THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

082 **ELECTRICAL ENGINEERING SCIENCE**

(For Both School and Private Candidates)

Time : 3 Hours **ANSWERS** **Year : 2004**

Instructions

1. This paper consists of sections A, B and C.
2. Answer all questions in section A and B and **three (3)** questions from section C.
3. Non-programmable calculators may be used.
4. Communication devices and any unauthorised materials are **not** allowed in the examination room.
5. Write your **Examination Number** on every page of your answer booklet(s).

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1. For each of the items (i–x) choose the correct answer from among the given alternatives and write its letter beside the item number.

(i) The S.I. unit of the luminous flux is

A. candela

B. lumens

C. lux

D. lumen per watt

E. weber

Correct answer: B. Luminous flux is measured in lumens.

(ii) When the length of a conductor is increased its resistance

A. increases

B. becomes zero

C. decreases

D. remains constant

E. doubles

Correct answer: A. Resistance is directly proportional to length, so it increases.

(iii) A current of 5 A flows in a 10-ohm resistor for 10 minutes. The energy consumed is

Energy = $I^2Rt = (5^2 \times 10 \times 600) = 25 \times 10 \times 600 = 150{,}000$ J = 150 kJ.

Correct answer: D. 150 kJ.

(iv) Four (4) cells each of e.m.f 1.5 V and internal resistance of 1.2 ohms are connected in parallel. The equivalent internal resistance is

Equivalent internal resistance = r/n = 1.2 / 4 = 0.3 Ω.

Correct answer: C. 0.3.

(v) The efficiency of a transformer having no losses is

A. zero

B. unity

C. maximum

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D. minimum

E. lowest

Correct answer: B. Unity (100%).

(vi) The mounting height of a lamp having 100 c.d. and giving the illumination of 25 lux directly below it is

$E = I/d^2 \rightarrow d = \sqrt{(I/E)} = \sqrt{(100/25)} = \sqrt{4} = 2$ m.

Correct answer: C. 2.0.

(vii) Given that, the maximum power in an a.c. circuit is 100 W, its r.m.s value is

$P_{max} = \sqrt{2} \times P_{rms}$. So $P_{rms} = 100/\sqrt{2} = 70.7$ W.

Correct answer: C. 70.7.

(viii) A d.c. motor that is not allowed to run without load is

A. series

B. shunt

C. repulsion

D. compound

E. permanent

Correct answer: A. Series motor (it can overspeed dangerously without load).

(ix) A coil having a resistance of 10 ohms and inductance of 0.5 henry, connected to a supply of frequency 50 Hz. The impedance $Z = \sqrt{(R^2 + (XL)^2)}$. $XL = 2\pi fL = 2\pi \times 50 \times 0.5 = 157\ \Omega$. So $Z \approx \sqrt{(10^2 + 157^2)} \approx \sqrt{(100 + 24649)} = \sqrt{24749} \approx 157\ \Omega$.

Correct answer: C. 157.

(x) The phase voltage of a certain circuit is 231 V. Its line voltage is approximately … V.

For star: $V_L = \sqrt{3} \times V_{ph} = 1.732 \times 231 \approx 400$ V.

Correct answer: B. 400 V.

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2. The resistance of a wire depends on four (4) factors. One factor is its length. Write down the remaining three (3) factors.

Cross-sectional area.
Resistivity of the material.
Temperature of the conductor.

3. The current supplied to a certain load is given by i = 25 sin 314t (Amps). Calculate:

(a) The frequency of the supply.
$\omega = 314$ rad/s. $f = \omega / 2\pi = 314 / 6.28 = 50$ Hz.

(b) The maximum current supplied.
Imax = 25 A.

4. A 1.0 kW kettle contains 10 litres of water at 15 °C. If the efficiency of the kettle is 0.85 per unit, what will the time for the water to boil be? Assume 1 litre = 1 kg and the specific heat capacity of water is 4.2 kJ/kgK.

Mass = 10 kg. $\Delta T = 100 - 15 = 85$ °C.
$Q = mc\Delta T = 10 \times 4200 \times 85 = 3{,}570{,}000$ J.
Effective power = $1000 \times 0.85 = 850$ W.
Time = $Q / P = 3{,}570{,}000 / 850 = 4200$ s ≈ 70 min.

5. (a) What instrument is used to measure the specific gravity of a battery?
Hydrometer.

(b) Name two defects of a primary cell.
Polarization and local action.

(c) State Kirchhoff's current law.
The algebraic sum of currents entering a junction is equal to the sum of currents leaving the junction.

6. A wire 0.2 m long is moved at a speed of 2 m/s across a magnetic flux density of 0.2 T. What will be induced e.m.f in the wire (in mV)?

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$E = B\,l\,v = 0.2 \times 0.2 \times 2 = 0.08\ V = 80\ mV.$

7. What is the cost of using an electric motor rated at 250 V, 3 kW for 10 hours, if the cost of electric energy is sh. 30 per unit?

Energy consumed = 3 kW × 10 h = 30 kWh.
Cost = 30 × 30 = sh. 900.

8. The slip of an induction motor is 4%. If the frequency of the rotor current is 2.4 Hz, what will the frequency of the supply be?

