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 : 2003**

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. 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) According to the law of electromagnetism, like poles

A. attract

B. attract and repel

C. repel

D. intersect

E. intersect at 45° angle

Correct answer: C. Like poles repel each other.

(ii) What is the period of a sinusoidal waveform whose frequency f is 50 Hz?

T = 1/f = 1/50 = 0.02 s.

Correct answer: B. 0.02 s.

(iii) The unit of resistivity of material is

A. ohms

B. ampere-hour

C. ohm-metre

D. mega-ohm

E. ohms/metre

Correct answer: C. Ohm-metre (Ω·m).

(iv) If a 100 W light bulb lights on at an average of 10 hours a day for one week, the weekly consumption of energy will be … units.

Energy = Power × Time = 100 × (10 × 7) = 7000 Wh = 7 kWh = 7 units.

Correct answer: A. 7.

(v) On a purely inductive circuit, the current will lag the voltage by an angle of

A. 90°

B. 45°

C. 120°

D. 60°

E. 30°

Correct answer: A. 90°.

(vi) Which of the following connections is best suited for 3-phase, 4 wire service?

A. Δ - Δ

B. Y - Y

C. Δ - Y

D. Y - Δ

E. series-parallel

Correct answer: C. Δ - Y connection.

(vii) The active material in lead acid cells is

A. spongy lead

B. hydrogen gas

C. calcium carbonate

D. nitrogen gas

E. nickel-cobalt

Correct answer: A. Spongy lead.

(viii) Transformers core are laminated in order to

A. simplify its construction

B. minimize eddy current

C. reduce cost

D. save core material

E. reduce hysteresis loss

Correct answer: B. Minimize eddy current.

(ix) Two heaters rated at 1000 W, 250 V each, are connected in series. 250 V, 50 Hz a.c mains is connected across them. The total power drawn from the supply is

Each heater in series gets half voltage = 125 V.

Power of each heater = V^2/R. R = $(250^2)/1000$ = 62.5 Ω.

Power per heater = $(125^2)/62.5$ = 250 W.

Total power = 2 × 250 = 500 W.

Correct answer: B. 500 W.

(x) Weber is the unit of

A. flux density

B. flux

C. reluctance

D. permeability

E. light intensity

Correct answer: B. Flux.

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2. A certain wire has a resistance of 50 Ω at 10 °C. Calculate the value of its resistance when the temperature rises to 110 °C given that the value of temperature coefficient of the wire is 0.0062 per °C at 0 °C.

R = R0 [1 + α (T – T0)].

= 50 [1 + 0.0062 × (110 – 10)].

= 50 [1 + 0.62].

= 50 × 1.62 = 81 Ω.

3. Two capacitors A and B are connected in series across a 100 V supply and it is observed that the capacitances of A and B are 60 μF and 40 μF respectively. Calculate the potential difference across each capacitor.

Ceq = (C1 × C2)/(C1 + C2) = (60 × 40)/(100) = 24 μF.

Charge Q = Ceq × V = 24 × 100 = 2400 μC.

VA = Q / C1 = 2400/60 = 40 V.

VB = Q / C2 = 2400/40 = 60 V.

4. State any two properties of a good heating element.

High resistivity.

High melting point.

Should not oxidize easily.

Good mechanical strength.

5. Calculate the primary current of a 6600/400 V transformer when its secondary current is 200 A.

I1/I2 = V2/V1.

I1 = (V2/V1) × I2 = (400/6600) × 200 = 12.12 A.

6. Calculate the total lamp flux required to provide a service value of 100 lux in a room of 7 m × 4 m. The utilization and maintenance factors are respectively 0.6 and 0.8.

Area = 7 × 4 = 28 m².

Flux required = (E × A)/(UF × MF).

= (100 × 28)/(0.6 × 0.8) = 2800/0.48 = 5833 lumens.

7. State three parameters which determine the resistance of a conductor.

Length of the conductor.

Cross-sectional area.

Resistivity of the material.

Temperature.

8. A moving coil instrument which has a resistance of 10 Ω gives a full-scale deflection with 10 mA. Calculate the resistance required in parallel to enable the instrument to read up to 2 A.

Current through shunt = 2 – 0.01 = 1.99 A.

Voltage across meter = Im × Rm = 0.01 × 10 = 0.1 V.

Rsh = V/Ish = 0.1 / 1.99 = 0.0503 Ω.

9. State two basic methods of battery charging.

Constant current method.

Constant voltage method.

10. Determine the magnetizing force of a coil of 90 turns carrying a current of 5 A on a 0.15 m long magnetic circuit.

Magnetizing force $H = NI/L = (90 \times 5)/0.15 = 450/0.15 = 3000$ A/m.

