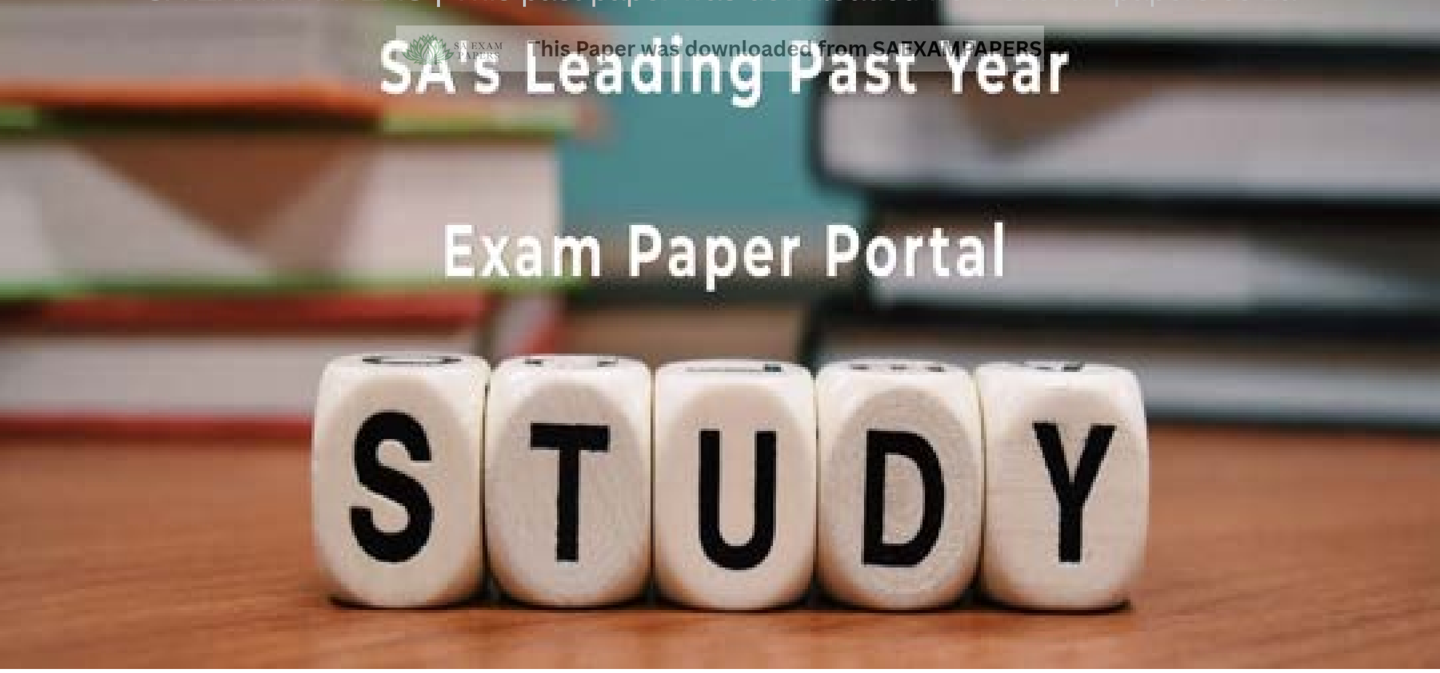
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STUDY

GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

JUNE EXAMINATION
GRADE 12

2026

NAME:	

DATE:	2	0	2	6	–	M	M	–	D	D

SCHOOL:	

SUBJECT:	**ELECTRICAL TECHNOLOGY: POWER SYSTEMS**

ANSWER ALL THE QUESTIONS IN THE QUESTION PAPER.

MARKER					INT. MODERATOR				DIST. MODERATOR				PROV. MODERATOR			
Question	Marks			Marker's code & initials	Marks			IM's code & initials	Marks			DM's code & initials	Marks			PM's code & initials
1																
2																
3																
4																
5																
6																
TOTAL																

