higher education & training

Department:
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REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ELECTROTECHNICS N4

(8080074)

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Nonprogrammable calculators may be used.

This question paper consists of 8 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 be kept together.
5. Start each question on a new page.
6. Only use a black or blue pen.
7. Write neatly and legibly.

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QUESTION 1: PRINCIPLES OF ELECTRICITY

1.1 Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–E) next to the question number (1.1.1–1.1.10) in the ANSWER BOOK.

1.1.1 The strength of a direct current is directly proportional to the potential difference and inversely proportional to the resistance of the circuit:

A Kirchhoff's law
B Ohm's law
C Lenz's law
D Faraday's law
E Joule's law

1.1.2 From his research, he deduced that the heat generated in a circuit is proportional to the square of the current, the resistance of the circuit, and the time during which the current flows:

A Kirchhoff's law
B Ohm's law
C Lenz's law
D Faraday's law
E Joule's law

1.1.3 In any complete loop within a circuit, the sum of all voltages across components that supply electrical energy must be equal to the sum of all voltages across the other components in the same loop:

A Kirchhoff's law
B Ohm's law
C Lenz's law
D Faraday's law
E Joule's law

1.1.4 The direction of an induced EMF is always such that it tends to set up a current opposing the motion or the change of flux responsible for inducing that EMF:

A Kirchhoff's law
B Ohm's law
C Lenz's law
D Faraday's law
E Joule's law

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1.1.5 The magnitude of the induced EMF is directly proportional to the rate of change of flux linkages:

A Kirchhoff's law
B Ohm's law
C Lenz's law
D Faraday's law
E Joule's law

1.1.6 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:

A Superposition theorem
B Fleming's left-hand rule
C Norton's theorem
D Right-hand grip rule
E Thevenin's theorem

1.1.7 Any network with two terminals consisting of resistances, voltage sources and current sources can be replaced by a single voltage source with its open-circuit EMF in series with a single resistance:

A Superposition theorem
B Fleming's left-hand rule
C Norton's theorem
D Right-hand grip rule
E Thevenin's theorem

1.1.8 In a network that contains more than one voltage or current source, the current flow of each source can be determined independently, and the current flow in each branch of the circuit is the algebraic sum of the independently determined currents:

A Superposition theorem
B Fleming's left-hand rule
C Norton's theorem
D Right-hand grip rule
E Thevenin's theorem

1.1.9 If a solenoid is gripped in the right hand with the fingers pointing in the direction of the current flow, the outstretched thumb, if held in parallel to the axis of the solenoid, will point to the north end of the solenoid:

A Superposition theorem
B Fleming's left-hand rule
C Norton's theorem
D Right-hand grip rule
E Thevenin's theorem

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1.1.10 If the thumb, index finger and middle finger are held at right angles to each other, with the index finger pointing in the direction of the flux and the middle finger in the direction of the current, the thumb will indicate the direction of the force:

A Superposition theorem
B Fleming's left-hand rule
C Norton's theorem
D Right-hand grip rule
E Thevenin's theorem

(10 × 1) (10)

1.2 A heater of 40 W, which draws 2 A, and a resistor of 20 Ω are connected in parallel. A resistor of unknown value is connected in series with the parallel branch.

Calculate the value of the unknown resistor if the circuit is connected across a DC supply of 32 V. (6)

1.3 Temperature coefficient of resistance is defined as the increase in unit resistance of a substance per unit rise in temperature from 0 °C to the applied voltage, and is inversely proportional to the resistance of the circuit.

1.3.1 Name TWO materials that have a positive temperature coefficient of resistance.

1.3.2 Name TWO materials that have a negative temperature coefficient of resistance.

(2 × 2) (4)

