higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ELECTROTECHNICS N4

(8080074)

21 November 2023 (X-paper)
09:00–12:00

Calculators may be used.

This question paper consists of 7 pages and a formula sheet of 3 pages.

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QUESTION 1: PRINCIPLES OF ELECTRICITY

1.1 Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–K) next to the question number (1.1.1–1.1.10) in the ANSWER BOOK.

	COLUMN A		COLUMN B
1.1.1	An atom that has lost or gained one or more electrons	A	Norton's theorem
1.1.2	The force that tends to produce an electric current in a circuit	B	negative temperature coefficient of resistance
1.1.3	When an increase in the temperature of a material causes the resistance of the material to fall	C	capacitance
1.1.4	When an increase in the temperature of a material causes the resistance of the material to rise	D	like poles repel each other
1.1.5	Any network that has two terminals and consists of resistances, voltage sources and current sources can be replaced by a single current source in parallel with a single resistance	E	ion
1.1.6	When a conductor moves through a coil, a voltage is induced in it, causing the current to flow	F	Lenz's law
1.1.7	When two magnets are placed close to each other	G	permeability
1.1.8	The direction of induced EMF is such that the current it sets up is in the opposite direction	H	electromotive force
1.1.9	The ease with which a magnetic field can be established in a material compared to the ease with which the same magnetic field can be established in air	I	Faraday's law
1.1.10	The ratio between the charge and the applied voltage	J	electromagnetic induction
		K	positive temperature coefficient of resistance

(10 × 1) (10)

1.2 An aluminium wire 7,5 m long is connected in parallel with a copper wire that is 6 m long. When a current of 5 A is passed through the combination, it is found that the current through the aluminium wire is 3 A. The diameter of the aluminium wire is 1 mm.

Determine the diameter of the copper wire. The resistivity of copper is 0,0017 micro-ohm metres and that of aluminium 0,028 micro-ohm metres. (10)

1.3 Apply Kirchhoff's law to FIGURE 1 below, and determine the value of the current in each branch of the circuit.

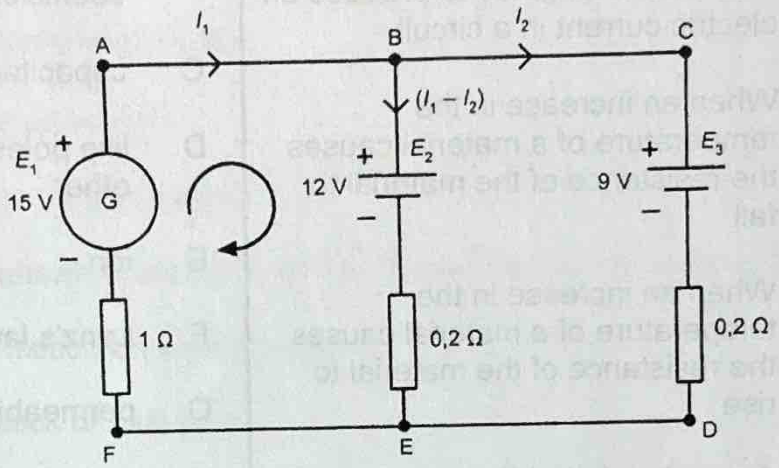

FIGURE 1 (10)
[30]

QUESTION 2: DC MACHINES

2.1 FIGURE 2 below shows the construction of a DC machine. Give the correct name for each of the labelled parts (A–H).

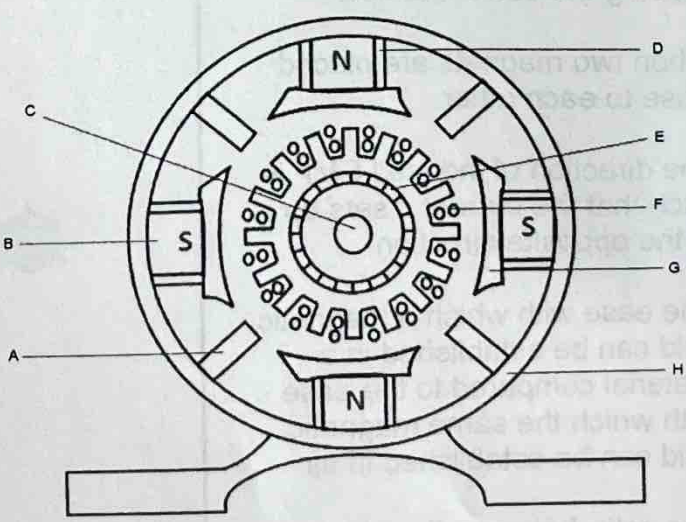

FIGURE 2 (8)

