



# basic education

Department:  
Basic Education  
**REPUBLIC OF SOUTH AFRICA**

**NATIONAL  
SENIOR CERTIFICATE**

**GRADE 12**

**ELECTRICAL TECHNOLOGY**

**NOVEMBER 2013**

**MARKS: 200**

**TIME: 3 hours**

**This question paper consists of 12 pages and 1 formula sheet.**

**INSTRUCTIONS AND INFORMATION**

1. Answer ALL the questions.
2. Sketches and diagrams must be large, neat and fully labelled.
3. ALL calculations must be shown and must be correctly rounded off to TWO decimal places.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Non-programmable calculators may be used.
6. Show the units of answers for all calculations.
7. A formula sheet is attached at the end of this question paper.
8. Write neatly and legibly.

**QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT**

- 1.1 The majority of electricity generated in South Africa uses coal as its primary source of energy.
- 1.1.1 State TWO environmentally friendly alternatives. (2)
- 1.1.2 Describe why it is important to look for alternatives to coal to generate electricity. (2)
- 1.2 The provision of electrical energy to all South Africans should be a basic human right.
- 1.2.1 Describe why access to electricity may have educational benefits. (2)
- 1.2.2 Describe ONE factor that may increase the cost of generating electricity. (2)
- 1.2.3 Explain why the provision of electricity to people's homes may reduce air pollution. (2)
- [10]**

**QUESTION 2: TECHNOLOGICAL PROCESS**

- 2.1 Describe the function of the following FOUR subsystems in the design of an electrical system:
- 2.1.1 Input (2)
- 2.1.2 Process (2)
- 2.1.3 Output (2)
- 2.1.4 Power supply (2)
- 2.2 Describe why it is important to evaluate a PAT project on completion. (2)
- [10]**

**QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY**

- 3.1 Name TWO unsafe acts that can cause injuries in an electrical technology workshop. (2)
- 3.2 List THREE electrical safety devices that will cut off the power supply in an emergency. (3)
- 3.3 Name the type of fire extinguisher that must be used to combat electrical fires. (1)
- 3.4 State TWO safety precautions that must be taken when connecting a multimeter in a circuit to measure current. (2)
- 3.5 Describe why it is important to have good ventilation in a workshop. (2)
- [10]**

**QUESTION 4: THREE-PHASE AC GENERATION**

- 4.1 State ONE advantage of a three-phase system over a single-phase system. (1)
- 4.2 Draw a delta-connected system showing the line and phase values of current and voltage. (4)
- 4.3 A three-phase balanced load is connected in star across a 380 V supply. At full load 60 kW, at a power factor of 0,85, is consumed.
- Given:
- $V_L = 380 \text{ V}$   
 $P_{\text{out}} = 60 \text{ kW}$   
 $\text{Cos } \theta = 0,85$
- 4.3.1 Calculate the current drawn at full load. (3)
- 4.3.2 If the power factor of the load was improved to 0,98, describe what would happen to the current drawn at full load. (2)
- [10]**

**QUESTION 5: RLC CIRCUITS**

- 5.1 Name TWO factors that influence the value of the capacitive reactance of a capacitor. (2)
- 5.2 Explain the term *inductive reactance* with reference to a coil. (2)
- 5.3 Describe how an increase in the number of turns on a coil will affect the inductive reactance of the coil. (2)
- 5.4 Draw the voltage and current waveforms on the same axis of the following when connected in an AC circuit:
- 5.4.1 A pure resistor (2)
- 5.4.2 A pure coil (2)

- 5.5 A series circuit with a  $200 \mu\text{F}$  capacitor, a  $180 \text{ mH}$  inductor and a resistor of  $10 \Omega$  is connected to a  $220 \text{ V}/50 \text{ Hz}$  supply.

Given:

$$\begin{aligned} C &= 200 \mu\text{F} \\ L &= 180 \text{ mH} \\ R &= 10 \Omega \\ V_S &= 220 \text{ V} \\ f &= 50 \text{ Hz} \end{aligned}$$

Calculate:

- 5.5.1 The inductive reactance of the inductor (3)
- 5.5.2 The capacitive reactance of the capacitor (3)
- 5.5.3 The impedance of the circuit (3)
- 5.5.4 The current through the circuit (3)
- 5.5.5 Draw the phasor diagram showing the current and voltages in the circuit. (5)
- 5.6 FIGURE 5.1 represents a parallel RLC circuit. Calculate the supply current of the circuit.

Given:

$$\begin{aligned} I_L &= 1,5 \text{ A} \\ I_C &= 2 \text{ A} \\ I_R &= 1 \text{ A} \\ V_S &= 220 \text{ V} \\ f &= 50 \text{ Hz} \end{aligned}$$

