basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

# NATIONAL SENIOR CERTIFICATE

## GRADE 12

## ELECTRICAL TECHNOLOGY

## NOVEMBER 2011

**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 unit for all answers of calculations.

7. A formula sheet is provided at the end of this question paper.

8. Write neatly and legibly.

## QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

1.1 List THREE disadvantages of a nuclear power station, based on the recent earthquake in Japan. Refer to the environment. (3)

1.2 The majority of power stations in South Africa are coal fired. Name TWO environmentally friendly alternatives. (2)

1.3 Explain why HIV/Aids can have a negative impact on the workforce of the country. (3)

1.4 State TWO skills that a successful entrepreneur should have. (2)
**[10]**

## QUESTION 2: TECHNOLOGICAL PROCESS

2.1 The technological process has four steps. Describe the following TWO steps with regard to a step-up transformer:

2.1.1 Process (2)

2.1.2 Output (2)

2.2 Describe why it is important to evaluate a completed electrical product against the original design of the product. (3)

2.3 List THREE appropriate methods of marketing a product. (3)
**[10]**

## QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 Name TWO electrical safety devices that protect equipment under fault conditions. (2)

3.2 Fault-finding is done on a motor control panel. Name and describe ONE safety precaution that must be taken before the test is started. (2)

3.3 Explain why no person under the influence of drugs may enter or remain in a workplace where machinery is used. (2)

3.4 Name and describe TWO safety precautions that must be taken when working with portable electrical equipment. (4)
**[10]**

## QUESTION 4: THREE-PHASE AC GENERATION

4.1 Give ONE reason why electricity is generated in three phase and not in single phase. (1)

4.2 Determine the value of the line current if the phase current is 300 A in a delta-connected system.

Given:

$I_{ph} = 300\ A$ (3)

4.3 A small alternator supplies power to a balanced inductive load. The current in each phase of the alternator is 20 A and it lags the voltage by 30°. The phase voltage is 220 V. The coils of the alternator are connected in star.

Given:

$I_{ph} = 20\ A$

$\theta = 30^\circ$

$V_{ph} = 220\ V$

Calculate:

4.3.1 The line voltage (3)

4.3.2 The power supplied by the alternator at full load (3)

**[10]**

## QUESTION 5: RLC CIRCUITS

5.1 State how an increase in frequency will affect the capacitive reactance of a capacitor. (1)

5.2 State how a decrease in frequency will affect the inductive reactance of an inductor. (1)

5.3 Explain the term *impedance* with reference to an RLC circuit. (2)

5.4 Refer to FIGURE 5.1.

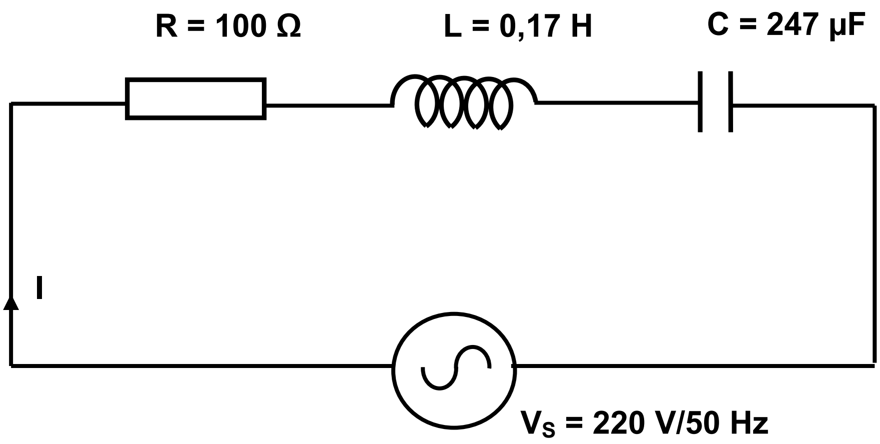


**FIGURE 5.1: RLC SERIES CIRCUIT**

Given:

C= 247 μF

L = 0,17 H

R = 100 Ω

$V_s$ = 220 V

f = 50 Hz

Calculate:

