



# higher education & training

Department:  
Higher Education and Training  
**REPUBLIC OF SOUTH AFRICA**

## **NATIONAL CERTIFICATE (VOCATIONAL)**

### **ELECTRICAL PRINCIPLES AND PRACTICE NQF LEVEL 4**

(12041004)

**1 December 2020 (X-paper)  
09:00–12:00**

**This question paper consists of 6 pages and a formula sheet of 3 pages.**

143Q1N2001

**TIME: 3 HOURS**  
**MARKS: 100**

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**INSTRUCTIONS AND INFORMATION**

1. Answer all the questions.
  2. Read all the questions carefully.
  3. Number the answers according to the numbering system used in this question paper.
  4. Write neatly and legibly.
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**QUESTION 1**

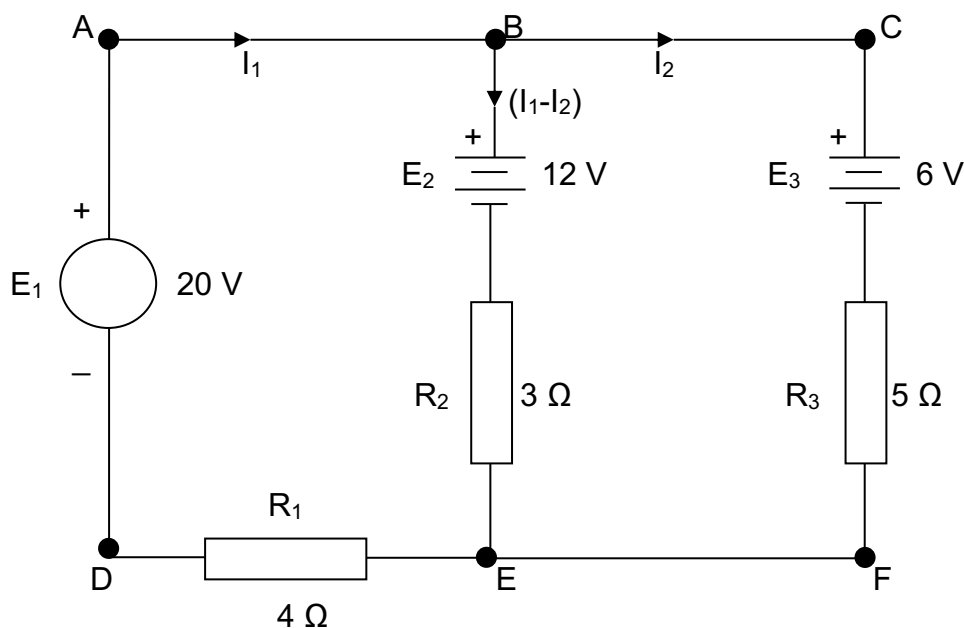
1.1 You are required to conduct an insulation resistance test on a domestic distribution board.



Explain how you should connect an insulation resistance tester to ensure that the live conductor and the neutral conductor are properly insulated.

(1)

1.2 Apply Kirchhoff's laws to the DIAGRAM below to determine the values of currents  $I_1$  and  $I_2$  (use Loop ABEDA and Loop ACFDA).



**DIAGRAM**

(10)

1.3 Explain how to connect the coils of a wattmeter in a single-phase circuit.

(2)

1.4 An alternating voltage is represented by  $v = 50 \sin (200\pi t - 0,75)$  volts.

Determine each of the following:

1.4.1 Peak-to-peak value

(1)

1.4.2 RMS value



(2)

1.4.3 Periodic time

(2)

1.4.4 Value of the voltage if  $t = 5 \text{ m/s}$

(3)

1.5 The resistance of a resistor can be measured using the voltmeter-ammeter method.

Name and explain TWO different methods of connecting these instruments to affect a high and a low resistance measurement. (2 × 2) (4)

1.6 Instruments transformers are only used in AC circuits. 

1.6.1 Name TWO types of measuring instruments used by instrument transformers. (2)

1.6.2 Which type of an instrument transformer is a step-up transformer? (1)


1.7 In an AC circuits, how does the frequency affect the reactance of the inductor and capacitor respectively. (2)

[30]

## QUESTION 2

2.1 Explain how electrical energy is generated using *nuclear energy*. (4)


2.2 Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–F) next to the question number (2.2.1–2.2.3) in the ANSWER BOOK.