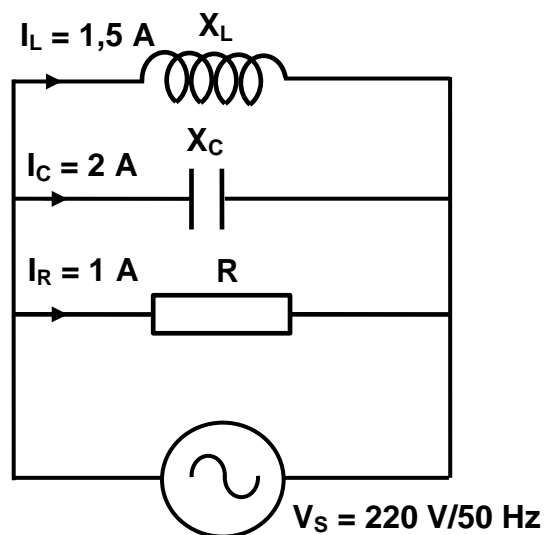
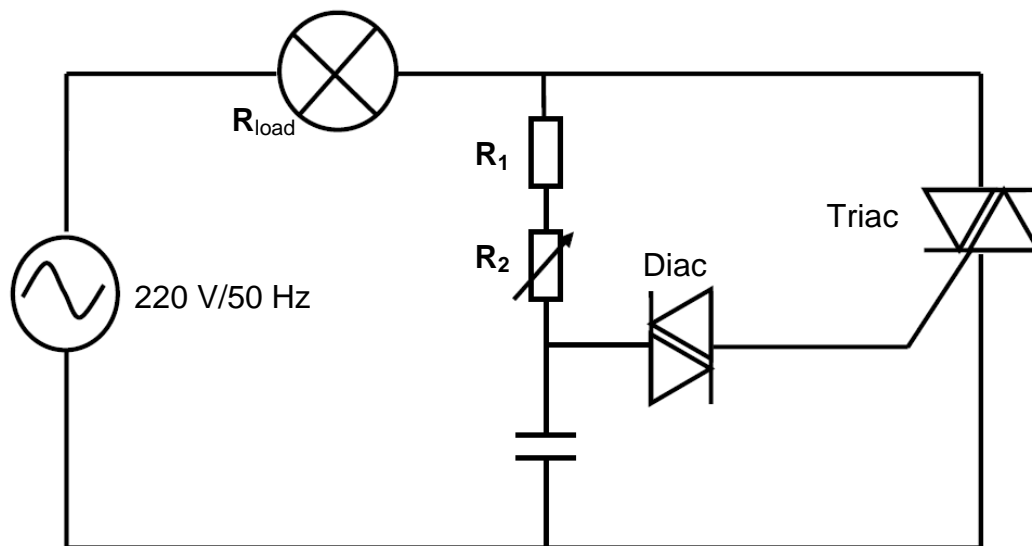


FIGURE 5.1: PARALLEL RLC CIRCUIT

(3)  
[30]

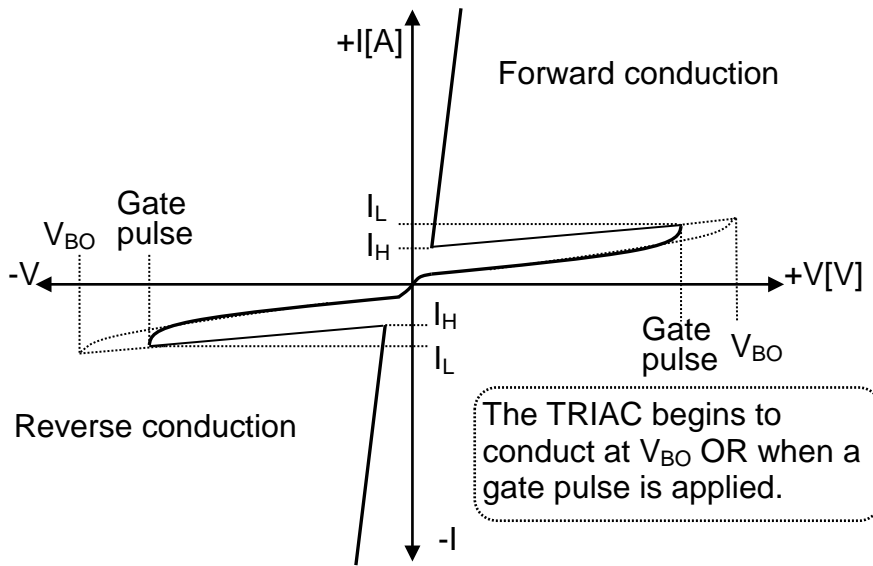
**QUESTION 6: SWITCHING AND CONTROL CIRCUITS**

- 6.1 Draw a fully labelled symbol of an SCR. (3)
- 6.2 State TWO applications of an SCR. (2)
- 6.3 Describe how an SCR is switched on using a controlled gate pulse. (3)
- 6.4 Explain what determines the physical size of an SCR. (2)
- 6.5 Describe how a DIAC is switched on. (3)
- 6.6 The lamp dimming circuit in FIGURE 6.1 below is connected to a 220 V/50 Hz supply.

**FIGURE 6.1: LAMP DIMMING CIRCUIT**

- 6.6.1 Describe the function of the DIAC. (2)
- 6.6.2 If the value of  $R_2$  is increased the brightness of the lamp will decrease. Explain how this occurs. (5)

6.7 The characteristic curve of a TRIAC is shown in FIGURE 6.2 below.



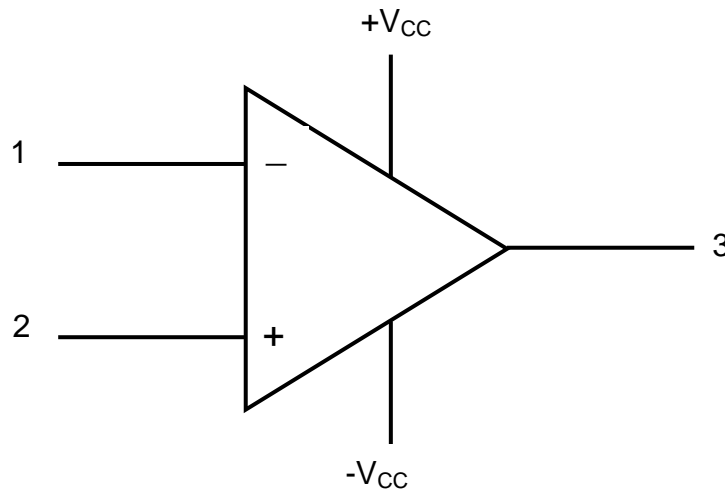
**FIGURE 6.2: CHARACTERISTIC CURVE OF A TRIAC**

- 6.7.1 Describe how the voltage will be affected when the TRIAC begins to conduct. (3)
  - 6.7.2 Explain the term *holding current* marked  $I_H$  on the characteristic curve. (2)
- [25]**