TIME: 3 hours

MARKS: 200

44 pages + a 2-page formula sheet

INSTRUCTIONS AND INFORMATION

1. This question paper consists of SIX questions. Answer ALL the questions in the spaces provided.
2. Use the mark allocation as a guide to the length of your answers.
3. Sketches and diagrams must be large, neat and FULLY LABELLED.
4. Show ALL calculations and round-off answers correctly to TWO decimal places.
5. You may use a non-programmable calculator.
6. A FORMULAE SHEET is attached at the end of this question paper.
7. Calculations must include:
   - 7.1 Formulae and manipulation where needed
   - 7.2 Correct replacement values
   - 7.3 Correct answer and relevant units where applicable
8. No pages may be torn from this question paper.
9. Candidates may not retain a question paper or remove it from the examination room. Question papers must be returned to the invigilator at the end of the examination session.
10. Answers must be written in black/blue ink as distinctly as possible. Do NOT write in the margins.
11. Indicate the questions you have answered by drawing a circle around the relevant numbers on the front cover of the question paper where marks are to be recorded.
12. Draw a neat line through any work/rough work that must NOT be marked.
13. In the event that you use the additional space provided:
    - 13.1 Write down the number of the question.
    - 13.2 Leave a line open and rule off after your answer.
14. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Write only the correct answer (A – D) for each of the corresponding questions (1.1 to 1.15) in the box provided.

1.1 The layer(s) of skin that is/are affected by a third-degree burn would be:

A The outer layer
B The second layer
C All layers of the skin
D None of the above (1)

1.2 The power in an inductor is …

A apparent power.
B active power.
C reactive power.
D true power.

1.3 An RLC circuit has a maximum impedance and a minimum current during … resonance.

A series
B parallel
C the frequencies before
D the frequencies after (1)

1.4 The … is the term used for the ratio of the applied voltage to the resulting circuit current where the applied voltage is the resultant of V_R, V_C and V_L in an RLC circuit.

A reactance
B resistance
C impedance
D phase angle (1)

1.5 Self-contained units controlled from the main control centres are called …

A switchgears.
B distribution networks.
C substations.
D power stations.

1.6 Efficiency of electrical systems in industries with large inductive loads causes …

A a high power factor with current leading the voltage.
B a low power factor with current leading the voltage.
C a high power factor with current lagging the voltage.
D a low power factor with current lagging the voltage. (1)

1.7 The apparent power of a delta-connected three-phase system with a line current of 5 A and phase voltage of 300 V is:

A 2 598,08 VA
B 1 500 VA
C 2 598,08 VAR
D 1 500 VAR (1)

1.8 The kWh meter is used to measure the …

A difference in phase between the voltage and current.
B amount of electrical energy consumed.
C power in a circuit.
D time that the power is on in a circuit.

1.9 The function of transformers in distribution networks is to …

A increase the voltages to the required values.
B change the AC voltages to the required dc voltage values.
C reduce the voltage to the required values.
D generate the required voltages.

1.10 The coils of a transformer are wound around a soft iron core to …

A make it more flexible.
B decrease the cost of the transformer.
C improve the magnetic coupling and get maximum power transfer.
D allow it to work with a DC supply. (1)

1.11 The following helps to avoid cogging and reduce magnetic hum:

A An armature
B A skewed rotor
C The stator
D A cooling fan

1.12 A continuity test on the windings of a three-phase induction motor is carried out between ... in the terminal box when the connections between the windings have been removed.

A U_1 and V_1
B V_1 and earth
C U_1 and W_1
D U_1 and V_2 (1)

1.13 The … of a contactor is/are wired into the main/power circuit with reference to motor starters.

A main contacts
B auxiliary contacts
C zero-volt coil
D A1 and A2 terminals (1)

1.14 The ratio of the output power to the input power of a three-phase motor is known as:

A Power factor
B Efficiency
C Slip
D Apparent power (1)

1.15 Starters remain energised after the start button is released because a:

A N/O main contact is connected in parallel with the start button
B N/C main contact is connected in parallel with the start button
C N/O main contact is connected in series with the start button
D N/C main contact is connected in series with the start button (1)
[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1	Name TWO effects that a third-degree burn has on a person's body.	
		(2)

2.2	State TWO actions by an employer that are forbidden, with reference to victimisation.	
		(2)

2.3	Define the term *a non-critical incident*.	
		(2)

2.4	Discuss the general duties that manufacturers perform when designing or manufacturing articles used at work.	
		(2)

2.5	Explain the term *high impact, low probability* with reference to risk analysis.	
		(2)

[10]

QUESTION 3: RLC CIRCUITS

3.1	State the phase relationship between the current and voltage in a pure capacitive AC circuit.	
		(2)

3.2	Name TWO factors that determine the quality factor (Q) of a resonant circuit.	
		(2)

3.3	Define the following with reference to RLC circuits connected across an alternating voltage supply.	
	3.3.1 Phasor diagram	
		(2)

	3.3.2 Resonant frequency	
		(2)

3.4 Draw a fully labelled cycle of the waveforms representing the phasor diagram in FIGURE 3.4.

FIGURE 3.4: VOLTAGE AND CURRENT PHASOR DIAGRAM

(3)

3.5 A series RLC circuit has a resistance of unknown value, a capacitor with a capacitance of 200 μF and an inductor with a reactance of 31,55 Ω connected to a 110 V/60 Hz AC supply. The impedance of the circuit is 101,65 Ω.