2.2 The open-circuit characteristic of a DC shunt generator, running at 600 r/m, is:

Current (A)	1	2	3	4	5	6	7	8	9	10
EMF (V)	100	260	390	470	530	570	600	620	630	640

Determine the voltage to which the machine will build up if:

2.2.1 The speed is 600 r/min and the resistance of the field circuit is 84 Ω (6)

2.2.2 The speed is increased to 660 r/min and the resistance of the field circuit is reduced to 72 Ω (6)

[20]

QUESTION 3: AC THEORY

3.1 The armature of an alternator rotates at 3 000 rev/min between the poles of a magnet. The maximum voltage of the generated wave is 35,36 V and the waveform is sinusoidal.

Calculate the following:

3.1.1 The frequency (1)

3.1.2 The instantaneous EMF after 0,004 seconds (2)

3.1.3 The time taken from the instant zero to reach 20 V for the first time (5)

3.2 Define the term *phasor diagram.* (2)

3.3 A coil with a resistance of 20 Ω and an inductance of 51 mH is connected in series with a 318-μF capacitor. This circuit is connected across a 220-V, 50-Hz supply.

Calculate the following:

3.3.1 The inductive and capacitive reactance of the circuit (2)

3.3.2 The voltage drop across the coil (7)

3.3.3 The voltage drop across the capacitor (1)

[20]

QUESTION 4: TRANSFORMERS

4.1 A transformer working on no load draws 2,5 A from the supply at a power factor of 0,3 lagging. Calculate the following:

4.1.1 The no-load phase angle (1)

4.1.2 The magnetising component of I_o (2)

4.1.3 The core loss component of I_o (2)

4.2 FIGURE 3 below shows an oil-immersed air-cooled transformer. Name the FIVE parts (A–E).

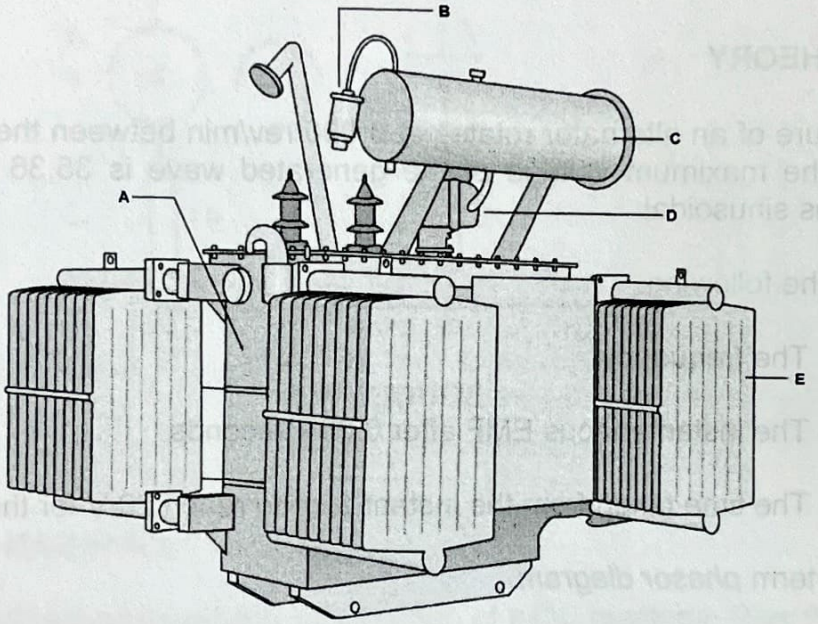

FIGURE 3 (5)
[10]

QUESTION 5: AC MACHINES

5.1 Draw a fully labelled circuit diagram of a capacitor-start, capacitor-run single-phase induction motor. (5)

5.2 Name TWO disadvantages of a single-phase induction motor over a three-phase induction motor. (2)

5.3 Briefly explain how to reverse the direction of rotation of a single-phase, split-phase induction motor. (3)
[10]

QUESTION 6: GENERATION AND SUPPLY OF AC POWER AND MEASURING INSTRUMENTS

6.1 Power stations derive their names from the method used to drive their turbines. Name THREE types of power stations that do not rely on a vast quantity of water to operate. (3)

6.2 State TWO reasons for stepping up the voltage on transmission lines. (2)

6.3 Complete the following sentence by writing only the missing word or words next to the question number (6.3) in the ANSWER BOOK.