**QUESTION 7: AMPLIFIERS**

- 7.1 With reference to positive feedback:
  - 7.1.1 Describe the term *positive feedback*. (3)
  - 7.1.2 Name the main disadvantage of positive feedback. (1)
  - 7.1.3 State ONE application of positive feedback in amplifiers. (1)

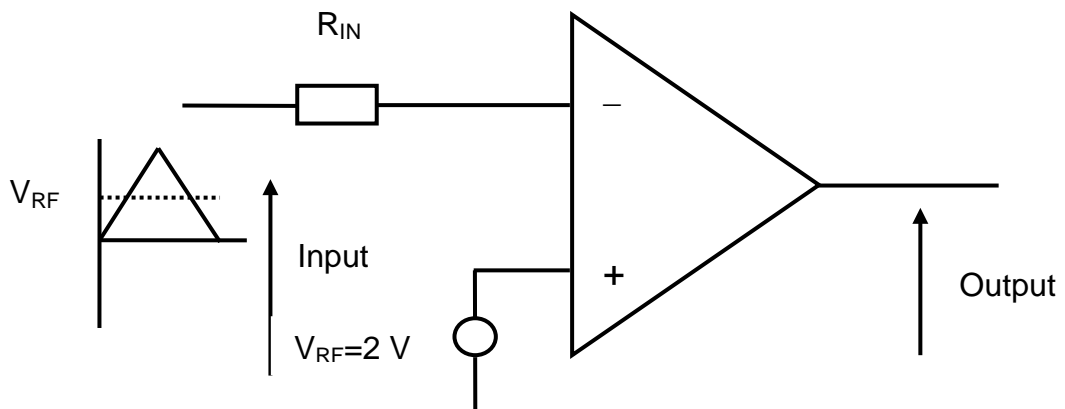
7.2 FIGURE 7.1 below is the symbol of an op-amp. Identify the labels marked 1, 2 and 3.



**FIGURE 7.1: OP-AMP SYMBOL**

(3)

7.3 FIGURE 7.2 below is an op-amp circuit.



**FIGURE 7.2: OP-AMP CIRCUIT**

7.3.1 Name the op-amp circuit. (1)

7.3.2 Draw the input and output waveforms on the same axis. (5)

7.3.3 Describe the function of the reference voltage. (3)

7.4 Draw a non-inverting amplifier circuit using an op-amp. (5)

7.5 Explain how a non-inverting op-amp may be converted into a voltage follower. (3)

**[25]**



**QUESTION 8: THREE-PHASE TRANSFORMERS**

- 8.1 Name ONE practical application of a transformer. (1)
- 8.2 Describe the basic operation of a transformer. (5)
- 8.3 If the load of an ideal transformer was doubled, what effect would it have on the following:
- 8.3.1 Input power (1)
- 8.3.2 Current (1)
- 8.3.3 Voltage (1)
- 8.4 A delta-star connected transformer supplies a factory with 66 kW at a power factor of 0,85. The primary line voltage is 11 kV, the secondary line voltage is 380 V. The transformer is 100% efficient.

Given:

$$P_{\text{out}} = 66 \text{ kW}$$

$$V_{L(p)} = 11 \text{ kV}$$

$$V_{L(s)} = 380 \text{ V}$$

$$\text{Cos } \theta = 0,85$$

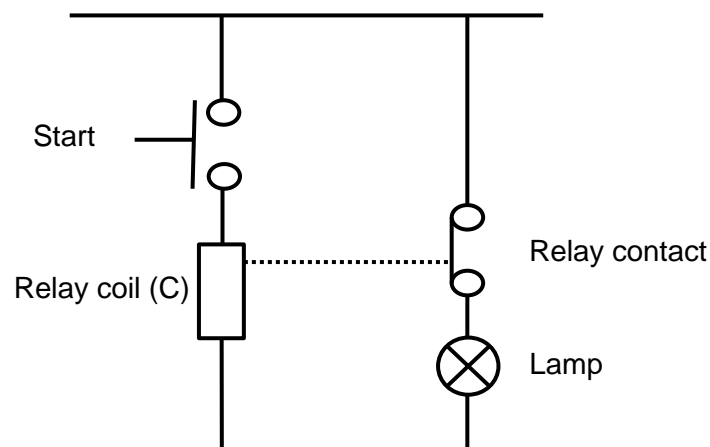
Calculate:

- 8.4.1 The secondary line current (3)
- 8.4.2 The primary line current (3)

**[15]**

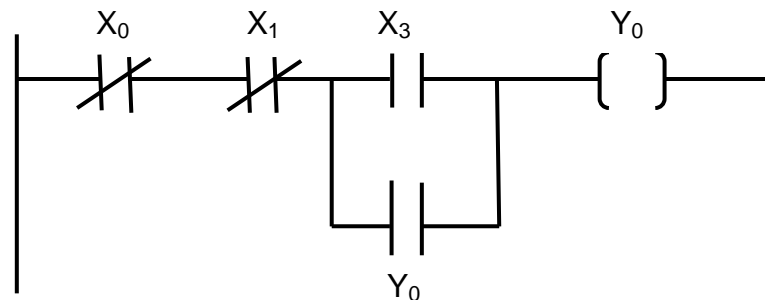
**QUESTION 9: LOGIC CONCEPTS AND PLCs**

- 9.1 Name TWO practical applications of a PLC. (2)
- 9.2 Describe the function of the following PLC components:
- 9.2.1 Memory (2)
- 9.2.2 CPU (2)
- 9.2.3 Input interfaces (2)
- 9.3 Name THREE types of programming languages used in PLC programming. (3)
- 9.4 The circuit in FIGURE 9.1 below represents a relay logic function.