5.4.1 The capacitive reactance of the capacitor (3)

5.4.2 The inductive reactance of the inductor (3)

5.4.3 The impedance of the circuit (3)

5.5 Refer to FIGURE 5.2.

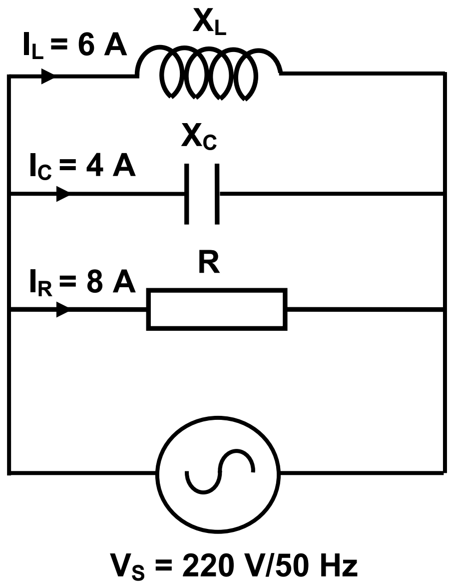


**FIGURE 5.2: RLC PARALLEL CIRCUIT**

Given:

$I_L$ = 6 A

$I_C$ = 4 A

$I_R$ = 8 A

$V_S$ = 220 V

f = 50 Hz

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 resistance of the resistor (3)

5.5.4 The supply current of the circuit (3)

5.6 Draw the phasor diagram of the above circuit. Indicate the direction of rotation. (5)

**[30]**

## QUESTION 6: SWITCHING AND CONTROL CIRCUITS

6.1 The diagram in FIGURE 6.1 shows the characteristic curve of a DIAC.

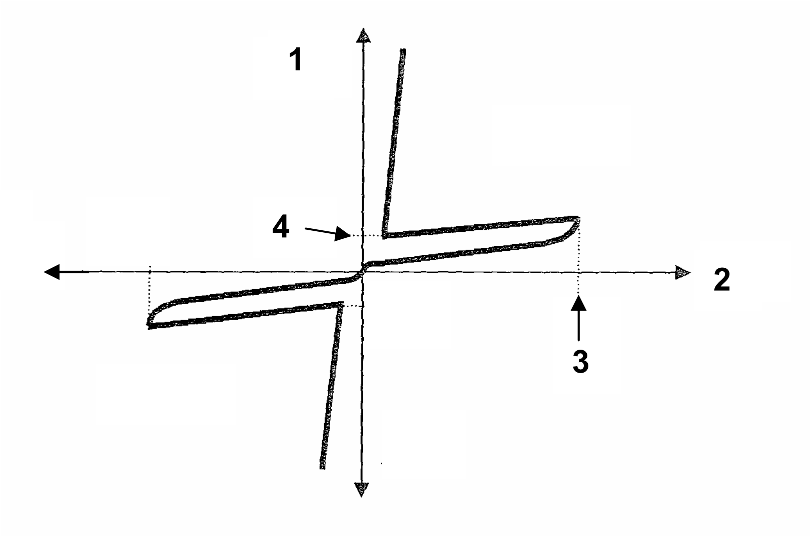


**FIGURE 6.1: CHARACTERISTIC CURVE OF A DIAC**

6.1.1 Name the unit of the axes numbered **1** and **2** and the labels numbered **3** and **4**. (4)

6.1.2 Draw a fully labelled symbol of a DIAC. (2)

6.1.3 With the aid of the characteristic curve shown in FIGURE 6.1, describe how a DIAC is switched on. (4)

6.2 Draw a fully labelled symbol of a TRIAC. (3)

6.3 Describe how a TRIAC is switched on. (3)

6.4 The circuit diagram in FIGURE 6.2 is connected to a 220 V/50 Hz supply. The circuit makes use of a SCR to control the temperature of the soldering iron indicated as resistor $R_3$.

