higher education & training

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ELECTROTECHNICS N4

(8080074)

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This question paper consists of 7 pages and a formula sheet of 2 pages.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ELECTROTECHNICS N4
TIME: 3 HOURS
MARKS: 100

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. Questions may be answered in any order but subsections of questions must NOT be separated.
5. Start each section on a new page.
6. Use only a black or a blue pen.
7. Write neatly and legibly.

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SECTION A

QUESTION 1: MATERIAL, COMPONENTS AND INTERPRETATION OF DRAWINGS

1.1 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (1.1.1–1.1.10) in the ANSWER BOOK.

1.1.1 The ampere is that current which, if maintained in two straight perpendicular conductors of infinite length of negligible cross-sectional area, and placed 1 metre apart in a vacuum, would produce between the conductors a force of $2x10^{-15}$ Newtons per metre of length.

1.1.2 Electromotive force is that force which tends to produce an electric current in a circuit.

1.1.3 The unit of resistance is that resistance in which a current of 1 ampere flowing for 1 second generates 1 joule of thermal energy, and the unit in which it is measured is the ohm.

1.1.4 Primary and secondary cells are the principal sources of EMF.

1.1.5 The resistance of material is always inversely proportional to the type of material, inversely proportional to its cross-sectional area, and proportional to the length of the material.

1.1.6 Materials such as paper and cotton become brittle if their temperature is allowed to exceed about 100 °C.

1.1.7 The third law of electromagnetism is known as Faraday's law.

1.1.8 An expression for the EMF in terms of inductance and the rate of change of current may be expressed as: $E_{ave} = \frac{-L\Delta I}{\Delta t} volts$.

1.1.9 Fleming's left-hand rule states that if the thumb, index and middle finger are held at right angles to each other with the index finger pointing in the direction of current and the middle finger in the direction of the force, the thumb will indicate the direction of flux.

1.1.10 The voltage is that amount of magnetic flux which, when cut at a uniform rate by a conductor in 1 second, generates an EMF of 1 volt.

(10 × 1) (10)

1.2 Choose the correct word(s) from those given in brackets. Write only the word(s) next to the question number (1.2.1–1.2.10) in the ANSWER BOOK.

1.2.1 At the centre of the atom is the (nucleus/electrons) consisting of protons and neutrons bound together by extremely powerful nuclear forces.

1.2.2 The residual flux density on hysteresis can be reduced to zero by applying (negative/positive) magnetic field strength.

1.2.3 When the magnet is pulled out of the coil, the meter registers a momentary current in the (same/opposite) direction. No current is registered while the magnet is at rest.

1.2.4 The third law of electromagnetism is known as (Lenz's law/ Ohm's law).

1.2.5 The capacitance of a capacitor is (inversely proportional/directly proportional) to the area of the plates and inversely proportional to the distance between them.

1.2.6 The main frame for the general construction of a four-pole DC generator or motor is referred to as the (yoke/flux) and is made up of a magnetic material.

1.2.7 Principles of generators and motors state that, if the conductor is moved (downwards/upwards), the EMF is in such direction that the current produced sets up upward force.

1.2.8 Lap windings can be compared to cells connected in (parallel/series), while wave winding can be compared to cells connected vice-versa of that lap winding.

1.2.9 A series-connected machine has its field coils connected in (series/parallel) with the armature and, therefore, both carry the same amount of current.

1.2.10 Commutation is the reversal of the EMF and current in the (open-circuited/short-circuited) coil during its transfer from one commutator segment to the next.

(10 × 1) (10)
[20]

TOTAL SECTION A: 20

SECTION B

QUESTION 2: PRINCIPLES OF ELECTRICITY

2.1 Why are certain currents that circulate in transformer cores undesirable and what are they called? (4)

2.2 What are the properties of hard and soft magnetic materials and where are they used? (4)

2.3 A learner electrician was instructed to connect three resistors (R_1, R_2 and R_3) in series across a supply. Later on, she was asked to disconnect them and reconnect them in parallel across the same supply.

2.3.1 What is the formula to calculate the total resistance when connected in series?

2.3.2 What is the formula to calculate the total resistance when connected in parallel?

(2 × 2) (4)

2.4 What is meant by a positive temperature coefficient of resistance? (2)

2.5 A resistor of 160 ohms is connected in parallel with a resistor of 15 ohms. This combination is then connected in series with an unknown resistor. The circuit is then connected across a 75 V DC supply.