**FIGURE 9.1: RELAY CIRCUIT**

- 9.4.1 Name the logic function this circuit represents. (1)
- 9.4.2 Draw the equivalent logic symbol for this circuit. (2)
- 9.4.3 Draw the truth table of the logic function. (2)
- 9.4.4 Draw the ladder diagram of this circuit. (5)

9.5 FIGURE 9.2 below represents a ladder logic diagram.



**FIGURE 9.2: LADDER LOGIC DIAGRAM**

9.5.1 Identify the control circuit represented in the ladder logic diagram. (1)

9.5.2 Draw the relay control circuit that represents the ladder diagram in FIGURE 9.2. (6)

9.6 Describe the following advantages of PLC control over relay control:

9.6.1 Simplified design (2)

9.6.2 Improved reliability (2)

9.6.3 Compactness and standardisation (2)

9.7 Name a digital device that may be used to count bottles in a cold drink factory. (1)

**[35]**

### QUESTION 10: THREE-PHASE MOTORS AND CONTROL

10.1 State the TWO modes in which a three-phase stator winding may be connected. (2)

10.2 Name THREE electrical tests that must be carried out on the stator winding of a motor before installation. (3)

10.3 Name TWO mechanical inspections that must be carried out on a motor during maintenance. (2)

10.4 State how the direction of rotation of a three-phase induction motor may be reversed. (1)

10.5 State TWO advantages of three-phase motors over single-phase motors. (2)

- 10.6 A three-phase 17 kW induction motor is connected in delta to a 380 V/50 Hz supply. The motor is 100% efficient with a power factor of 0,8 at full load.

Given:

$$P = 17 \text{ kW}$$

$$V_L = 380 \text{ V}$$

$$f = 50 \text{ Hz}$$

$$\eta = 100\%$$

$$\text{Cos } \theta = 0,8$$

Calculate:

- 10.6.1 The current drawn from the supply (3)
- 10.6.2 The apparent power of the motor (3)
- 10.7 Explain why the casing of a three-phase motor must be earthed. (2)
- 10.8 List THREE safety devices that must be included in a motor starter circuit. (3)
- 10.9 Describe ONE possible cause of overheating of a three-phase induction motor. (2)
- 10.10 Describe the term *normally open* with reference to electromagnetic relays. (2)
- 10.11 Explain the function of the end shield of the motor. (2)
- 10.12 Describe the purpose of using electrical switchgear in three-phase motor-control circuits. (3)

**[30]**

**TOTAL: 200**

**FORMULA SHEET**

$$X_L = 2\pi fL$$

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

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

$$I_T = \sqrt{I_R^2 + (I_C \cong I_L)^2}$$

$$V_T = \sqrt{V_R^2 + (V_C \cong V_L)^2}$$

$$V_R = IR$$

$$V_L = IX_L$$

$$V_C = IX_C$$

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

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

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

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

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

$$P = VI \cos\theta$$

$$S = VI$$

$$Q = VI \sin\theta$$

} Single phase

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

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

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

} Three phase

$$V_L = V_{ph}$$

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

} Delta

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

$$I_L = I_{ph}$$

} Star

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

$$\frac{V_{ph(P)}}{V_{ph(S)}} = \frac{N_P}{N_S} = \frac{I_{ph(S)}}{I_{ph(P)}}$$



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## **NATIONAL SENIOR CERTIFICATE**

**GRADE 12**

**ELECTRICAL TECHNOLOGY**

**NOVEMBER 2013**

**MEMORANDUM**

**MARKS: 200**

**This memorandum consists of 15 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.
  - 2.2 All answers must show the correct unit.
  - 2.3 Alternative methods must be marked.
  - 2.4 Where an erroneous answer is to be carried over to the next step, the first answer will be marked 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      Wind power ✓  
Solar power ✓  
Hydro power  
Wave power  
Geothermal Energy  
(any two)      (2)
- 1.1.2      Coal has a huge negative impact on the environment ✓ and coal is also not a renewable source of energy, at some stage there will be no more coal to burn in SA. ✓  
Coal pollution may also have a negative impact on the health of individuals / society  
(2)
- 1.2      1.2.1      Without electricity a person will not have the opportunity to make use of all the electrical and electronic devices ✓ that are educational and allow for communication therefore retarding a person's progress in education and life. ✓  
(2)
- 1.2.2      The cost ✓ of petrol increases which increase the cost of transporting coal to the power station ✓  
The cost of mining coal increases which increases the cost of generating electricity  
Water resources are becoming scarce and therefore will become expensive increasing cost of generation of electricity  
(This does not only limit the answer to Coal, could include any reference to generation of electricity)  
Archaic energy systems and ineffective energy designs waste energy.  
(2)
- 1.2.3      Without electricity people will have to rely on an alternative source of energy ✓ like wood and other inconvenient and polluting fuels such as coal, paraffin or candles. ✓  
(2)
- [10]**

**QUESTION 2: TECHNOLOGICAL PROCESS**

Consider all possible types of answers related to the answers OR related to the Technological Process as an interpretation thereof.

- 2.1      2.1.1      The input receives the electrical instruction ✓ and feeds into the CPU (central processing unit) ✓  
(2)
- 2.1.2      The processing unit will receive ✓ the input and interpret it and execute it and deliver it to the output ✓  
(2)
- 2.1.3      The output receives the executed instructions ✓ and delivers it to the external devices ✓  
(2)



- 2.1.4 The power supply supplies the processing unit✓ with the power to execute the instructions✓ (2)
- 2.2 To establish that the design specification has been met✓  
To establish the correct operation of the artefact✓ (Any relevant answer) (2)
- [10]**

### QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

- 3.1 Horseplay in the workshop.✓  
Working on a machine which does not have the correct guards or protective devices.✓  
Working with live, open terminals.  
Touching live conductors exposed in the workshop.  
Using incorrect tools in the workshop.  
Using correct tools incorrectly.  
Not using safety equipment/uniform. (Any two) (2)
- 3.2 Earth leakage protective devices.✓  
Emergency stop button. ✓  
Overload relay. ✓  
Fuses  
Circuit breakers  
Stop Button  
Emergency Disconnect Button  
Isolator Switch (Any three) (3)
- 3.3 Any fire extinguisher that uses a non-conductive material such as CO<sub>2</sub> type or powder type. ✓  
Fire bucket with Sand  
Type C Fire Extinguisher  
ABC Dry Chemical (popular)  
Carbon Dioxide (CO<sub>2</sub>)  
Halotron  
Halotron 1211  
High Performance Dry Chemical  
Regular Dry Chemical (1)
- 3.4 Before connecting the meter make sure the power is switched off.✓  
Set the meter to the highest current scale. ✓  
Make sure that the meter is connected in series in the circuit.  
Make sure the leads of the meter are plugged into the correct sockets of the meter.  
Make sure correct scale is used for AC or DC.  
After connecting the meter correctly proceed with the line test.  
Mention of a clamp meter as ammeter is acceptable (Any two) (2)

- 3.5 The workshop must be well ventilated to prevent drowsiness ✓ which may lead to an accident and possible injuries. ✓  
Some work processes may lead to fumes being released which, if not extracted, will cause health problems. (Any one)

(2)  
[10]

**QUESTION 4: THREE-PHASE AC GENERATION**

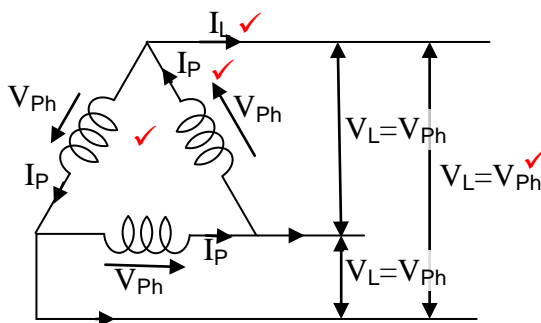
- 4.1 For high power generation the three-phase system is more functional and efficient. ✓  
For generators with the same size frame three-phase machines produce more power than single-phase machines.  
Three-phase generators may be connected in parallel to obtain an increased supply.

Three-phase systems can deliver both three-phase and single-phase power. (Any one)

(1)

If candidate speaks of motor- no penalisation

4.2



(4)

Marks not allocated for Direction of arrows but for the labels.

4.3 4.3.1

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

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

$$= \frac{60 \times 10^3}{\sqrt{3} \times 380 \times 0.85} \quad \checkmark$$

$$= 107.25A \quad \checkmark$$

(3)

- 4.3.2 If the power factor of the load was improved the current drawn by the load will be reduced ✓ while the load and the voltage across the load remains constant. ✓  
The load and the voltage across the load will remain constant; therefore the current drawn by the load will decrease with an improved power factor.  
The circuit Impedance changes.

(2)

[10]

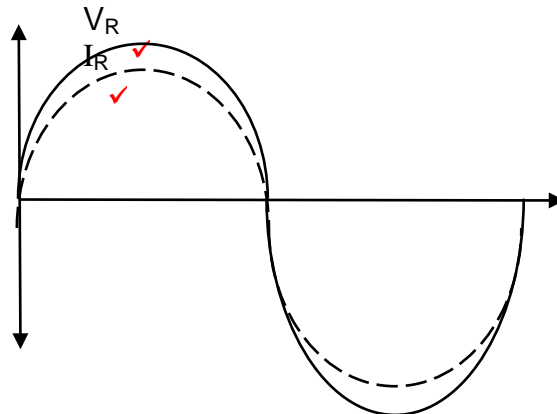
**QUESTION 5: RLC CIRCUITS**

5.1 The frequency of the supply ✓  
 Capacitance of the capacitor ✓  
 Size of the capacitor  
 If physical characteristics as well as capacitance are mentioned – Only one mark as these refer to the same component /factor (2)

5.2 Inductive reactance is the opposition offered ✓ by the inductor to the flow of current in a coil when the coil is connected across an alternating-voltage supply ✓ and it is measured in ohms. (2)  
 If mention is made of resistance – The learner will get 1 Mark Maximum

5.3 If the number of turns of the coil are increased the inductance of the coil will increase ✓ therefore the inductive reactance of the coil will increase. ✓ (2)

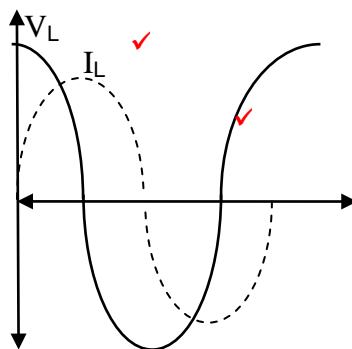
5.4 5.4.1



(Must show that V and I are in phase)

(2)

5.4.2



Must show that I lags V  
 Labelling is important to show lag of the current with respect to the applied voltage.

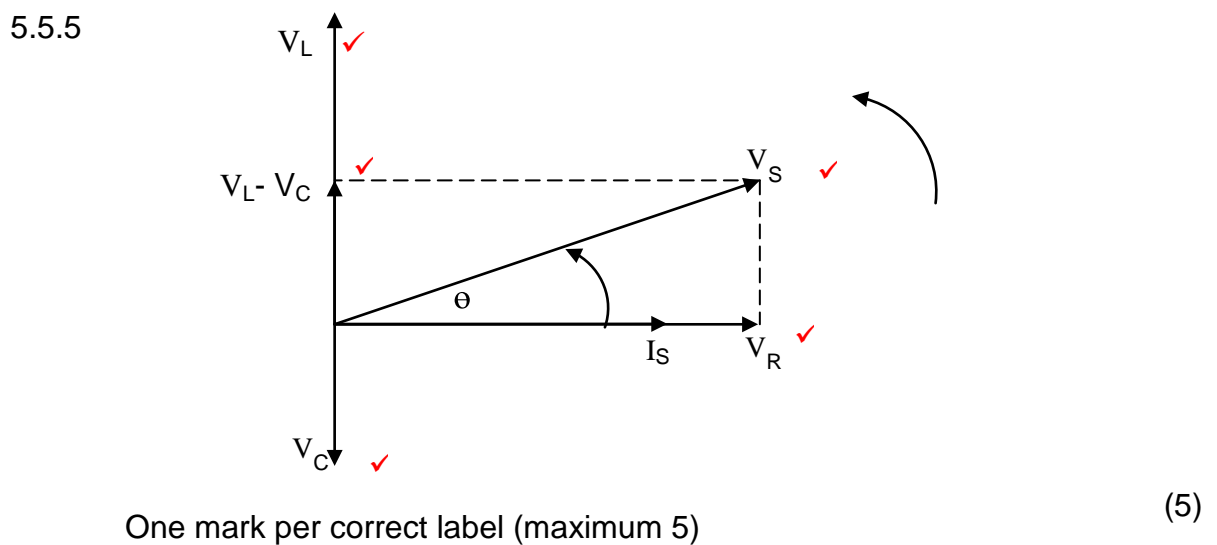
(2)