Given:

$C = 200\ \mu F$
$X_L = 31,55\ \Omega$
$V_T = 110\ V$
$f = 60\ Hz$
$Z = 101,65\ \Omega$

Calculate the:

3.5.1 Capacitive reactance (3)

3.5.2 Current flowing through the circuit (3)

	3.5.3	Value of the resistance in the circuit	
			(3)

	3.5.4	Inductance of the inductor	
			(3)

3.6 Refer to FIGURE 3.6 below and answer the questions that follow.

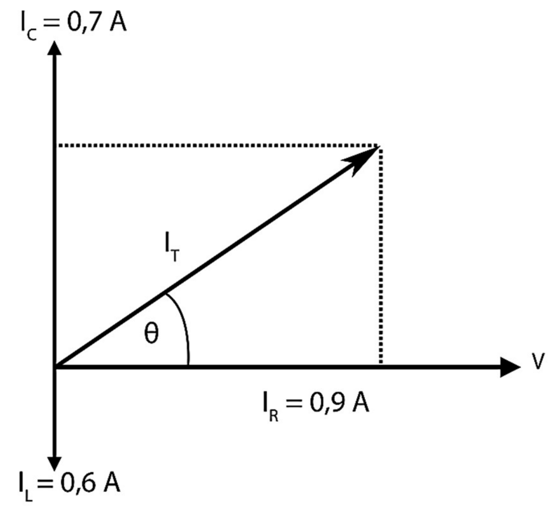

FIGURE 3.6: PARALLEL RLC PHASOR DIAGRAM

Given:

$I_C = 0,7$ A
$I_R = 0,9$ A
$I_L = 0,6$ A

Calculate the:

	3.6.1	Total current flowing through the circuit	
			(3)

	3.6.2	Voltage if the resistance has a value of 120 Ω	
			(3)

	3.6.3	Total impedance of the circuit	
			(3)

	3.6.4	Phase-angle and state whether the current is leading or lagging the voltage	
			(4)

3.7	Define *the selectivity* of a resonant circuit.	
		(2)

3.8 FIGURE 3.8 below shows the current vs frequency response curves of a series resonant circuit with a variable resistor. The inductive reactance of the circuit is 1 500 Ω at resonance and each response curve is for a different resistance value.