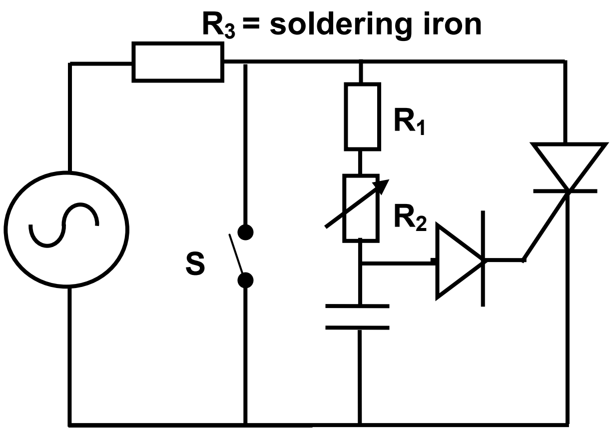


**FIGURE 6.2: TEMPERATURE CONTROL**

6.4.1 If S is closed, what will the voltage across the soldering iron be? (1)

6.4.2 When S is open, the temperature control part of the circuit becomes active. Explain what will happen to the temperature of the soldering iron if the value of $R_2$ is increased. (5)

6.4.3 What disadvantage does an SCR have in AC circuits? (1)

6.5 Explain why the current rating plays an important role in determining the physical size of an SCR. (2)
**[25]**

## QUESTION 7: AMPLIFIERS

7.1 Name TWO applications of an operational amplifier (op amp). (2)

7.2 Name ONE disadvantage of an operational amplifier (op amp). (1)

7.3 List THREE characteristics of an ideal operational amplifier (op amp). (3)

7.4 Describe the term *open loop* with reference to an operational amplifier (op amp). (3)

7.5 Draw the diagram of an operational amplifier (op amp) as an inverting voltage comparator. (5)

7.6 Refer to FIGURE 7.1.

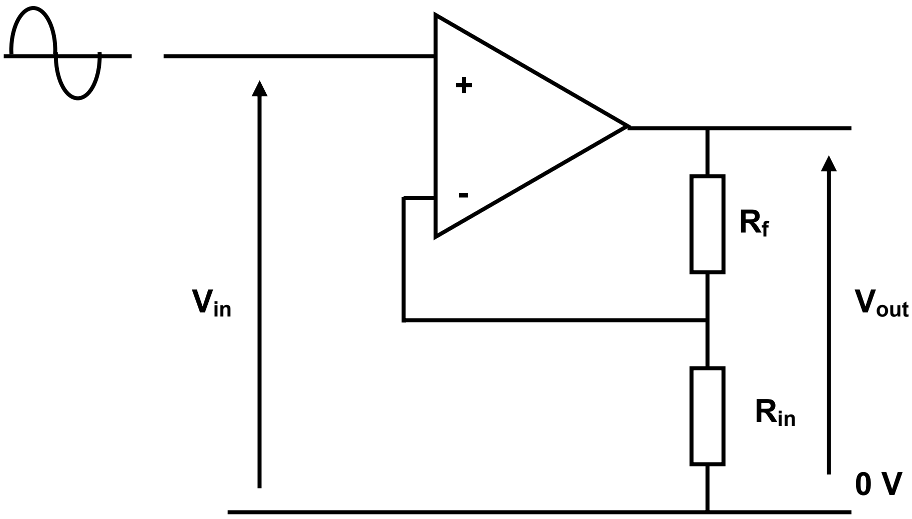


**FIGURE 7.1: OPERATIONAL AMPLIFIER CIRCUIT**

7.6.1 Name the operational amplifier circuit in FIGURE 7.1. (1)

7.6.2 With the given input signal at the non-inverting input, draw both the input and output signals on the same axis. (2)

7.6.3 Explain the function of $R_f$ in the circuit. (3)

7.6.4 Explain what will occur to the gain of the operational amplifier (op amp) if the value of $R_f$ is increased. (3)

7.6.5 What is the function of $R_{in}$ in the circuit? (2)
**[25]**

## QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 Give ONE function of a transformer. (2)

8.2 Name ONE loss that occurs in three-phase transformers. (1)

8.3 A three-phase transformer with a turns ratio of 50 : 1 is connected in delta-star. The supply voltage is 11 kV and the secondary phase current is 450 A.