5.5      5.5.1       $X_L = 2\pi fL$  ✓  
 $= 2 \times \pi \times 50 \times 180 \times 10^{-3}$  ✓  
 $= 56.55 \Omega$  ✓ (3)

5.5.2       $X_C = \frac{1}{2\pi fC}$  ✓  
 $= \frac{1}{2\pi \times 50 \times 200 \times 10^{-6}}$  ✓  
 $= 15.92 \Omega$  ✓ (3)

5.5.3       $Z = \sqrt{R^2 + (X_L - X_C)^2}$  ✓  
 $= \sqrt{10^2 + (56.55 - 15.92)^2}$  ✓  
 $= 41.84 \Omega$  ✓ (3)

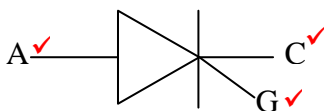
5.5.4       $I = \frac{V}{Z}$  ✓  
 $= \frac{220}{41.84}$  ✓  
 $= 5.26 A$  ✓ (3)



5.6       $I_S = \sqrt{I_R^2 + (I_C - I_L)^2}$  ✓  
 $= \sqrt{1^2 + (2 - 1.5)^2}$  ✓  
 $= 1.12 A$  ✓ (3)  
**[30]**

**QUESTION 6: SWITCHING AND CONTROL CIRCUITS**

6.1



(one mark for correct drawing without labels) (3)

6.2 Speed control of electrical motors ✓  
Lamp dimming of incandescent lamps ✓  
Temperature control of furnaces  
Inverters (Any two) (2)

6.3 A voltage must be applied across the two main terminals of the SCR with the anode made positive ✓ and the cathode negative. ✓ It can now be triggered into conduction by a positive pulse to the gate. ✓ (3)

6.4 The physical size of an SCR is determined by the supply voltage ✓ it will be connected across and the maximum current ✓ that will flow through the device.  
The higher the current, the larger the device should be.  
External environmental heat factors (2)

6.5 A voltage in any direction (of any polarity) ✓ must be applied across the DIAC ✓ this voltage must now be increased to the break-over voltage ✓ of the DIAC, about 30 V to 50 V. The DIAC will now switch on and allow current to flow through it. (3)

6.6 6.6.1 To allow a specific gate voltage ✓ to the gate of the TRIAC to fire it into conduction ✓. OR to prevent transient signals to the gate of the TRIAC and therefore triggering the TRIAC. (2)

6.6.2 The time it takes for the capacitor to fully charge depends upon the value of  $R_2$  ✓ and the value of the capacitor. ✓ The time constant is calculated by  $T=5RC$ . Therefore if  $R_2$  is increased the capacitor will take longer to charge ✓ to the required voltage to trigger the TRIAC into conduction. ✓ The current will therefore flow through the lamp for a shorter period reducing its brightness. ✓ (5)

6.7 6.7.1 When the TRIAC begins to conduct its internal resistance falls ✓ this will result in the voltage drop across the TRIAC dropping ✓ to a lower voltage (almost Zero). ✓  
(The reduction /fall /drop / lowering / decrease of internal resistance is the crux of the question – If no mention is made thereof – only award 2 marks maximum) (3)

6.7.2  $I_H$  is the holding current which is the minimum current ✓ that must flow through the TRIAC to maintain conduction. ✓  
If the current drops below  $I_H$  the TRIAC will stop conducting. (2)

**[25]**

**QUESTION 7: AMPLIFIERS**

7.1 7.1.1 Positive feedback: the output signal ✓ is fed back into the input and added ✓ in phase ✓ to the input signal resulting an increased input signal therefore leading to an increased gain. (3)

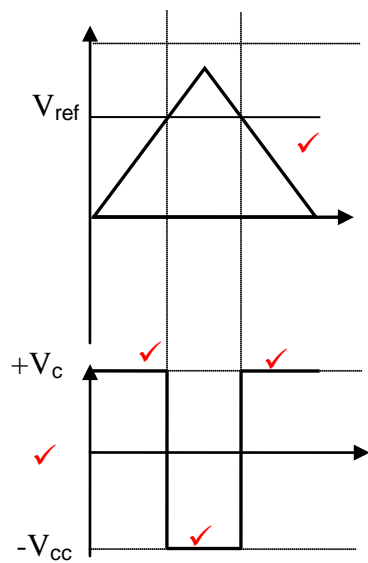
7.1.2 Leads to instability in circuits. ✓  
Causes ring feed (shock oscillation)  
Renders the output therefore unpredictable (Any one) (1)

7.1.3 Design of oscillator circuits to overcome losses of natural oscillation ✓ (1)

7.2 1 - Inverting input ✓  
2 - Non-inverting input ✓  
3 - Output ✓ (3)

7.3 7.3.1 Inverting comparator op-amp ✓ (1)