1.4 An electrical network has two or more voltage sources.

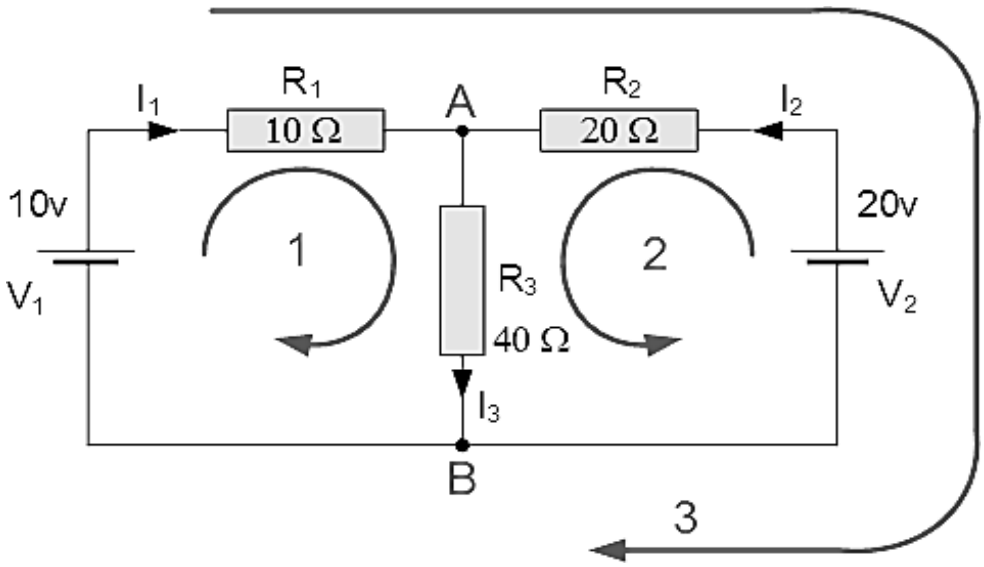

FIGURE 1

Apply Kirchhoff's laws and determine the magnitude of the current flowing in each branch of the circuit in FIGURE 1 above:

1.4.1 I1 (6)

1.4.2 I2 (2)

1.4.3 I3 (2)

[30]

QUESTION 2: DC MACHINES

2.1 An eight-pole, lap-connected armature, driven at 450 r/min, is required to generate 250 V. The useful flux per pole is 0,05 Wb. The armature has 120 slots.

Calculate a suitable number of conductors per slot. (5)

2.2 A long-shunt compound-wound direct-current machine has an armature resistance of 0,2 Ω, a series field resistance of 0,133 Ω, and shunt field resistance of 120 Ω. The machine draws a current of 40 A from a DC supply of 480 V when run as a motor.

2.2.1 Draw a circuit diagram and show the voltage and current distribution in the circuit. (5)

2.2.2 Calculate the EMF induced in the armature. (5)

2.3 Calculate the total resistance of a starter for a 400 V DC shunt motor requiring an input of 12 kW. The maximum armature current is not to exceed 1,5 times the full-load armature current. The armature resistance is 0,35 Ω. Neglect the current flowing in the field circuit. (5)

[20]

QUESTION 3: AC THEORY

3.1 With reference to AC, explain briefly what you understand by *one cycle*. (2)

3.2 An impedance of 6 + j4 Ω and an impedance of 4 – j2 Ω are connected in series across a 50 Hz supply of 200 V.

3.2.1 Calculate the true power and apparent power of the circuit. (6)

3.2.2 Calculate the power factor of the circuit. (2)

3.2.3 Calculate the voltage drop across each impedance. (4)

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3.2.4 Draw a phasor diagram to represent the distribution of the voltage and current in the circuit. (4)

3.3 Calculate the power supplied, in kW, to a load when connected to a 50 Hz supply of 250 V, which draws a current of 10 A at a power factor of 0,8 lagging. (2)

[20]

QUESTION 4: TRANSFORMERS

4.1 Briefly describe FIVE characteristics of an ideal transformer. (5)

4.2 A 4,4 kVA, 440/120 V, 50 Hz single-phase transformer has 48 turns on the secondary winding.

Calculate the following:

4.2.1 The number of turns on the primary winding (1)

4.2.2 The primary and secondary full-load currents (2)

4.2.3 The maximum value of the core flux (2)

[10]

QUESTION 5: AC MACHINES

5.1 A 525 V, 50 Hz three-phase induction motor has a synchronous speed of 1500 r/min.

Calculate the following:

5.1.1 The rotor speed if the induction motor is operating at a slip of 20%

5.1.2 The number of poles of the induction motor

(2 × 2) (4)

5.2 According to your own understanding, which term clearly defines the difference between the rotor speed and the synchronous speed? (1)

5.3 Thus far, you have learned a lot about induction motors.

According to your knowledge, what is the role of a centrifugal switch in a single-phase induction motor? (2)

5.4 Where are capacitor-start split-phase motors used, and what are TWO practical applications of this motor? (3)

[10]

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

6.1 Mainly an overhead, three-phase grid network is used to interconnect the power stations and bulk consumers. Use FIGURE 2 below to show your understanding on how electricity is distributed.