COLUMN A		COLUMN B	
2.2.1	Common means of supporting conductors on poles	A	circuit breaker
2.2.2	Pieces of wire used to attach conductors to insulators on overhead systems	B	switchgear
2.2.3	Used to protect, control and monitor low-voltage distribution systems	C	ties 
		D	strut
		E	transformer
		F	cross arms

(3 × 1)

(3)

2.3 A star connected three-phase motor is supplied by 400 V and draws a current of 20 amperes at a power factor of 0,8 lagging.

Calculate the following: 

2.3.1 The phase voltage (2)

2.3.2 The input power to the motor (3)

2.4 Complete the following sentences by filling in the missing word or words. Write only the word or words next to the question number (2.4.1–2.4.3) in the ANSWER BOOK

2.4.1 In a star connection, the line voltage ... the respective phase by  $30^\circ$ .

2.4.2 In a delta connection, the line current ... the respective phase current by  $30^\circ$ .



2.4.3 A ... system allows the use of two different voltages from all three phases. (3 × 1)

(3)  
[15]

### QUESTION 3

3.1 Define the following terms used in earthing:

3.1.1 Earth

3.1.2 Continuity conductor

3.1.3 Earthed



(3 × 2) (6)

3.2 Explain how a single-phase earth-leakage relay will operate when the predetermined value of 30 mA is exceeded. (5)

3.3 Explain how to earth a stove. (1)

3.4 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (3.4.1–3.4.3) in the ANSWER BOOK.

3.4.1 The sensitivity of an earth-leakage tester can be determined by an insulation resistance tester.



3.4.2 The earth leakage protection device disconnects one phase in a single-phase system.





3.4.3 Up to the point of supply only TN-C-S and TN-S earthing systems are permitted in South Africa.


(3 × 1) (3)  
[15]

**QUESTION 4**

- 4.1 Briefly explain how eddy-current losses affects the efficiency of a transformer. (3)
- 4.2 Discuss the conditions for maximum efficiency of a transformer.  (1)
- 4.3 Three single-phase transformers, each with a winding ratio of 20:1, are connected in delta-star to a 6,6-kV supply. The secondary phase current is 240 amperes.
- Calculate each of the following:
- 4.3.1 Secondary line voltage (4)
- 4.3.2 Primary line current (4)
- 4.3.3 Rating of transformer in kVA (3)
- 4.4 Explain why a shell-core transformer can offer high efficiency in a transformer. (2)
- 4.5 A transformer has an input power of 9 kW.  Calculate the efficiency of the transformer when it delivers an output power of 7.2 kW. (2)
- 4.6 Which type of losses in a transformer result from domain in the core having to realign themselves during each cycle of an alternating current? (1)
- [20]**

**QUESTION 5**

- 5.1 State FOUR factors affecting the performance of induction motors. (4)
- 5.2 Draw the characteristic curves of a cumulative compound motor and a differential compound motor, clearly showing the speed against armature current.  (4)
- 5.3 List FOUR parameters that can be determined using a blocked rotor test on an induction motor. (4)
- 5.4 Complete the following sentences by writing only the missing word or words next to the question number (5.4.1–5.4.3) in the ANSWER BOOK
- 5.4.1 A compound motor has two field coils, namely ... field coil and ... field coil. (2)
- 5.4.2 To reverse the direction of rotation of a DC motor, the rule is to reverse the connections of either the ... or the ....but not both.  (2)
- 5.4.3 A magnetic or ... overload protection device safeguards a motor against excessive circuit. (1)