Slip $s = fr/fs \rightarrow fs = fr/s = 2.4 / 0.04 = 60$ Hz.

9. A 16 c.d. lamp is kept 4 m from the screen of a photometer bench. Calculate the distance of the second lamp of 100 c.d., kept on another side of the screen, so that the illuminations on both sides of the screen are equal.

$E1 = E2 \rightarrow I1/d1^2 = I2/d2^2$.
$16/4^2 = 100/d2^2 \rightarrow 16/16 = 100/d2^2 \rightarrow 1 = 100/d2^2$.
$d2^2 = 100 \rightarrow d2 = 10$ m.

10. Convert the following units into convenient units stated in standard form:

(a) 20 µA into mA = 20×10^{-6} A = 0.02 mA.
(b) 15 pF into µF = 15×10^{-12} F = 0.000015 µF = 1.5×10^{-5} µF.
(c) 7,500,000 cm into km = 7,500,000 × 0.00001 = 75 km.

12. (a) Define the following terms as referred to instruments:

(i) Shunt – A low resistance connected in parallel with a galvanometer or ammeter to allow most of the current to bypass the instrument, thereby extending its range.

(ii) Multiplier – A high resistance connected in series with a galvanometer to limit current flow, thereby enabling it to measure higher voltages.

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(b) A moving coil instrument has a resistance of 40 ohms and it gives a full scale deflection on a current of 20 mA.

(i) Calculate the necessary resistance to enable the instrument read as voltmeter up to 100 V.

Full-scale current Ig = 20 mA = 0.02 A.

Resistance of the coil Rg = 40 Ω.

Voltage to be measured V = 100 V.

Total resistance needed Rt = V / Ig = 100 / 0.02 = 5000 Ω.

Series resistance Rs = Rt – Rg = 5000 – 40 = 4960 Ω.

(ii) Calculate the resistance required to enable the instrument read as an ammeter up to 100 A.

Current through the meter Ig = 0.02 A.

Total current = 100 A.

Shunt current Ish = 100 – 0.02 = 99.98 A.

Voltage across shunt = Ig × Rg = 0.02 × 40 = 0.8 V.

Shunt resistance Rs = V / Ish = 0.8 / 99.98 ≈ 0.008 Ω.

13. (a) Name the three (3) types of self-excited d.c. motor in use.

The three types of self-excited d.c. motors are:

Shunt motor.

Series motor.

Compound motor.

(b) A short shunt compound motor takes 20 A from a supply of 200 V. If its series field, armature and shunt field resistances are 0.5 Ω, 0.2 Ω and 190 Ω respectively, calculate the:

(i) Shunt field current.

Ish = V / Rsh = 200 / 190 = 1.05 A.

(ii) Armature current.

IL = 20 A, Ish = 1.05 A.

Ia = IL – Ish = 20 – 1.05 = 18.95 A.

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(iii) E.m.f. generated.

Ea = V – (Ia × Ra) – (IL × Rse).

= 200 – (18.95 × 0.2) – (20 × 0.5).

= 200 – 3.79 – 10 = 186.2 V.

14. A twin core cable is supplied on both ends and is used to supply currents to the loads X and Y as shown in figure 2. If the resistance per 100 m run of a single core is 0.1 Ω, calculate the p.d. across each load point.

For load X: Distance = 50 m, resistance of each core = (50/100) × 0.1 = 0.05 Ω.

Total loop resistance = 2 × 0.05 = 0.1 Ω.

Voltage drop = I × R = 20 × 0.1 = 2 V.

P.d. across load X = 200 – 2 = 198 V.

For load Y: Distance = (50 + 100 + 40) m = 190 m.

Resistance per core = (190/100) × 0.1 = 0.19 Ω.

Total loop resistance = 2 × 0.19 = 0.38 Ω.

Voltage drop = I × R = 30 × 0.38 = 11.4 V.

P.d. across load Y = 200 – 11.4 = 188.6 V.

15. An a.c. motor develops a power of 40 kW with an efficiency of 80% when rotating at a speed of 1450 r.p.m. Assuming a slip of 4%, calculate the:

(a) Power input to the motor.

Efficiency = Pout / Pin → Pin = Pout / η.

= 40,000 / 0.8 = 50,000 W = 50 kW.

(b) Synchronous speed of the motor.

Ns = Nr / (1 – s) = 1450 / (1 – 0.04).

= 1450 / 0.96 = 1510 rpm.

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16. (a) Define the term “capacitance” as applied to capacitors and state its SI units.

Capacitance is the ability of a capacitor to store electric charge per unit voltage across its plates.
It is given by C = Q/V.
The SI unit is the farad (F).

(b) In the given circuit below, calculate the:

(i) Equivalent capacitance.

The 13 μF and 7 μF are in parallel:
Ceq1 = 13 + 7 = 20 μF.

This Ceq1 is in series with 10 μF:
1/Ceq = 1/10 + 1/20 = (2 + 1)/20 = 3/20.
Ceq = 20/3 = 6.67 μF.

(ii) Total charge supplied in (μC).
Q = Ceq × V = 6.67 × 100 = 667 μC.

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