higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

## NATIONAL CERTIFICATE (VOCATIONAL)

# ELECTRICAL PRINCIPLES AND PRACTICE
## NQF LEVEL 3

(12041003)

**6 December 2023 (X-paper)**
**09:00–12:00**

**This question paper consists of 6 pages and a formula sheet of 2 pages.**

573Q1N2306

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# DEPARTMENT OF HIGHER EDUCATION AND TRAINING
# REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)
ELECTRICAL PRINCIPLES AND PRACTICE
NQF LEVEL 3
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. Start each question on a new page.
5. Use only a black or blue pen.
6. Write neatly and legibly.

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## QUESTION 1

1.1 Differentiate between the term *electron* and *free electrons.* (4)

1.2 The field coils of a motor have a resistance of 20 Ω at 0 °C.

Determine the temperature at which these coils will have a resistance of 24 Ω. Take the temperature coefficient of resistance at 0 °C to be 0,0043 per °C. (3)

1.3 What will happen to the resistance of each of the following materials as their temperature decreases?

1.3.1 Carbon

1.3.2 Semiconductor

1.3.3 Aluminium

1.3.4 Alloy

(4 × 1) (4)

1.4 Define the term *charge*. (2)

1.5 State the nature of the temperature coefficient of resistance of each of the following:

1.5.1 Conductors

1.5.2 Insulators

(2 × 1) (2)

**[15]**

## QUESTION 2

2.1 State ONE of the two fundamental laws of magnetism. (2)

2.2 Calculate the force experienced by a conductor that is 60 cm long and carries a current of 5 A when:

2.2.1 It is at a right angle to a magnetic field with a flux density of 500 mWb/m$^2$

2.2.2 It lies at 60° to a magnetic field with a flux density of 30 mWb/m$^2$

(2 × 2) (4)

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2.3 Complete the following sentences by writing only the missing word or words next to the question number (2.3.1–2.3.4) in the ANSWER BOOK.

2.3.1 The direction of induced emf can be determined using …… and …… (2)

2.3.2 The …….. is used to identify the poles of a magnetic field. (1)

2.3.3 The strength of a magnetic field in a coil of wire is called the …… (1)

2.3.4 An electric current flowing through a wire produces a/an ……. in the wire. (1)

2.4 State Lenz's law. (2)

2.5 A conductor of length 17,5 cm moves through a magnetic field with a uniform flux density at a velocity of 12,5 m/s.

If the emf induced in the conductor is 7,25 V when the conductor is at right angles to the magnetic lines of flux, calculate:

2.5.1 The magnetic flux density of the field

2.5.2 The current needed to pass through the conductor for the force to be 11 N when the conductor is at right angles to the magnetic field lines

(2 × 2) (4)

2.6 Briefly explain how to apply the *right-hand grip rule.* (3)

**[20]**

**QUESTION 3**

3.1 Two capacitors are connected in series across a DC supply. The voltage drops across the capacitors are 150 V and 100 V respectively and the charge flowing through the circuit is 2 300 µC.

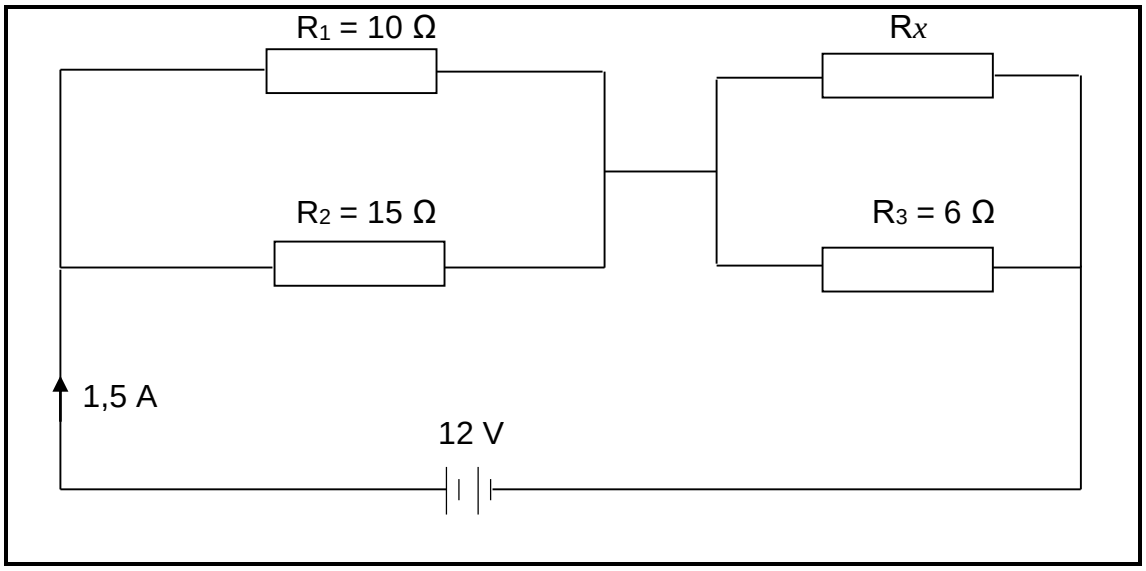
Calculate:

3.1.1 The total capacitance (3)

3.1.2 The capacitance of each capacitor (4)

3.2 Differentiate between the *electromotive force* and the *terminal voltage* of a battery. (2 + 2) (4)

3.3




Refer to the circuit diagram and calculate:

3.3.1 The total resistance of the circuit (2)

3.3.2 The value of the unknown resistor R*x* (7)

3.3.3 What will happen to the circuit when $R_3$ is a short circuit? (2)

3.4 Calculate the inductance of a coil if an emf of 3,2 V is induced in the coil by a changing current of 16 A/s. (3)

3.5 List THREE methods used to cool oil-immersed transformers. (3)

3.6 In a three phase star connected systems, how would you measure the line voltage and phase voltage? (2)

**[30]**

## QUESTION 4

4.1 Describe step by step how to perform insulation resistance test in a new installation between the earth continuity conductor and live conductors. (6)

4.2 Name THREE basic mechanisms in analogue-type measuring instruments. (3)

4.3 Give THREE advantages of a moving coil permanent magnet type instrument. (3)

4.4 Give THREE disadvantages of a dynamometer moving coil instrument (3)

**[15]**

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## QUESTION 5

5.1 Give TWO main types of losses in DC machines. (2)

5.2 Complete the following table by writing only the missing word or words next to the question number (5.2.1–5.2.3) in the ANSWER BOOK.

| LAP WINDING | WAVE WINDING |
|---|---|
| There are as many parallel paths for the current as there are field poles. | There are (5.2.1) …….. parallel paths regardless of the number of field poles. |
| 5.2.2…….. of brush positions is equal to the number of poles. | Only two brush positions are required regardless of the number of field poles. |
| It is used in machines with a low-voltage/high-current capacity. | It is used in machines with a (5.2.3) ……..capacity. |

(3 × 1) (3)

5.3 DC motors are the most used motors in smaller appliances. (3)

List THREE main components of a DC motor.

5.4 A DC generator with an armature resistance of 5 Ω is connected to a 150 V supply.

Calculate the armature current if the machine generates an emf of 210 V. (3)

5.5 What is the purpose of an *autotransformer starter*. (2)

5.6 Draw the terminal box of the three phase induction motor connected in star. (6)

5.7 Give ONE practical application of a shaded-pole induction motor. (1)

**[20]**

**TOTAL: 100**

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## FORMULA SHEET

1. $\boldsymbol{Cos\phi = \frac{R}{Z}}$

2. $\boldsymbol{P = V\ I\ Cos\phi}$

3. $Q = V\ I\ Sin\phi$

4. $\boldsymbol{S = V\ I}$

5. $V_1 = \left(\frac{R_1}{R_t}\right) V_T$

6. $\boldsymbol{I_1 = \left(\frac{R_2}{R_1 + R_2}\right) I_T}$

7. $R_T = R_1 + R_2 + R_3 + \cdots + R_n$

8. $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_n}$

9. $\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$

10. $V_L = \sqrt{3}\, V\ p\, h$

11. $\boldsymbol{E = V - I_a\, R_a}$

12. $\boldsymbol{f = \frac{Np}{60}}$

13. $S = \frac{N_s - N_r}{N_s}$

14. $\boldsymbol{R_{sh} = \frac{I_m\, R_m}{I_{sh}}}$

15. $\tan\boldsymbol{\phi} = \sqrt{3}\left(\frac{\boldsymbol{W_1 - W_2}}{\boldsymbol{W_1 + W_2}}\right)$

16. $E = V + I\, r$

17. $\boldsymbol{V = I\, R}$

18. $R = \frac{p\ l}{A}$

19. $\boldsymbol{R_t = R_0(1 + \alpha t)}$

20. $R_t = R_0[1 + \propto_0 (t - \emptyset)]$

21. $P = V\ I$

22. $E = I^2\ R\, t$

23. $\boldsymbol{\eta = \frac{P_0}{P_{in}} \times 100}$

24. $\boldsymbol{X_L = 2\pi\ f\ L}$

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

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

27. $Mmf = N\ I$

28. $H = \frac{Mmf}{l}$

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29. $R_{se} = \frac{V_t}{I_t} - R_m$

30. $F = BIl \sin \emptyset$

31. $E = -L\frac{di}{dt}$

32. $A = \frac{\pi\, d^2}{4}$

33. $E = \frac{1}{2}\ C\, V^2$

34. $Q = C\, V$

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

36. $I = \frac{emf}{R + r_T}$

37. $L = N\frac{\Delta\, \phi}{\Delta\, I}$

38. $E = V + \ R_a I_a$

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

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

41. $B = \frac{\Phi}{A}$

42. $E = Blv \sin \emptyset$

43. $E = -N\ \frac{d\emptyset}{dt}$

44. $E = \frac{V}{d}$

45. $E = \frac{1}{2} LI^2$

46. $Q = It$

47. $C_T = C_1 + \ C_2 + \ C_3 + \cdots + C_n$

48. $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_n}$

49. $L_T = L_1 + \ L_2 + \ L_3 + \cdots + L_n$

50. $\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \cdots + \frac{1}{L_n}$

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

52. $Pf = cos\theta$

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