is that for the same size frame a three phase motor delivers more power.✓
It is also more efficient than a single-phase motor as no additional starting circuit is required.✓
Less expensive than single-phase motors with the same output power.✓
Rotation change simple.
Self-starting.
Higher starting torque than single-phase motors for same size frame.
(Any THREE acceptable answers) (3)

10.9 10.9.1 Coil of contactor✓ (1)

10.9.2 The motor will keep on operating, but to maintain the same output power✓ the current on the other two phases will increase. ✓If the protection is set correctly, it will engage, protecting the motor from permanent damage. ✓ (3)

10.9.3 The overload relay is designed to protect the motor✓ and motor wiring against current fault conditions. ✓ It will open and cut power to the motor. ✓ (3)
[30]

TOTAL: 200