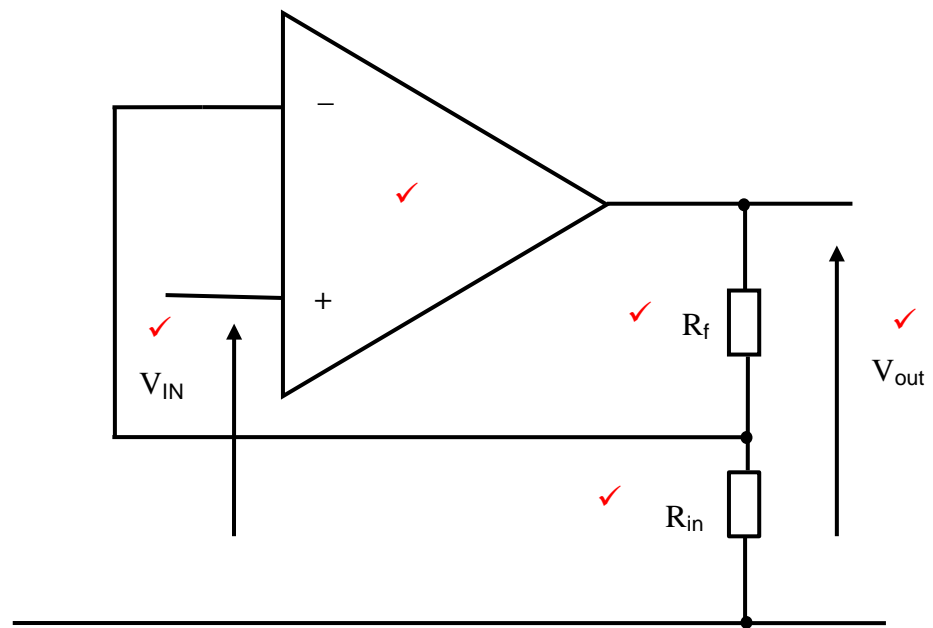
7.3.2



(5)

7.3.3  $V_{ref}$  determines when the output voltage is switched ✓ due to a change in the input voltage ✓ above or below  $V_{ref}$  ✓. (3)

7.4



(5)

7.5 By making  $R_f$  small (zero or short-circuited) and  $R_{in}$  very large

(3)  
[25]

**QUESTION 8: THREE-PHASE TRANSFORMERS**

8.1 To step down the mains voltage in a domestic supply for use in a cellphone charger. ✓  
Any practical application. (1)

8.2 An alternating voltage is connected to the primary winding of the transformer. ✓  
This sets up an alternating current in the primary. ✓  
This sets up a magnetic field that is linked to the secondary winding via a laminated iron core. ✓  
The magnetic field expands outwards and collapses inwards cutting the secondary winding.  
The relative movement between the magnetic field and the secondary winding results in an EMF being induced across the secondary winding. ✓  
Lenz's law.  
The process is due to mutual induction. ✓ (5)

8.3 8.3.1 The input power doubles (increase 100% -same amount) ✓

8.3.2 The current will also double (increase 100% -same amount) ✓

8.3.3 The voltage stays the same ✓

8.4 8.4.1

$$P_{OUT} = \sqrt{3}V_{L(S)}I_{L(S)} \cos \theta$$
$$I_{L(S)} = \frac{P_{OUT}}{\sqrt{3}V_{L(S)} \cos \theta} \quad \checkmark$$
$$= \frac{66 \times 10^3}{\sqrt{3} \times 380 \times 0.85} \quad \checkmark$$
$$= 117.97 \text{ A} \quad \checkmark \quad (3)$$

8.4.2

$$P_{OUT} = P_{IN}$$
$$P_{IN} = \sqrt{3}V_{L(P)}I_{L(P)} \cos \theta$$
$$I_{L(S)} = \frac{P_{IN}}{\sqrt{3}V_{L(P)} \cos \theta} \quad \checkmark$$
$$= \frac{66 \times 10^3}{\sqrt{3} \times 11000 \times 0.85} \quad \checkmark$$
$$= 4.08 \text{ A} \quad \checkmark \quad (3)$$

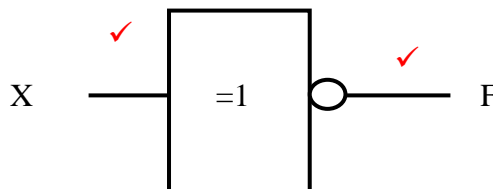
Alternative method using Ratios and Phase Values is acceptable

**[15]**



**QUESTION 9: LOGIC CONCEPTS AND PLCs**

- 9.1 Sequencing of robots ✓  
Control of machinery in factories ✓  
Automation of machinery in assembly lines  
(Any relevant answer) (2)
- 9.2 9.2.1 The program is written ✓ to memory from a device  
( PC ) ✓ OR The programme is stored here (2)  
OR  
(Function of the memory is to store the information ✓ it receives  
during programming process ✓)
- 9.2.2 Execute ✓ the tasks (instructions program) ✓ that were written into (2)  
memory.  
OR  
Process ✓ the information ✓
- 9.2.3 Connecting the input ✓ devices from the electrical circuits to the PLC. (2)  
✓  
OR  
(The function of the input interface is to accept the input signal ✓ and  
feed it into the PLC ✓)
- 9.3 Ladder logic ( LL) ✓  
Instruction list (IL) ✓  
Logic block diagram ( LBD) ✓ (3)  
Flow Diagram  
Function Blocks  
Structured Text
- 9.4 9.4.1 NOT function ✓ (1)
- 9.4.2



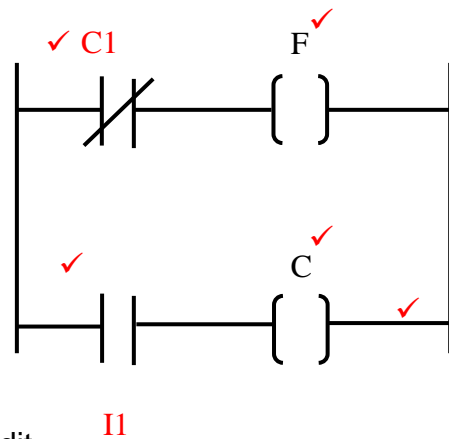
Alternative symbols acceptable (2)  
Any two correct labels

