higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T530**(E)**(J24)T

NATIONAL CERTIFICATE

ELECTROTECHNICS N4

(8080074)

24 July 2018 (X-Paper)
09:00–12:00

REQUIREMENTS: Graph paper

Calculators may be used.

This question paper consists of 6 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. Keep subsections of questions together.
5. Write neatly and legibly.

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QUESTION 1

Choose the correct word or words from those given in brackets. Write only the word or words next to the question number (1.1–1.10) in the ANSWER BOOK.

1.1 To gain insight into the nature of electric currents, it is necessary to consider the (structure/circle) of the atom.

1.2 The coil produces the magnetization of the circuit and this property of the coil is called its (electromagnetic/magneto-motive) force.

1.3 If the armature is driven (clockwise/anti-clockwise), the direction of the EMF is generated in the various conductors represented by the dots and crosses.

1.4 When the shunt field of a compound generator is connected in parallel with the armature only, the connection is called a (long-shunt/short-shunt) connection.

1.5 The waveform of the EMF generated in (an alternator/a generator), undergoes one complete cycle of variation when the conductors move past a north pole and a south pole.

1.6 The construction of the transformer is the simplest of all (AC/DC) machines; it has the added advantage of not having rotating parts or bearings and requires very little care and maintenance.

1.7 Since the (resultant/reluctance) of the magnetic circuit is low, the self-inductance of the primary winding is large compared to its resistance.

1.8 A (wound-rotor/slip-ring motor) differs from the squirrel-cage motor in construction.

1.9 (Power stations/Sub-stations) are often situated at considerable distances from centres of power consumption.

1.10 (Multipliers/Dividers) are used to limit the current through the meter to the value that will give full-scale deflection when the supply to be measured is at its maximum.

(10 × 1) **[10]**

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QUESTION 2

2.1 A 100 W heater element is connected in parallel with a 1 000 ohm resistor. When connected across a certain supply, a current of 0,5 A flows through the heater element.

Calculate the value of the resistor which must be connected in series with this parallel circuit so that the same current flows through the heater element when the supply voltage is 250 V. (6)

2.2 Calculate the cross-sectional area of a 74 m long copper conductor that will be able to carry a current of 16 A with a maximum allowed voltage drop of 6,4 V across the conductor. Take the resistivity of copper as 0,017 micro-ohm metre. (4)

2.3 The field coils of a motor have a resistance of 128 ohms at 22 ºC. After a run at full load, the resistance increases to 136 ohms.

Find the temperature of the coils if the temperature coefficient of resistance is 0,004 per ºC at 0 ºC. (4)

2.4 Two capacitors of 5 microfarads and 8 microfarads respectively are connected in series across 90 volts, DC supply.

Calculate the total capacitance and the potential difference (PD) across each capacitor. (4)
[18]

QUESTION 3

3.1 Name TWO sources of EMF. (2)

3.2 What effect will an increase in temperature have on the resistance of the following materials:

3.2.1 Pure metals

3.2.2 Carbon

(2 × 1) (2)

3.3 A conductor with an effective length of 15 m moves with a velocity of 12 m/s perpendicular to a magnetic field of uniform flux density of 0,7 T.

Calculate the force acting on the conductor when it carries a current of 0,5 A as well as the power required to move the conductor. (4)

3.4 Two batteries are connected in parallel and must be charged from a DC generator having an open-circuit voltage of 28 V and an internal resistance of 0,2 ohms. The batteries have open circuit voltages of 20 V and 16 V and an internal resistance of 0,5 ohms and 0,7 ohms respectively.

Use Kirchhoff's laws to determine the initial charging currents of the batteries. (10)
[18]

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QUESTION 4

4.1 When a shunt generator is starting up, the field current may fail to build up and the field coils may fail to excite. There may be several reasons for this.

Name and explain THREE reasons why a generator may fail to excite. (8)

4.2 Calculate the resistance of the starting resistor required to start a 440 V DC shunt motor with an input of 10 kW. The maximum armature current is not to exceed 1,5 times the full-load armature current. The armature has a resistance of 0,67 ohms and the field resistance is 161 ohms. (7)

4.3 The armature of a four-pole DC motor has 540 conductors. The armature winding is lap connected and the flux per pole is 0,025 Wb.

At what speed must the machine be driven to generate an EMF of 406 V? (3)
[18]

QUESTION 5

5.1 A 50 Hz sinusoidal voltage has a maximum value of 311 V.

Find the time for the voltage to reach a value of 180 V for the first time if the initial instantaneous voltage is zero and rising positively. (3)

5.2 The voltage in a series circuit are given by:

$$e_1 = 75\sin(wt + \frac{\pi}{6})$$

$$e_2 = 98\sin(wt - \frac{\pi}{4})$$

Calculate the RMS value of the supply voltage. (6)

5.3 A coil which has a resistance of 5 ohms and an inductance of 0,011 henry is connected in parallel with a 198-microfarad capacitor.

Calculate the supply current and the relative displacement between the voltage and the current if this circuit is connected to a 225-volt 50 Hz AC supply. (9)
[18]

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QUESTION 6

6.1 A 250/60 V, 50 Hz single-phase transformer has a core with an effective cross-sectional area of 0,04 m² and a high-voltage winding of 142 turns.

Calculate the following:

6.1.1 The number of turns on a low-voltage winding (2)

6.1.2 The maximum flux density in the core (4)

6.1.3 The approximate secondary current if the transformer supplied a load of 5 kW at a power factor of 0,8 lagging (2)

6.2 A moving-coil instrument has a resistance of 75 ohms and requires 300 mA to give full scale deflection.

Calculate the value of the additional component necessary to enable the instrument to measure a voltage of 60 V. (4)

6.3 State THREE advantages of an induction motor in contrast with a DC motor. (3)

6.4 Give THREE reasons why power stations are normally built far away from the main load points. (3)

[18]

TOTAL: 100

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ELECTROTECHNICS N4

FORMULA SHEET

Any applicable formula may also be used.

1. Principles of electricity

$$E = V + Ir$$

$$V = IR$$

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

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

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

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

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

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

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

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

$$F = B\ell I$$

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

$$E = B\ell v$$

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

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

$$Q = VC$$

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

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

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

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

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

$$\omega = 2\pi f$$

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

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

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

$$S = VI$$

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

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

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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