higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ELECTROTECHNICS N4

(8080074)

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09:00–12:00

Calculators may be used.

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

020Q1A2031

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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 blue pen.
7. Write neatly and legibly.

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SECTION A

QUESTION 1: GENERAL

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

	COLUMN A		COLUMN B
1.1.1	The sum of the currents flowing towards a junction is equal to the sum of the currents flowing away from the junction	A	electromagnetic induction
1.1.2	The algebraic sum of the voltage drops in any closed circuit is equal to the algebraic sum of the applied EMF's	B	pole shoe
1.1.3	Inside the magnet, each line of force passes from the south pole to the north pole, thus forming a complete closed loop	C	self-excited generators
1.1.4	If the solenoid is held in the right hand with the fingers pointing in the direction of the current flow, the outstretched thumb, if held parallel to the axis of the solenoid, will point to the north end of the solenoid	D	speed
1.1.5	When the magnet is pulled out of the coil, the meter registers a momentary current in the opposite direction. No current is registered while the magnet is at rest	E	Kirchhoff's first law
1.1.6	These are somewhat similar in construction to paper dielectric capacitors	F	magnetism
1.1.7	It is used to increase the cross-sectional area which reduces the reluctance of the air gap	G	electrolytic type
1.1.8	It can be compared to cells connected in parallel, while another one can be compared to cells connected in series	H	lap winding
1.1.9	The field windings are connected to the armature windings in various ways	I	transformer
1.1.10	This is the opposition that is offered to the flow of current in a capacitive circuit when an alternating current passes through it. It is inversely proportional to the frequency and the capacitance of the circuit	J	Kirchhoff's second law
		K	right-hand grip rule
		L	capacitive reactance

(10 × 1) **[10]**

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1.2 Choose the correct word or words from those given in brackets and write only the answer next to the question number (1.2.1–1.2.10) in the ANSWER BOOK.

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

1.2.2 The resistance of material is (inversely/directly) proportional to its cross-sectional area.

1.2.3 In hysteresis, the residual flux density can be (increased/reduced) to zero by applying a negative magnetic field strength.

1.2.4 The two principal laws of electromagnetism are known as (Faraday's laws/Lenz's laws).

1.2.5 A (capacitor/resistor) comprises plates and an insulating material, referred to as the dielectric.

1.2.6 If, for the generator and motor principles, the conductor is moved (upwards/downwards), the EMF is in such a direction that the current produced, set up an upward force.

1.2.7 A low power factor (decreases/increases) the total current for a given power which, in turn, increases the resistance losses.

1.2.8 When the (primary/secondary) stator windings are connected to a three-phase supply, a rotating magnetic field is established, which rotates at a synchronous speed.

1.2.9 The reason for (stepping up/stepping down) the voltage, is that it reduces the size of the conductors required.

1.2.10 The (short shunt/long shunt) method of connection is used when measuring resistances of low ohm values.

(10 × 1) **[10]**

TOTAL SECTION A: 20

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SECTION B

QUESTION 2: PRINCIPLES OF ELECTRICITY

2.1 What does the term *electromotive force* mean? (2)

2.2 What are the FIVE characteristics of magnetism? (5)

2.3 Two series circuit branches of 6 ohms and 4 ohms, and 10 ohms and 5 ohms respectively, are connected in parallel across a battery which has an EMF of 25 V and an internal resistance of 0,25 ohms.

Calculate the potential difference across each of the external resistance. (10)

2.4 The resistance of a coil of wire increases from 40 ohms at 10 ºC to 48,25 ohms at 60 ºC. Find the temperature coefficient of the conductor at 0 ºC. (3)

[20]

QUESTION 3: DC MACHINES

3.1 Briefly explain the following methods of self-excited field coil connections:

3.1.1 Shunt-connected

3.1.2 Series-connected

3.1.3 Compound-connected

(3 × 2) (6)

3.2 Give THREE reasons why the shunt generator may fail to excite. (3)

3.3 A DC generator has an armature EMF of 100 V when the flux/pole is 20 mWb and the armature speed is 800 r/min.

Calculate the EMF with:

3.3.1 The same flux but an armature speed of 1 000 r/min

3.3.2 A flux/pole of 24 mWb and an armature speed of 900 r/min

(2 × 3) (6)

3.4 A long shunt compound generator supplies a load current of 60 A. It has an armature resistance of 0,1 ohms and a series field resistance 0,025 ohms. With the shunt field resistance of 60 ohms, the generated EMF is 248 V.

Find the terminal voltage. (5)

[20]

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QUESTION 4: AC THEORY

4.1 Briefly explain the following terms:

4.1.1 Virtual value

4.1.2 Mean value

(2 × 2) (4)

4.2 State FOUR disadvantages of a low power factor. (4)

4.3 A rectangular coil has a length of 40 cm and a breadth of 20 cm. It has 1 000 turns and rotates in a uniform magnetic field about an axis in the plane of the coil joining the centre points of the two shorter sides. The field of 15 mWb/m² is perpendicular to the axis. The coil rotates at a uniform speed of 10 r/s.

Find the trigonometrical expression representing this EMF. (3)

4.4 A 50 Hz sinusoidal voltage has an RMS value of 200 V. The initial instantaneous voltage is zero and it is rising positively.

Find the time it takes the voltage to reach a value of 141,4 V for the first time. (4)

[15]

QUESTION 5: AC MACHINES

5.1 An ideal single-phase transformer is connected to a 240 V, 50 Hz supply. The maximum flux in the core is to be no more than 0,003 Wb. The transformer is required to produce a secondary pd of 50 V.

Calculate the number of turns on the primary and secondary windings and state the voltage per turn for each coil. (7)

5.2 Nomcebo Mthembu, a student from Majuba TVET College is doing her training in electrical motor installation, repairs and maintenance in one of the electrical workshops. These motors are for single-phase and three-phase induction motors.

5.2.1 State FOUR disadvantages of a single-phase induction motor that Nomcebo would have learned during her training. (4)

5.2.2 Three-phase induction motors have advantages and disadvantages to consider.

State FOUR advantages of a three-phase induction motor. (4)

[15]

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QUESTION 6: MEASURING INSTRUMENTS

6.1 The resistance of an armature was measured by means of the ammeter-voltmeter method. A current of 10 amperes was drawn and a millivoltmeter connected across the armature terminals indicated 220 millivolts. The resistance of the instrument is 5 ohms.

Find the resistance of the armature:

6.1.1 Neglecting the voltmeter current (2)

6.1.2 Taking the voltmeter current into account (3)

6.2 Determine the percentage error. (3)

6.3 The ratio arms of a Wheatstone bridge are 1 000 and 100 ohms respectively. An unknown resistor has to be measured using a resistor adjustable between 60 ohms and 100 ohms. The bridge is balanced when the adjustable resistor is set to 77,6 ohms.

Calculate the value of the unknown resistor. (2)
[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

$$E = V + Ir$$

$$V = IR$$

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

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

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

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

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

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

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

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

$$F = B\ell I$$

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

$$E = B\ell v$$

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

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

$$Q = VC$$

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

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

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

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

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

$$\omega = 2\pi f$$

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

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

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

$$S = VI$$

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

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

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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