5.5 Name TWO conditions in which the no-volt protection device will protect the motor against damage.  (2)

5.6 Which type of a compound motor has a series winding connected to aid the shunt winding? (1)  
**[20]**

**TOTAL: 100**

## ELECTRICAL PRINCIPLES AND PRACTICE L4

## FORMULA SHEET

- |     |   |    |   |
|-----|---|----|---|
| 1.  | $\cos \phi = \frac{R}{Z}$   | 16 | $\tan \phi = \sqrt{3} \left( \frac{W_1 - W_2}{W_1 + W_2} \right)$ |
| 2.  | $P = V I \cos \phi$   | 17 | $E = V + I r$   |
| 3.  | $Q = V I \sin \phi$   | 18 | $V = I R$   |
| 4.  | $S = V I$   | 19 | $R = \frac{\rho l}{A}$  |
| 5.  | $V_1 = \left( \frac{R_1}{R_t} \right) V_T$  | 20 | $R_t = R_0(1 + \alpha t)$   |
| 6.  | $I_1 = \left( \frac{R_2}{R_1 + R_2} \right) I_T$  | 21 | $R_t = R_0[1 + \alpha_0(t - \phi)]$                               |
| 7.  | $R_T = R_1 + R_2 + R_3 + \dots + R_n$   | 22 | $P = V I$   |
| 8.  | $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}$ | 23 | $E = I^2 R t$   |
| 9.  | $\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$                                   | 24 | $\eta = \frac{P_o}{P_{in}} \times 100$                            |
| 10. | $V_L = \sqrt{3} V p h$  | 25 | $X_L = 2\pi f L$  |
| 11. | $E = V - I_a R_a$   | 26 | $X_C = \frac{1}{2\pi f C}$  |
| 12. | $n_s = \frac{f}{p}$   | 27 | $Z = \sqrt{R^2 + (X_L - X_C)^2}$                                  |
| 13. | $S = \frac{N_s - N_r}{N_s}$   | 28 | $Mmf = N I$   |
| 14. | $R_{sh} = \frac{I_m R_m}{I_{sh}}$   | 29 | $H = \frac{Mmf}{l}$   |
| 15. | $R_{se} = \frac{V_t}{I_t} - R_m$  | 30 | $B = \frac{\Phi}{A}$  |



31  $F = B I l$

32  $E = -L \frac{di}{dt}$

33  $A = \frac{\pi d^2}{4}$

34  $E = \frac{1}{2} C V^2$

35  $Q = C V$

36  $F = 2 \times 10^{-7} \times \frac{I_1 I_2}{d}$

37  $I = \frac{Emf}{R + r_T}$

38  $L = N \frac{\Delta \phi}{\Delta I}$

39  $v = V_m \sin(\omega t \pm \phi)$

40  $Z = \frac{V}{I}$

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

42  $\tan \phi = \frac{X_L - X_C}{R}$

43  $I_{sh} = \frac{V + I_{se} R_{se}}{R_{sh}}$

44  $T = \frac{0,318 I_a Z p \phi}{c}$

45  $E = V - I_a (R_a + R_{se})$

46  $E = B l v$

47  $E = -N \frac{d\phi}{dt}$

48  $E = \frac{V}{d}$

49  $E = \frac{1}{2} L I^2$

50  $Q = It$

51  $C_T = C_1 + C_2 + C_3 + \dots + C_n$

52  $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots + \frac{1}{C_n}$

53  $L_T = L_1 + L_2 + L_3 + \dots + L_n$

54  $\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \dots + \frac{1}{L_n}$

55  $\tan \phi = \frac{I_L - I_C}{I_R}$

56  $E = V + I_a R_a$

57  $V = E - I (R_a + R_{se})$

58  $E = V + I_a (R_a + R_{se})$

59  $E = V + I_a R_a + I R_{se}$

60  $E = V - I_a R_a - I R_{se}$

$$61 \quad E = \frac{2p\phi ZN}{60 c}$$

$$62 \quad V_T = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$63 \quad V_L = IX_L$$

$$64 \quad E_{rms} \text{ or } I_{rms} = 0,707 E_m \text{ or } I_m$$

$$65 \quad N = \frac{V}{k\phi}$$

$$66 \quad E = 4,44 f\phi_m N$$

$$67 \quad V_C = IX_C$$

$$68 \quad E_{ave} \text{ or } I_{ave} = 0,637 E_m \text{ or } I_m$$

$$69 \quad P = \sqrt{3} V_L I_L \cos\theta$$

$$70 \quad S = \sqrt{3} V_L I_L$$

$$71 \quad Q = \sqrt{3} V_L I_L \sin\theta$$