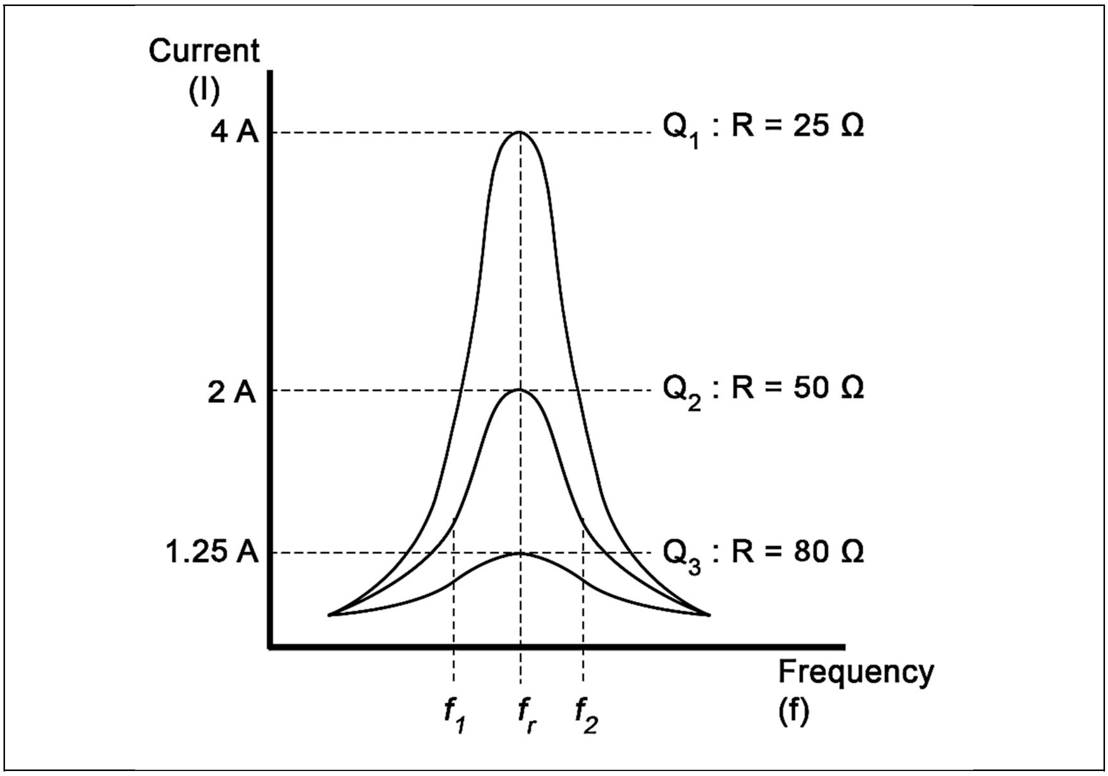

FIGURE 3.8: FREQUENCY RESPONSE

Given:

X_L = 1 500 Ω

	3.8.1	State how a decrease in resistance affects the Q-factor of the circuit.	
			(1)

	3.8.2	Calculate the Q-factor when R = 50 Ω.	
			(3)

	3.8.3	Calculate the resonant frequency when f_1 = 1 000 Hz and f_2 = 2 000 Hz.	
			(3)

[45]

QUESTION 4: THREE-PHASE AC GENERATION

4.1	State TWO reasons why an industrial consumer would prefer a three-phase supply rather than a single-phase supply.	
		(2)

4.2	Name TWO advantages of power factor correction.	
		(2)

4.3	Name the device used by the supplier to improve the power factor.	
		(1)

4.4	Explain the term *line voltage* in a three-phase supply system.	
		(2)

4.5	Draw a diagrammatic representation of a delta connection.	
		(4)

4.6	Answer the following questions which relate to electricity generation at power stations in South Africa		
	4.6.1	State the voltage and frequency at which electricity is generated in South Africa.	(2)
	4.6.2	Explain the function of a kilowatt-hour meter.	(2)
4.7	The input power to a three-phase system is 4 kW. The system produces 3,8 kW effective power on the output. Calculate the efficiency of the system.		(3)

4.8	Explain how both household and industrial loads can be powered by a step-down transformer.	
		(2)

4.9	Explain how transformers reduce copper losses in transmission lines.	
		(2)

4.10 A three-phase generator supplies power to a star-connected load. The phase voltage of the load is 230 V with a line current of 35 amps. The phase angle is 18°.

Given:

V_{ph} = 230 V
I_L = 35 A
θ = 18°

Calculate the:

	4.10.1	Line voltage	
			(3)

	4.10.2	Active power	
			(3)

4.11 A 180 kW three-phase delta-connected load is powered by a 200 kVA generator. The line voltage is 400 V.

Given:

S = 200 kVA
V_L = 400 V
P = 180 kW

Calculate the:

	4.11.1	Line current	
			(3)

	4.11.2	Phase current	
			(3)

	4.11.3	Power factor	
			(3)

	4.11.4	Reactive power	
			(3)

[40]

QUESTION 5: THREE-PHASE TRANSFORMERS

5.1	Name TWO types of transformer core constructions used in three-phase transformers.	
		(2)

5.2	Name TWO factors that can contribute to excessive heating in a three-phase transformer.	
		(2)

5.3	Single-phase transformers can be used to create a three-phase transformer unit. Answer the questions that follow.

	5.3.1	List THREE characteristics of single-phase transformers that must be identical.	
			(3)

	5.3.2	Name the connection on the secondary side of a three-phase transformer that creates a neutral point.	
			(1)

5.4	Transformers generate much heat during normal operation and therefore require cooling systems. Answer the questions that follow.		
	5.4.1	The cooling of transformers can be divided into two categories. Name the TWO categories.	
			(2)
	5.4.2	Name the protection device that monitors gas formation in high-power transformers.	
			(1)
5.5	Briefly describe the principle on which a transformer operates.		
			(2)
5.6	State THREE applications of a transformer.		
			(3)