Calculate the following:

2.5.1 The value of an unknown resistor when 2,5 A current is drawn from the supply. (4)

2.5.2 The total resistance of the circuit. (1)

2.5.3 The power dissipated in the circuit. (1)

[20]

QUESTION 3: DIRECT-CURRENT (DC) MACHINES

3.1 What is the function of a pole core in a DC machine? (1)

3.2 What are the TWO methods of connecting field coils of a DC machine? (2)

3.3 How can the field coils of DC machines be connected with self-excited machines? (3)

3.4 What is the chief purpose of a DC motor starter? (2)

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3.5 What type of winding would be used for each of the following:

3.5.1 A high-voltage low-current DC machine?

3.5.2 A high-current low-voltage DC machine?

(2 × 1) (2)

3.6 A short-shunt compound generator supplies a load current of 210 A. It has a shunt field resistance of 60 ohms, an armature resistance of 0,2 ohms and a field resistance of 0,07 ohms.

Calculate the armature EMF if the terminal voltage is 240 V. (5)

3.7 A six-pole, lap-connected armature, driven at 300 r/min, is required to generate 250 V. The useful flux per pole is 0,07 Wb. If the armature has 115 slots, calculate a suitable number of conductors per slot. (5)

[20]

QUESTION 4: ALTERNATING-CURRENT (AC) THEORY

4.1 Briefly explain what you understand with the following AC series circuits involving RLC:

4.1.1 Consider X_L to be greater than Xc

4.1.2 Consider Xc to be greater than X_L

(2 × 2) (4)

4.2 Briefly explain what you understand with the following AC parallel circuits involving RLC:

4.2.1 Consider X_L to be greater than Xc

4.2.2 Consider Xc to be greater than X_L

(2 × 2) (4)

4.3 What can a consumer do to improve a poor power factor? (2)

4.4 An instantaneous value of a current is represented by $i = 45 \sin 314\ t$

Calculate:

4.4.1 The RMS value of the current. (1)

4.4.2 The frequency. (1)

4.4.3 The instantaneous value of the current 1,2 milli-seconds after the start of a cycle (3)

[15]

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QUESTION 5: ALTERNATING-CURRENT (AC) MACHINES

5.1 The construction of transformers is simplest of all AC machines.

What are the THREE advantages of transformers? (3)

5.2 Transformers are constructed by means of different types of elements.

Name at least FIVE principal elements of transformers. (5)

5.3 Name THREE practical applications for capacitor-start, split-phase motors. (3)

5.4 Briefly explain how to reverse the direction of rotation of a single-phase, split-phase induction motor. (2)

5.5 Why is water an important consideration for the location of a power station? (2)
[15]

QUESTION 6: MEASURING INSTRUMENTS

A voltmeter which has a resistance of 1 000 ohms and an ammeter which has a resistance of 0,3 ohms were used to measure the value of two resistors. To measure the first resistor, the short shunt method was used and the readings obtained were 15 V and 0,07 A on the voltmeter and ammeter respectively. In order to measure the second resistor, the long shunt method was used with the following readings being obtained, 6 V and 2 A.

6.1 Calculate the percentage error in each case. (9)

6.2 What does the minus sign indicates in this case? (1)
[10]

TOTAL SECTION B: 80
GRAND TOTAL: 100

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ELECTROTECHNICS N4

FORMULA SHEET

Any applicable formula may also be used.

1. PRINCIPLES OF ELECTRICITY

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

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. $\boldsymbol{\eta} = \frac{\boldsymbol{P}_0}{\boldsymbol{P}_{in}} \times 100$

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

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

13. $F = BlI$

14. $E = Blv$

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

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

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

18. $L = \frac{\Delta\phi}{\Delta l}.N$

19. $Q = VC$

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

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

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

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

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

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2. DIRECT-CURRENT MACHINES

25. $E = \frac{2ZNp\phi}{60c}$

26. $E = kN\phi$

27. $c = 2a$

28. $E = I_{sh}R_{sh} + L\frac{\Delta I}{\Delta t}$

29. $R_{start} = \frac{(V - E)}{I_a} - R_a$

30. $I_{a_{start}} = \frac{V}{R_a + R_{start}}$

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

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

3. ALTERNATING-CURRENT THEORY

33. $E_m = 2\pi BANn$

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

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

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

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

38. $f = \frac{Np}{60}$

39. $\omega = 2\pi f$

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

41. $\cos\phi = \frac{R}{Z}$

42. $\tan\phi = \frac{X}{R}$

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

44. $Z_C = R - j\frac{1}{\omega C}$

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

46. $pf = Cos\phi = \frac{R}{Z}$

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

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

4. ALTERNATING-CURRENT MACHINES

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

50. $k_t = \frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{E_1}{E_2} = \frac{I_2}{I_1}$

5. MEASURING INSTRUMENTS

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

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

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

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

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