9.4.3

X	F
0	1 ✓
1	0 ✓

9.4.4 Start = I1  
Relay Coil = C  
Relay Contact = C1  
Lamp = F

Can be interpreted either way  
Different labelling techniques  
Acceptable  
Correct answer will receive full credit



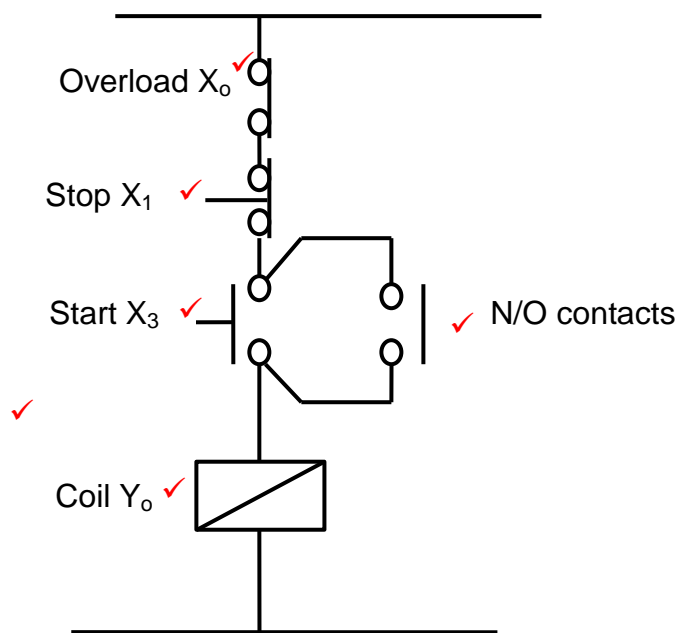
(2)

(5)

9.5 9.5.1 Direct online starter control circuit ✓  
Holding Circuit

(1)

9.5.2



(6)

9.6 9.6.1 The design effort ✓ is simpler ✓ owing to fewer components and easy sequence planning.

(2)

9.6.2 Relay and timer ✓ problems are reduced. ✓  
Fewer Moving Parts  
Solid State

(2)

- 9.6.3 They are much more compact than a relay panel ✓. Mass production is possible by repeat of programs. ✓ (2)  
(Compact – The device takes up less physical space – This has many advantages, reducing cost of manufacturing, using surface mount devices with automated manufacturing)  
Standardised programming approaches and inter product compatibility. Industry standards such as profibus etc.
- 9.7 Counter ✓  
PLC (any other relevant answer) (1)  
**[35]**

**QUESTION 10: THREE-PHASE MOTORS AND CONTROL**

- 10.1 Star connection ✓  
Delta connection ✓ (2)
- 10.2 Insulation resistance between windings test. ✓  
Insulation resistance to earth test. ✓  
Short-circuit or open-circuit test. (3)  
continuity test of the windings ✓
- 10.3 Is the cooling fan intact and turning freely but mounted securely on the motor shaft? ✓  
Does the frame have any cracks or missing parts? ✓  
Are the bearings noisy or feel rough when turning?  
Is the motor mounted securely and are the bolts tightened properly?  
End plates fastened properly? (Any two) (2)
- 10.4 By reversing/swapping the connections of any two of the supply lines to the stator. ✓ (1)
- 10.5 Large power range available ✓  
Self-starting ✓  
Higher starting torque  
More efficient than single-phase motors  
Physically smaller than single-phase motors for the same output (Any two) (2)
- 10.6 10.6.1  $P = \sqrt{3}V_L I_L \cos \theta$   
 $I_L = \frac{P}{\sqrt{3}V_L \cos \theta}$  ✓  
 $= \frac{17000}{\sqrt{3} \times 380 \times 0.8}$  ✓  
 $= 32.29 \text{ A}$  ✓ (3)

$$\begin{aligned}
 10.6.2 \quad S &= \frac{P}{\cos\theta} \checkmark \\
 &= \frac{17000}{0.8} \checkmark \\
 &= 21.25 \text{ kVA} \checkmark
 \end{aligned}$$

**OR**

$$\begin{aligned}
 S &= \sqrt{3} \times V_L \times I_L \\
 &= \sqrt{3} \times 380 \times 32.29 \\
 &= 21.25 \text{ kVA}
 \end{aligned}$$

- 10.7 The casing of the motor is made from a conducting material, earthing it will activate protection under fault conditions  $\checkmark$  preventing electric shock.  $\checkmark$  (3)
- 10.8 Overload unit  $\checkmark$   
 No-volt coil  $\checkmark$   
 Emergency stop buttons  $\checkmark$   
 Circuit breakers  
 Isolator switch  
 MCB  
 Fuse (3)
- (Any three)
- 10.9 Excessive current to the motor.  $\checkmark$   
 Motor not running on all three phases.  $\checkmark$   
 Motor used over long periods without switching and cooling off.  
 Overloading the motor  
 Insufficient ventilation (2)  
 Over and under voltage condition
- (Any two)
- 10.10 Normally open contacts are contacts open in the de-energised state  $\checkmark$  and closed in the energised state.  $\checkmark$  (2)
- 10.11 Protect the fan from damage  $\checkmark$   
 Protect users from injuries  $\checkmark$   
 Force the air over the motor fins for cooling. (2)  
 Take note that the Afrikaans version can be interpreted as an endplate!
- 10.12 The purpose of electrical switchgear is to safely distribute  $\checkmark$  and control electrical energy and provide electrical protection  $\checkmark$  as well protect the operator of the equipment.  $\checkmark$  (3)

**[30]****TOTAL: 200**