5.7 FIGURE 5.7 below shows a three-phase delta-star transformer.

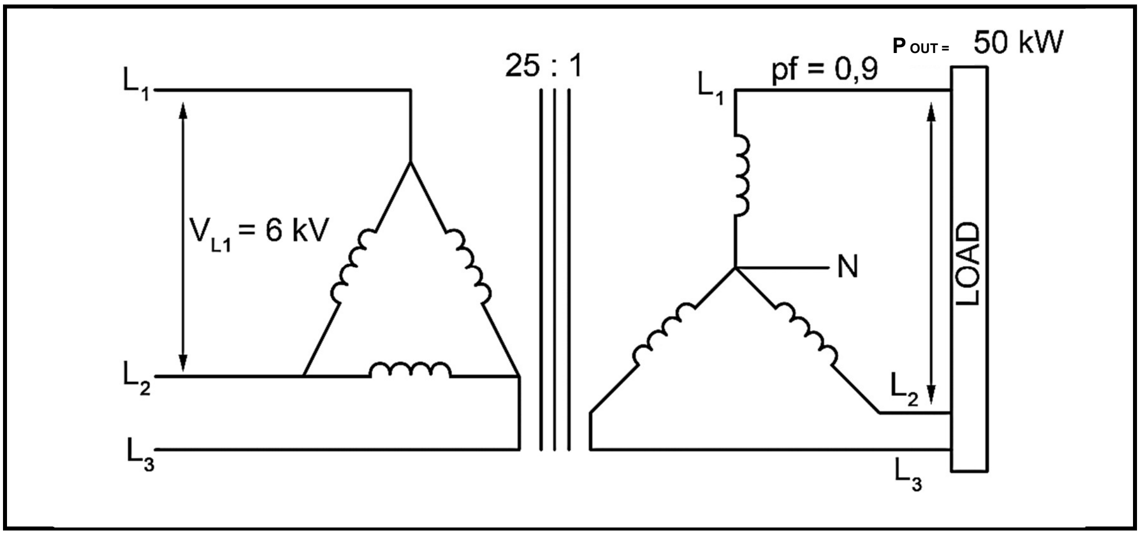

FIGURE 5.7 THREE-PHASE DELTA-STAR TRANSFORMER

Given:

V_{L1} = 6 kV
TR = 25 : 1
P_{out} = 50 kW
pf = 0,9

Calculate the:

5.7.1 Secondary phase voltage (3)

	5.7.2	Secondary line voltage	
			(3)

	5.7.3	Apparent power	
			(3)

	5.7.4	Primary line current	
			(4)

5.8 FIGURE 5.8 below shows a 200 kVA three-phase transformer. The primary line voltage is 6 kV and the secondary line voltage is 380 V with 80 turns on the secondary side.

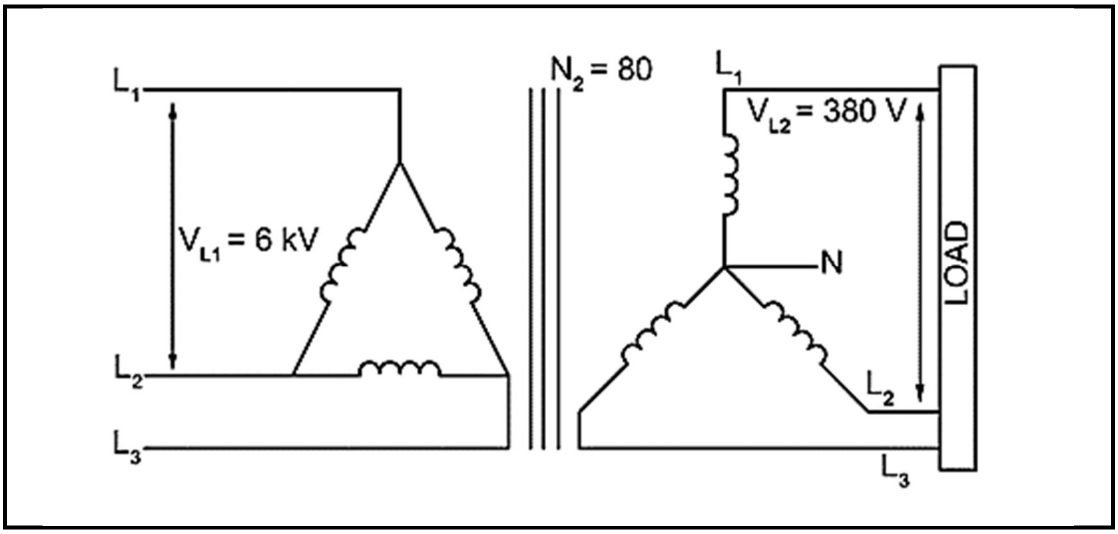

FIGURE 5.8 THREE-PHASE TRANSFORMER

Given:

S = 200 kVA
V_{L1} = 6 kV
V_{L2} = 380 V
N_2 = 80

Calculate the:

	5.8.1	Secondary phase voltage	
			(3)

5.8.2	Number of primary turns	
		(3)

5.8.3	Turn ratio	
		(3)

5.9	Describe how insulation failure is controlled in dry-type transformers.	
		(2)

[40]

QUESTION 6: THREE-PHASE MOTORS AND STARTERS

6.1	Name TWO rotating parts of a three-phase induction motor.	
		(2)

6.2	Name TWO tests that you would perform on an AC motor before installing it.	
		(2)

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

6.4 FIGURE 6.4 below shows how the coils of a three-phase induction motor are placed in a stator. Answer the questions that follow.

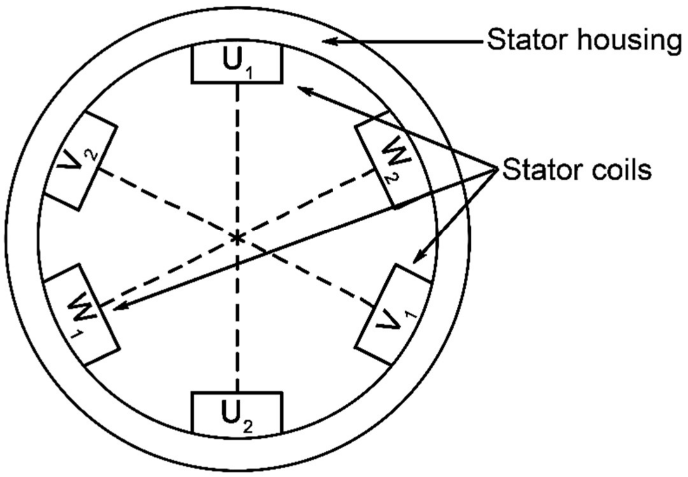

FIGURE 6.4: THREE-PHASE STATOR

	6.4.1	State why a squirrel-cage motor is less of a fire hazard (explosion-proof).	
			(2)

	6.4.2	Determine the angle between coil U_1 and coil V_1.	
			(1)

	6.4.3	Explain how a rotating magnetic field is created when a three-phase supply is connected to the stator windings.	
			(4)

6.5 The table below represents the results of two types of electrical tests performed on a three-phase motor. Study the table below and answer the questions that follow.

TEST	RESULTS	TEST	RESULTS	TEST	RESULTS
U_1 - U_2	42 Ω	U_1 - E	∞	U_2 - E	∞
V_1 - V_2	∞	V_1 - E	∞	V_2 - E	0 Ω
W_1 - W_2	42 Ω	W_1 - E	∞	W_2 - E	∞

TABLE 6.5

	6.5.1	Name the TWO types of tests that were performed.	
			(2)

	6.5.2	Explain, with reasons, whether the motor is suitable for installation in industry.	
			(3)

6.6	Describe why it is necessary to have protective devices as part of motor control.	
		(2)

6.7 Explain what occurs to the three-phase induction motor if one phase fails.

(3)

6.8 Refer to TABLE 6.8 below and answer the questions that follow.

VOLTS	380 V	Full load speed	3 000 rpm
PHASE	3	Cos θ	0,8
CURRENT	24 A	kW	10
FREQUENCY	50 Hz	Model no.	12 341 A

TABLE 6.8: MOTOR NAMEPLATE

6.8.1 State whether the motor is suitable for South African commercial consumers.

(1)

	6.8.2	Calculate the input power of the motor.	
			(3)

	6.8.3	Calculate the efficiency of the motor.	
			(3)

	6.8.4	Calculate the synchronous speed if the slip is 4%.	
			(3)

6.9 A delta-connected three-phase motor with an input power of 9 kW draws 16 A when connected to the supply. The motor has a power factor of 0,85 and an efficiency of 90%.