Given:

Ratio = 50 : 1

$V_{L(P)}$ = 11 kV

$I_{Ph(S)}$ = 450 A

Calculate:

8.3.1 The secondary phase voltage (3)

8.3.2 The secondary line voltage (3)

8.3.3 The primary phase current (3)

8.3.4 The primary line current (3)
**[15]**

**QUESTION 9: LOGIC CONCEPTS AND PLCs**

9.1 What do the letters *PLC* represent? (1)

9.2 Name the FOUR main parts of a PLC. (4)

9.3 Explain the term *program* when referring to a PLC. (3)

9.4 Draw the ladder logic symbol for each of the following:

9.4.1 Normally open switch (1)

9.4.2 Normally closed switch (1)

9.4.3 Relay (1)

9.5 Name THREE advantages of PLCs in comparison to relay control. (3)

9.6 Name THREE basic devices used in programming PLCs. (3)

9.7 Name the THREE programming languages used in programming PLCs. (3)

9.8 With reference to an OR-gate, draw the following:

9.8.1 The logic symbol (2)

9.8.2 The circuit diagram, using two switches and a lamp to simulate the gate operation (4)

9.8.3 The ladder logic diagram (3)

9.9 Draw the ladder logic diagram of the circuit in FIGURE 9.1.

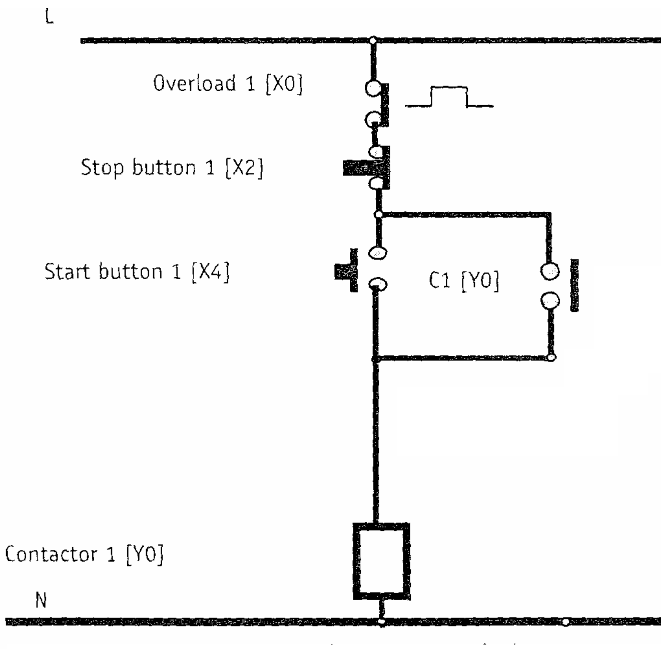


**FIGURE 9.1: DIRECT-ON-LINE STARTER** (6)

**[35]**

## QUESTION 10: THREE-PHASE MOTORS AND CONTROL

10.1 With reference to insulation resistance tests on the stator of a three-phase induction motor:

10.1.1 Name the type of instrument you would use to do the test. (1)

10.1.2 Describe why it is important to test the insulation resistance between the windings and the frame of the motor. (3)

10.1.3 Describe the resistance reading you would expect when measuring between the windings of the motor. (3)

10.1.4 Use the exact lay-out in FIGURE 10.1, redraw the figure and draw in the windings, and then draw the windings connected in star.

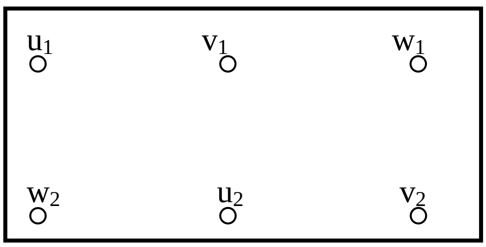


**FIGURE 10.1: TERMINAL BOX OF A THREE-PHASE INDUCTION MOTOR** (3)

10.2 A three-phase 15 kW induction motor is connected in delta to a 380 V/50 Hz supply. The motor is 100% efficient with a power factor of 0,9 at full load.

Given:

P = 15 kW

$V_L$ = 380 V

f = 50 Hz

$\eta$ = 100%

Cos θ = 0,9

Calculate:

10.2.1 The current drawn from the supply (3)

10.2.2 The apparent power of the motor (3)

10.2.3 The phase current of the motor (3)

10.3 Explain why a star-delta starter is used to start three-phase induction motors. (3)

10.4 Name THREE parts of a three-phase induction motor. (3)

10.5 State TWO possible causes of overheating in a three-phase induction motor. (2)

10.6 How are the stator windings spaced in a three-phase induction motor? (1)

10.7 After a motor has been started and is running, what other function does the starter perform? (2)
**[30]**

**TOTAL: 200**

## FORMULA SHEET

$$X_L = 2\pi FL$$

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

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

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

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

$$V_R = IR$$

$$V_L = IX_L$$

$$V_C = IX_C$$

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

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

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

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

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

Single phase:

$$P = VI\cos\theta$$

$$S = VI$$

$$Q = VI\sin\theta$$

Three phase:

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

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

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

Delta:

$$V_L = V_{Ph}$$

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

Star:

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

$$I_L = I_{Ph}$$

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

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

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## 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)

4.2 $I_L = \sqrt{3}\, I_{ph}$ ✓

$= \sqrt{3} \times 300$ ✓

$= 519{,}62\ \text{A}$ ✓ (3)

4.3 4.3.1 Star connection $I_L = I_{Ph} = 20$ A

$V_L = \sqrt{3}\ V_{Ph}$ ✓

$= \sqrt{3} \times 220$ ✓

$= 381{,}1$ V ✓ (3)

4.3.2 $P_T = 3V_{PH} \times I_{PH} Cos\theta$ ✓

$= 3 \times 220 \times 20 \times 0{,}867$ ✓

$= 11{,}49$ kW ✓

**OR**

$P_T = \sqrt{3} V_L \times I_L Cos\theta$

$= \sqrt{3} \times 381{,}1 \times 20 \times 0{,}867$

$= 11{,}49$ kW (3)

**[10]**

## QUESTION 5: RLC CIRCUITS

5.1 The capacitive reactance will decrease. ✓ (1)

5.2 The inductive reactance will decrease. ✓ (1)

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

5.4 5.4.1 $X_C = \frac{1}{2\pi FC}$ ✓

$= \frac{1}{2\pi \times 50 \times 247 \times 10^{-6}}$ ✓

$= 12{,}89\ \Omega$ ✓ (3)

5.4.2 $X_L = 2\pi FL$ ✓

$= 2\pi \times 50 \times 0{,}17$ ✓

$= 53{,}41\ \Omega$ ✓ (3)

5.4.3 $Z = \sqrt{R^2 + (X_L - X_C)^2}$ ✓

$= \sqrt{100^2 + (53{,}41 - 12{,}89)^2}$ ✓

$= 107{,}89\ \Omega$ ✓ (3)

5.5 5.5.1

$$X_L = \frac{V}{I_L} \checkmark$$

$$= \frac{220}{6} \checkmark$$

$$= 36,67\ \Omega \checkmark$$

(3)

5.5.2

$$X_C = \frac{V}{I_C} \checkmark$$

$$= \frac{220}{4} \checkmark$$

$$= 55\ \Omega \checkmark$$

(3)

5.5.3

$$R = \frac{V}{I_R} \checkmark$$

$$= \frac{220}{8} \checkmark$$

$$= 27,5\ \Omega \checkmark$$

(3)

5.5.4

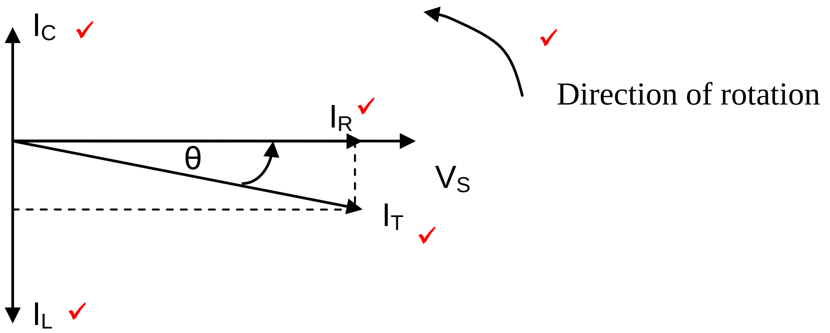
$$I_T = \sqrt{I_R^2 + (I_L - I_C)^2} \checkmark$$

$$= \sqrt{8^2 + (6-4)^2} \checkmark$$

$$= 8,25\ \text{A} \checkmark$$

(3)

5.6




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

(5)

**[30]**

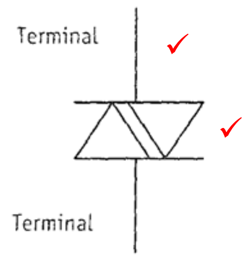
## QUESTION 6: SWITCHING AND CONTROL CIRCUITS