Name the FIVE stages, as represented by the numbers 1 to 5. (5)

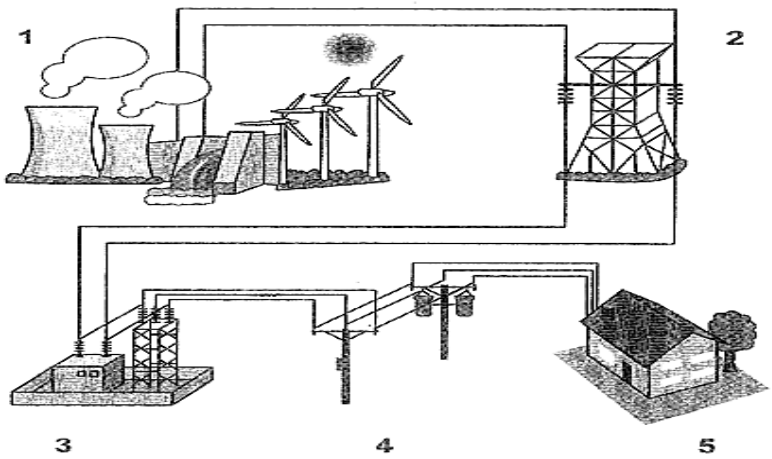

FIGURE 2

6.2 When the current coil and voltage coils are combined, they normally give one operational instrument.

What is the name of the instrument? (1)

6.3 Briefly explain how the shunt resistor and multiplier relate to a connection of current coil and voltage coil when connecting a wattmeter in a circuit. (2)

6.4 The ratio arms of a Wheatstone bridge are 100 Ω and 10 Ω. An unknown resistor is to be measured using a resistor adjustable between 20 Ω and 10 Ω.

If the bridge is balanced when the adjustable resistor is set to 45 Ω, calculate the value of the unknown resistor. (2)

[10]

TOTAL: 100

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ELECTROTECHNICS N4

FORMULA SHEET

Any other applicable formula may also be used.

1. Principles of electricity

$$E = V + Ir$$

$$V = IR$$

$$R_{se} = R_1 + R_2 + \ldots R_n$$

$$R_p = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \ldots \frac{1}{R_n}}$$

$$R = \rho \frac{\ell}{a}$$

$$\frac{R_1}{R_2} = \frac{1 + \alpha_o T_1}{1 + \alpha_o T_2}$$

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

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

$$\Phi = \frac{mmf}{S} = \frac{IN}{S}$$

$$H = \frac{IN}{\ell}$$

$$F = B\ell I$$

$$E = \frac{\Delta\Phi}{\Delta t} \, . \, N$$

$$E = B\ell v$$

$$E = \frac{L\Delta \, I}{\Delta t}$$

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

$$Q = VC$$

$$Q_{se} = Q_t = Q_1 = Q_2 \ldots = Q_n$$

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

$$Q_p = Q_1 + Q_2 + \ldots Q_n$$

$$C_p = C_1 + C_2 + \ldots C_n$$

2. Direct-current machines

$$E = \frac{2Z}{c} \, . \, \frac{Np}{60} \, . \, \Phi$$

$$c = 2a$$

$$E_{gen} = V + I_a \, R_a$$

$$E_{mot} = V - I_a \, R_a$$

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

3. Alternating-current machines

$$E_m = 2\pi BANn$$

$$e = E_m \sin \, (2\pi f. \, t \times 57{,}3)°$$

$$E_{ave} = 0{,}637 \, E_m$$

$$E_{rms} = 0{,}707 \, E_m$$

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

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

$$\omega = 2\pi f$$

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

$$Z_c = R - j\frac{1}{\omega C}$$

$$pf = \cos\phi = \frac{R}{Z}$$

$$S = VI$$

$$P = V.I\cos\phi = I^2 R$$

$$Q = V.I\sin\phi$$

4. Transformers

$$E = 4{,}44\ f\ \Phi_m\ N$$

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

5. Measuring instruments

$$R_{SH} = \frac{i_m\ R_m}{I_{sh}}$$

$$R_{se} = \frac{V}{i_m} - R_m$$

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