In order to connect a ... in a circuit by means of a shunt resistor and multiplier, the current coil is connected across a shunt resistor and the voltage coil in series with a multiplier. (1)

6.4 A moving-coil instrument has a resistance of 30 Ω and gives a full-scale deflection when 50 mA flows through it. Calculate the value of the additional circuit component required to enable the instrument to be used as:

6.4.1 An ammeter, reading 0–5 A

6.4.2 A voltmeter, reading 0–50 V

(2 × 2) (4)
[10]

TOTAL: 100

ELECTROTECHNICS N4

FORMULA SHEET

Any applicable formula may also be used.

PRINCIPLES OF ELECTRICITY

1. $E = V + Ir$

2. $V = IR$

3. $R_T = R_{se} = R_1 + R_2 + R_3 + ... R_n$

4. $\frac{1}{R_T} = \frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ... \frac{1}{R_n}$

5. $P = V\ I = I^2R = \frac{V^2}{R}$

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

7. $R = \rho \frac{l}{A}$

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

9. $\frac{R_1}{R_2} = \frac{1 + \alpha_0 T_1}{1 + \alpha_0 T_2}$

10. $R_t = R_\theta [1 + \alpha_\theta (t - \theta)]$

11. $R_T = R_1 + \frac{R_2 \ x \ R_3}{R_2 + R_3}$

12. $I_{SC} = I_N = \left[\frac{R_2}{R_2 + R_3}\right] I_T$

13. $R_{SC} = R_N = R_3 + \frac{R_1 \ x \ R_2}{R_1 + R_2}$

14. $I_L = \left[\frac{R_N}{R_N + R_2}\right] I_N$

15. $\phi = \frac{mmf}{S} = \frac{IN}{S}$

16. $H = \frac{IN}{l}$

17. $F = BlI$

18. $E = Blv$

19. $B = \frac{\phi}{a}$

20. $E = \frac{\Delta \phi}{\Delta t}.N$

21. $E = \frac{L \Delta I}{\Delta t}$

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

23. $Q = VC$

24. $V = \frac{Q}{C}$

25. $Q_{se} = Q_1 = Q_2 = Q_3 ... = Q_n$

26. $Q_p = Q_1 + Q_2 + ... Q_n$

27. $C_{se} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + ... \frac{1}{C_n}}$

28. $C_p = C_1 + C_2 + ... C_n$

DIRECT CURRENT MACHINES

29. $E = \dfrac{2ZNp\phi}{60c}$

30. $E = kN\phi$

31. $c = 2a$

32. $E = I_{sh}R_{sh} + L\dfrac{\Delta I}{\Delta t}$

33. $R_{start} = \dfrac{(V - E)}{I_a} - R_a$

34. $I_{a_{start}} = \dfrac{V}{R_a + R_{start}}$

35. $E_{gen} = V + I_a R_a$

36. $E_{mot} = V - I_a R_a$

ALTERNATING CURRENT THEORY

37. $E_m = 2\pi BANn$

38. $e = E_m \sin(2\pi f\, t.57,3)^0$

39. $E_{rms} or I_{rms} = 0,707 E_m or I_m$

40. $E_{ave} or I_{ave} = 0,637 I_m or I_m$

41. $T = \dfrac{1}{f}$

42. $f = \dfrac{Np}{60}$

43. $\omega = 2\pi f$

44. $Z = \sqrt{R^2 + X^2}$

45. $\cos\phi = \dfrac{R}{Z}$

46. $\tan\phi = \dfrac{X}{R}$

47. $Z_L = R + j\omega L$

48. $Z_C = R - j\dfrac{1}{\omega C}$

49. $P = V\ I\ Cos\phi = I^2 R$

50. $pf = Cos\phi = \dfrac{R}{Z}$

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

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

TRANSFORMERS

53. $E = 4,44 f \phi_m N$

54. $k_t = \dfrac{N_1}{N_2} = \dfrac{V_1}{V_2} = \dfrac{E_1}{E_2} = \dfrac{I_2}{I_1}$

ALTERNATING CURRENT MACHINES

55. $\mathrm{Ns} = \dfrac{f}{p}$

56. $s = \dfrac{Ns - Nr}{Ns}$

MEASURING INSTRUMENTS

57. $$R_{sh} = \frac{I_m R_m}{I_{sh}}$$

58. $$R_x = \frac{V}{I} - R_a$$

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

60. $$R_x = \frac{V}{I - I_v}$$