6.1 6.1.1

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

(4)

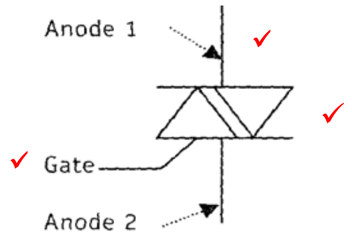
6.1.2




(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

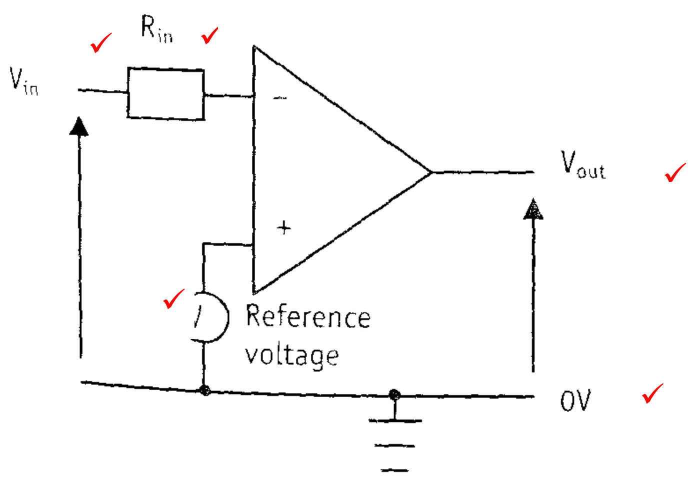
7.1 Linear amplifiers. ✓
Pulse amplifiers. ✓
Buffer circuits
Integrating or
Differentiating or
Summing amplifiers
(Any two) (2)

7.2 Current gain is very small✓
It must be connected to a dual supply with – 15 V to + 15 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

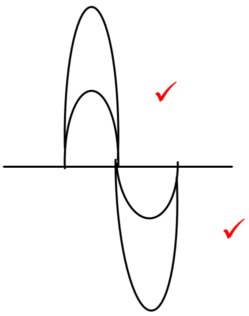



**Op-amp as an inverting voltage comparator**

(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 $V_{L1} = 11kV = 11000\ V$
$I_{P1} = 450\ A$

8.3.1

$$V_{ph(s)} = \frac{V_{Ph(P)} x N_S}{N_P} ✓$$
$$= \frac{11000x1}{50} ✓$$
$$= 220\text{ V} ✓$$

(3)

8.3.2 $V_{L(S)} = \sqrt{3}V_{Ph(S)}$ ✓

$$= \sqrt{3}x220 ✓$$
$$= 380\text{ V} ✓$$

(3)

8.3.3

$$I_{Ph(P)} = \frac{I_{Ph(S)} x N_S}{N_P} ✓$$
$$= \frac{450x1}{50} ✓$$
$$= 9\text{ A} ✓$$

(3)

8.3.4 $I_{L(P)} = \sqrt{3}I_{Ph}$ ✓

$$= \sqrt{3}x9 ✓$$
$$= 15{,}59\text{ A} ✓$$

(3)

**[15]**

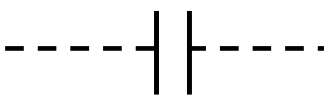
## QUESTION 9: LOGIC CONCEPTS AND PLCs

9.1 Programmable Logic Controller. ✓ (1)

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

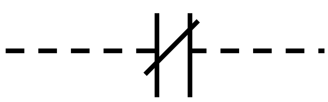
9.3 A series of instructions✓ written in a language✓ that a PLC can recognise and interpret into an output .✓
**OR**
That is language used to program PLCs. (3)

9.4 9.4.1 ✓



(1)

9.4.2



✓

(1)

9.4.3

---[ ]--- ✓

(1)

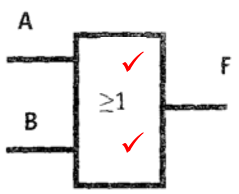
9.5 Economical. ✓
Simplified design. ✓
Quick delivery. ✓
Compact and standardised.
Improved reliability.
Reduced maintenance.
(Any three) (3)

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

(3)

