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 : Nov. 1999**

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).

1. What is meant by the term "resistivity" of a material? Give its SI unit.

Resistivity is the property of a material that quantifies how strongly it resists the flow of electric current. It is defined as the resistance of a unit cube of the material when current flows between opposite faces.
Its SI unit is ohm metre ($\Omega \cdot m$).

2. What are the uses of the following instruments in electrical circuits?

(a) Ohmmeter – It is used to measure electrical resistance in a circuit or component.
(b) Ammeter – It is used to measure the electric current flowing through a circuit in amperes.

3. What are the main losses in transformers?

The main losses in transformers are:
Copper losses due to resistance of the windings.
Iron or core losses which include hysteresis losses and eddy current losses.
Leakage flux losses caused by imperfect magnetic coupling between windings.

4. A double-wound transformer has a 240 V in the primary winding consisting of 2400 turns. Calculate the "volt per turn".

Volt per turn = Primary voltage / Number of turns = 240 / 2400 = 0.1 V per turn.

5. State how eddy-current losses can be reduced in d.c. machines.

Eddy current losses can be reduced by laminating the core, so that eddy currents are restricted within thin sheets.
They can also be reduced by using high-resistivity core materials to limit current flow.

6. The frequency of an oscillating quantity is 50 Hz. What is the period of oscillation?

The period $T = 1 / f = 1 / 50 = 0.02$ seconds.

7. A conductor 0.5 m long carries a current of 25 A and lies at right angles to a magnetic field of density 0.25 T. Determine the force exerted on the conductor.

Force $F = BIL = 0.25 \times 25 \times 0.5 = 3.125$ N.

8. Explain how the power factor of an inductive load may be improved.

The power factor of an inductive load can be improved by connecting capacitors in parallel to supply reactive power locally and reduce the reactive demand from the supply.

It can also be improved by using synchronous condensers or phase-advancing devices to neutralize the lagging reactive power.

9. Define the term "a time constant" of an RC circuit.

The time constant of an RC circuit is the time taken for the voltage across the capacitor to rise to 63% of its final value during charging, or to fall to 37% of its initial value during discharging.
It is given by $\tau = RC$, where R is resistance in ohms and C is capacitance in farads.

10. What is meant by Polarization in a simple voltaic cell?

Polarization is the accumulation of hydrogen gas bubbles on the negative plate of a simple voltaic cell during operation.
It increases internal resistance, reduces the current output, and lowers the efficiency of the cell.

11. What is the power factor of a coil of resistance 5 Ω and inductance 0.1 H when connected to a 250 V, 50 Hz supply? What power will the coil consume under these conditions?

Inductive reactance, $X_L = 2\pi fL = 2 \times 3.142 \times 50 \times 0.1 = 31.4\ \Omega$.
Impedance, $Z = \sqrt{(R^2 + X_L^2)} = \sqrt{(5^2 + 31.4^2)} \approx 31.8\ \Omega$.
Power factor $= R/Z = 5 / 31.8 = 0.157$.
Current $I = V/Z = 250 / 31.8 \approx 7.86$ A.
Power consumed $P = VI \cos\varphi = 250 \times 7.86 \times 0.157 \approx 308.6$ W.

12. A water heater holds 20 litres of water. Calculate the rating in kW of the electric immersion heater which will raise the temperature of the water from 10°C to 88°C in 55 minutes, assuming an efficiency of 85%.

Mass of water = 20 kg (since 1 litre = 1 kg).

Temperature rise $\Delta T = 88 - 10 = 78°C$.

Heat required $Q = mc\Delta T = 20 \times 4200 \times 78 = 6,552,000$ J.

Time $= 55 \times 60 = 3300$ s.

Power input = Q / (t × efficiency) = 6,552,000 / (3300 × 0.85) = 2327 W ≈ 2.33 kW.

13. A load of 19.2 kW is supplied from the terminal of a generator at 240 V. The shunt winding of the generator has a resistance of 96 Ω and the resistance of the armature is 0.2 Ω. There is a brush contact volts drop of 2 V. Calculate:

(a) The armature current

Load current = P/V = 19200 / 240 = 80 A.

Shunt current = V/Rsh = 240 / 96 = 2.5 A.

Armature current = Load current + Shunt current = 80 + 2.5 = 82.5 A.

(b) The generated e.m.f.

Eg = Vt + IaRa + brush drop = 240 + (82.5 × 0.2) + 2 = 240 + 16.5 + 2 = 258.5 V.

14. (a) A double-wound transformer is used to supply 50 V from the 250 V mains. The primary winding contains 1500 turns. Find:

(i) The number of secondary turns

Vs/Vp = Ns/Np → 50/250 = Ns/1500 → Ns = (50 × 1500) / 250 = 300 turns.

(ii) The secondary current when the primary is 5 A

Power in = Power out (ignoring losses).

VpIp = VsIs → 250 × 5 = 50 × Is → Is = 1250/50 = 25 A.

(b) The primary winding of a double-wound step-down transformer takes a current of 6 A at 2000 V. If the transformer ratio is 20:1, calculate:

(i) The secondary voltage

Vs = Vp / 20 = 2000 / 20 = 100 V.

(ii) The secondary current

Power in = Power out (ignoring losses).

$V_pI_p = V_sI_s \rightarrow 2000 \times 6 = 100 \times I_s \rightarrow I_s = 12000/100 = 120$ A.

15. Four Leclanche cells are joined, two in series and two such groups in parallel. The e.m.f. of each cell is 1.5 V and internal resistance 3 Ω. The combination is connected to an external resistance of 3 Ω. Find:

(a) The total internal resistance

Two in series → R = 3 + 3 = 6 Ω.

Two such series groups in parallel → R = 6/2 = 3 Ω.

(b) The current

Total emf = 3 V (since 1.5 + 1.5).

Total resistance = 3 + 3 = 6 Ω.

Current = V/R = 3/6 = 0.5 A.

(c) The current through each cell

Total current = 0.5 A splits equally in two parallel branches.

So each branch carries 0.25 A, and each cell in series also carries 0.25 A.

(d) The voltage across the external resistance

V = IR = 0.5 × 3 = 1.5 V.

16. (a) Define the Inverse Square Law of Illumination.

The illumination (E) on a surface is inversely proportional to the square of the distance (d) from the light source, i.e., $E \propto 1/d^2$.

(b) A fitting designed for a shop window gives a light intensity of 1000 candela downwards. Calculate:

(i) The distance required to produce an illumination of 10 lux on a horizontal display counter.

$E = I/d^2 \rightarrow d^2 = I/E = 1000/10 = 100 \rightarrow d = 10$ m.

(ii) If the distance is doubled, what must be the power of the source to produce the same illumination?

At 20 m, $E = I/d^2 = I/400$. For E to be 10 lux, I must be $10 \times 400 = 4000$ cd.

So the source must have intensity 4000 cd, i.e., 4 times the original.