Given:

P_{INPUT} = 9 kW
I_L = 16 A
Cos θ = 0,85
η = 90%

Calculate the:

	6.9.1	Line voltage of the motor	
			(3)

	6.9.2	Output power of the motor	
			(3)

	6.9.3	Reactive power at the phase angle of 31,79°	
			(3)

6.10 Refer to FIGURE 6.10 below and answer the questions that follow.

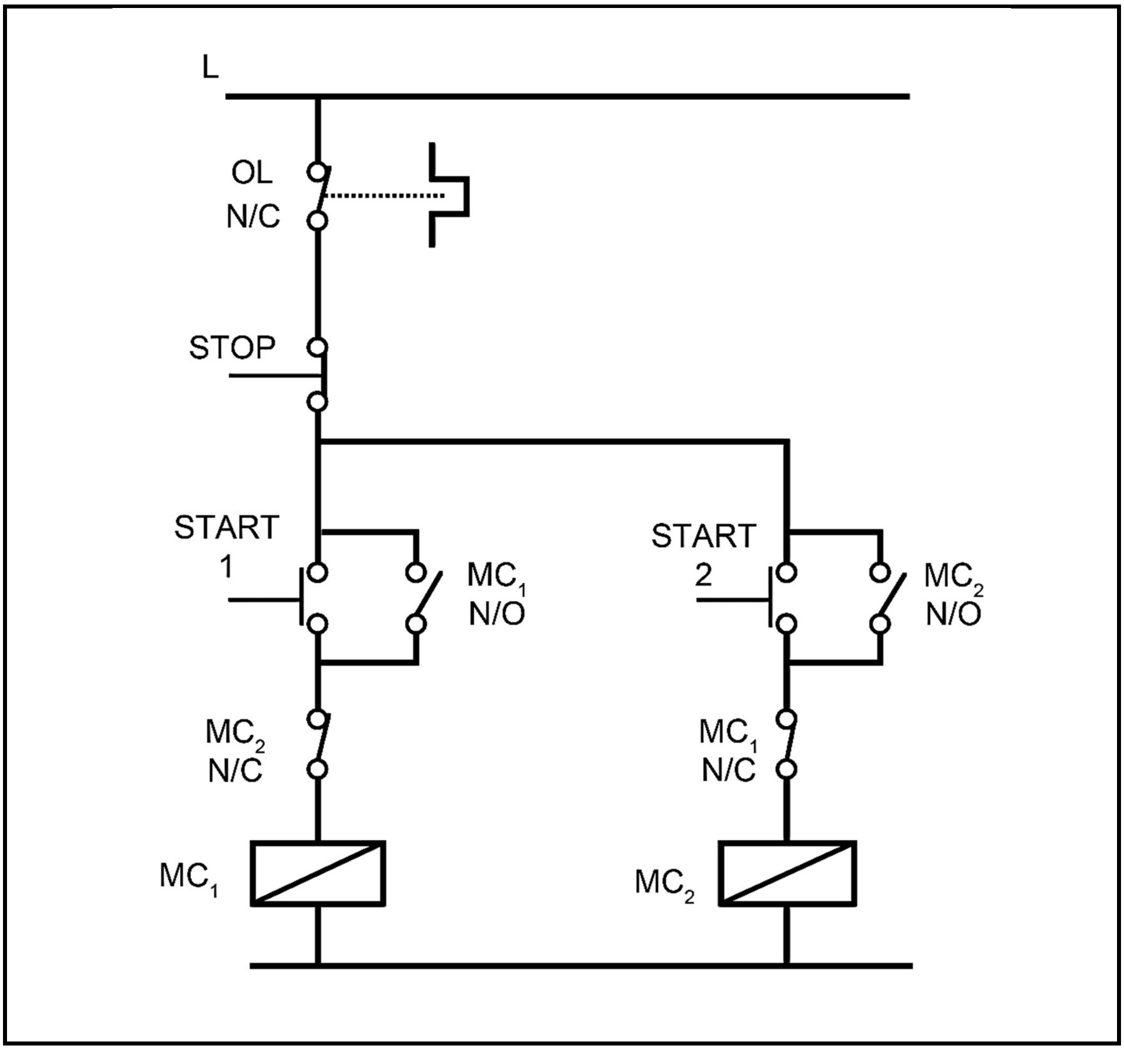

FIGURE 6.10: MOTOR CONTROL CIRCUIT

	6.10.1	Name the contacts that create the interlocking function of the circuit in FIGURE 6.10 above.	
			(2)

	6.10.2	Explain why a normally closed contact of the overload is used and not a normally open contact.	
			(3)

	6.10.3	Refer to the control mechanisms in the control circuit and explain why MC_2 cannot be energised at the same time as MC_1.	
			(2)

[50]