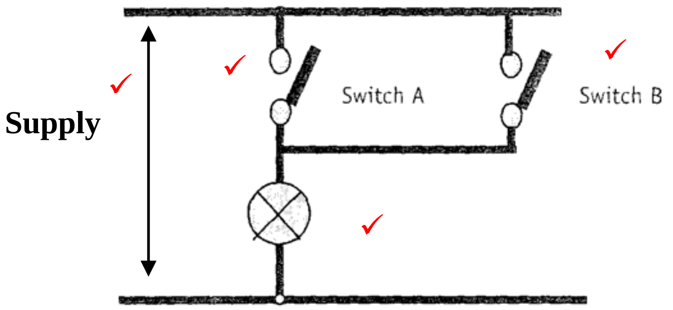
9.7 Ladder logic (LL). ✓
Instruction list (IL). ✓
Logic block diagram (LBD). ✓ (3)
Function Block Diagram (FBD)
Structured Text
Sequential Flow / Function Chart
(Any Three)

9.8 9.8.1




OR-GATE SYMBOL
American Symbols Accepted. (2)

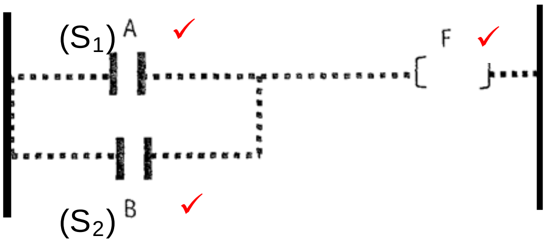
9.8.2




OR-GATE CIRCUIT

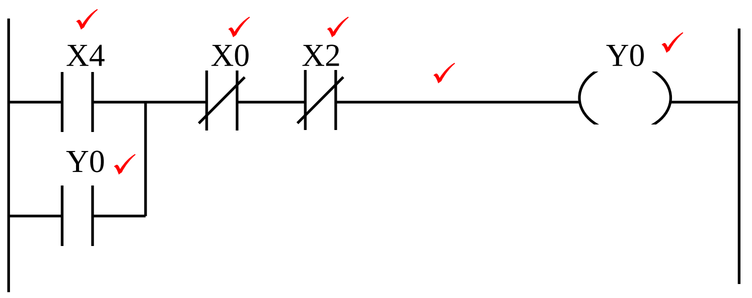
(4)

9.8.3



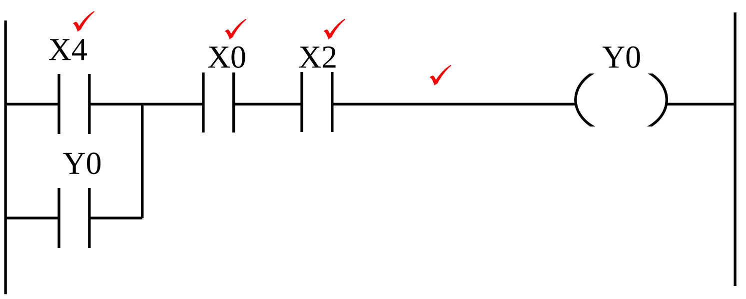

OR-GATE LADDER LOGIC (3)

9.9




(6)

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




**[35]**

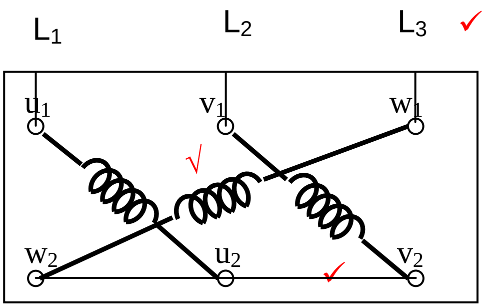
## QUESTION 10: THREE-PHASE MOTORS AND CONTROL

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

$P = \sqrt{3} \times V_L \times I_L \times \text{COS } Ø$

$I_L = P / \sqrt{3} \times V_L \times \text{COS } Ø$ ✓

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

$= 25{,}32$ A ✓ (3)

10.2.2

$S = \frac{P}{Cos\theta}$ ✓

$= \frac{15000}{0{,}9}$ ✓

$= 16{,}67$ kVA ✓

**OR**

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

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

$= 16{,}67$ kVA (3)

10.2.3

$I_{ph} = I_L / \sqrt{3}$ ✓

$= 25{,}32 / \sqrt{3}$ ✓

$= 14{,}62$ 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**