Additional space	

Additional space	

TOTAL: 200

END

FORMULA SHEET

RLC circuits

$P = V \times I \times Cos\,\theta$

$X_L = 2\pi f L$

$X_C = \frac{1}{2\pi f C}$

$f_r = \frac{1}{2\pi\sqrt{LC}}$ **OR** $f_r = \frac{f_1 + f_2}{2}$

$BW = \frac{f_r}{Q}$ **OR** $BW = f_2 - f_1$

SERIES

$V_R = IR$

$V_L = IX_L$

$V_C = IX_C$

$I_T = \frac{V_T}{Z}$ **OR** $I_T = I_R = I_C = I_L$

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

$V_T = \sqrt{{V_R}^2 + (V_L - V_C)^2}$ **OR** $V_T = IZ$

$Cos\theta = \frac{R}{Z}$ **OR** $Cos\,\theta = \frac{V_R}{V_T}$

$Q = \frac{X_L}{R} = \frac{X_C}{R} = \frac{V_L}{V_T} = \frac{V_C}{V_T} = \frac{1}{R}\sqrt{\frac{L}{C}}$

PARALLEL

$V_T = V_R = V_L = V_C$

$I_R = \frac{V_T}{R}$

$I_C = \frac{V_T}{X_C}$

$I_L = \frac{V_T}{X_L}$

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

$Z = \frac{V_T}{I_T}$

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

$Q = \frac{R}{X_L} = \frac{R}{X_C}$

THREE-PHASE AC GENERATION

STAR

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

$V_{PH} = I_{PH} \times Z_{PH}$

$I_L = I_{PH}$

DELTA

$V_L = V_{PH}$

$V_{PH} = I_{PH} \times Z_{PH}$

$I_L = \sqrt{3}\,I_{PH}$

POWER

$S\ (P_{app}) = \sqrt{3}\,V_L\,I_L$

$Q\ (P_r) = \sqrt{3}\,V_L\,I_L\,Sin\,\theta$

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

$Cos\,\theta = \frac{P}{S}$

EFFICIENCY

$\eta = \frac{P_{OUT}}{P_{IN}} \times 100$

TWO-WATTMETER METHOD

$P_T = P_1 + P_2$

$Tan\,\theta = \sqrt{3}\left(\frac{P_1 - P_2}{P_1 + P_2}\right)$

THREE-WATTMETER METHOD

$P_T = P_1 + P_2 + P_3$

THREE-PHASE TRANSFORMERS	THREE-PHASE MOTORS AND STARTERS
STAR	**STAR**
$V_L = \sqrt{3}V_{PH}$ $I_L = I_{PH}$	$V_L = \sqrt{3}V_{PH}$ $I_L = I_{PH}$
DELTA	**DELTA**
$V_L = V_{PH}$ $I_L = \sqrt{3}I_{PH}$	$V_L = V_{PH}$ $I_L = \sqrt{3}I_{PH}$
POWER	**POWER**
$S\ (P_{app}) = \sqrt{3}\ V_L\ I_L$ $Q\ (P_r) = \sqrt{3}\ V_L\ I_L Sin\ \Theta$ $P = \sqrt{3}\ V_L\ I_L Cos\ \Theta$ $Cos\ \Theta = \frac{P}{S}$ $\frac{V_{ph(1)}}{V_{ph(2)}} = \frac{N_1}{N_2} = \frac{I_{ph(1)}}{I_{ph(2)}}$ $TR = \frac{N_1}{N_2}$	$S\ (P_{app}) = \sqrt{3}\ V_L\ I_L$ $Q\ (P_r) = \sqrt{3}\ V_L\ I_L Sin\ \Theta$ $P = \sqrt{3}\ V_L\ I_L Cos\ \Theta$ $P = \sqrt{3}\ V_L\ I_L Cos\ \Theta\ \eta$ $Cos\ \Theta = \frac{P}{S}$
	EFFICIENCY
	$\eta = \frac{P_{IN} - losses}{P_{IN}} \times 100$ $\eta = \frac{P_{OUT}}{P_{OUT} + loss} \times 100$ $\eta = \frac{P_{OUT}}{P_{IN}} \times 100$ $n_s = \frac{60 \times f}{p}$ $\%\ slip = \frac{n_s - n_r}{n_s} \times 100$
	SPEED
	$p = \frac{poles\ per\ phase}{2}$ $n_s = \frac{60 \text{ x } f}{p}$ $Per\ Unit\ Slip = \frac{n_s - n_r}{n_s}$ $\%\ Slip = \frac{n_s - n_r}{n_s} \text{ x } 100$ $n_r = n_s(1 - \%\ slip)$ $Slip = n_s - n_r$

GAUTENG PROVINCE
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REPUBLIC OF SOUTH AFRICA

JUNE EXAMINATION
GRADE 12

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ELECTRICAL TECHNOLOGY: POWER SYSTEMS

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