11. Calculate the synchronous speed of a two pole machine supplied with 220 V, 50 Hz.

$Ns = 120f/P = (120 \times 50)/2 = 3000$ rpm.

12. The primary winding of a single phase transformer is connected to a 230 V, 50 Hz supply. The secondary winding has 1600 turns. If the maximum value of flux is 2 mWb, determine:

(a) The number of turns in the primary winding.
Formula: $V1 = 4.44\ f\ N1\ \Phi max$.
Rearrange: $N1 = V1 / (4.44 \times f \times \Phi max)$.
$= 230 / (4.44 \times 50 \times 2 \times 10^{-3})$.
$= 230 / (0.444)$.
$= 518$ turns (approx).

(b) The secondary induced e.m.f.
$E2/E1 = N2/N1$.
$E1 = V1 = 230$ V.
$E2 = (N2/N1) \times E1 = (1600 / 518) \times 230$.
$= 3.09 \times 230 = 710$ V (approx).

(c) The cross sectional area of core if the flux density is 0.5 Tesla.
Flux density $B = \Phi/A$.
$A = \Phi/B = (2 \times 10^{-3}) / 0.5$.
$= 0.004$ m².
$= 40$ cm².

13. (a) Explain the effect of armature reaction on the flux distribution of the DC machine.

Armature reaction in a DC machine is the effect of the magnetic field set up by the armature current on the distribution of the main flux. It distorts the flux distribution, causing a shift in the magnetic neutral

axis. This distortion leads to sparking at the brushes, reduced efficiency, and demagnetization of the main poles, which weakens the generated emf or torque.

(b) An eight pole lap connected armature has 96 slots with 6 conductors per slot and is driven at 600 rev/min. The useful flux per pole is 0.09 Wb. Calculate the generated e.m.f.

Total conductors, $Z = 96 \times 6 = 576$.
Poles, $P = 8$.
Parallel paths, $A = 8$ (lap winding).
Flux per pole, $\Phi = 0.09$ Wb.
Speed, $N = 600$ rpm.

Generated emf $Eg = (\Phi \times Z \times P \times N) / (60 \times A)$.
$= (0.09 \times 576 \times 8 \times 600) / (60 \times 8)$.
$= (0.09 \times 576 \times 600) / 60$.
$= (31{,}104) / 60$.
$= 518.4$ V.

Eg = **518 V**.

14. (a) Write the expression for resonance frequency in a circuit consisting of R, L and C in series.

The resonance frequency is given by:
$fr = 1 / (2\pi\sqrt{(LC)})$.

(b) A 15 Ω non-reactive resistor is connected in series with a coil of inductance 0.08 H and negligible resistance. The combined circuit is connected to a 240 V, 50 Hz supply. Calculate:

(i) The reactance of the coil.
$XL = 2\pi fL = 2\pi \times 50 \times 0.08 = 25.13\ \Omega$.

(ii) The impedance of the circuit.
$Z = \sqrt{(R^2 + XL^2)} = \sqrt{(15^2 + 25.13^2)}$.
$= \sqrt{(225 + 631.5)} = \sqrt{856.5} = 29.3\ \Omega$.

(iii) The current in the circuit.

$I = V / Z = 240 / 29.3 = 8.19$ A.

(iv) The power factor of the circuit.

$\cos\varphi = R / Z = 15 / 29.3 = 0.512$.

15. (a) Write down Kirchhoff's laws.

Kirchhoff's Current Law (KCL): The algebraic sum of currents at a junction is zero, i.e. total current entering a node equals the total current leaving.

Kirchhoff's Voltage Law (KVL): The algebraic sum of all voltages around a closed loop is zero, i.e. sum of EMFs = sum of potential drops.

(b) Two batteries are connected in parallel. The e.m.f. and internal resistance of one battery are 120 V and 10 Ω respectively and the corresponding values for the other are 150 V and 20 Ω. A resistor of 50 Ω is connected across the battery terminals. Calculate:

(i) The current through the 50 Ω resistor.

Let V = terminal voltage across the batteries.

Equation using KCL:

$(V – 120)/10 + (V – 150)/20 + V/50 = 0$.

Multiply through by 100:

$10(V – 120) + 5(V – 150) + 2V = 0$.

$10V – 1200 + 5V – 750 + 2V = 0$.

$17V – 1950 = 0$.

$V = 1950 / 17 = 114.7$ V.

Current through 50 Ω resistor $= V / 50 = 114.7 / 50 = 2.29$ A.

(ii) The value and direction of the current through the battery.

Current from 120 V battery = (120 – V)/10 = (120 – 114.7)/10 = 0.53 A (delivering).
Current from 150 V battery = (150 – V)/20 = (150 – 114.7)/20 = 1.77 A (delivering).

So both batteries deliver current, with total supplied = 0.53 + 1.77 = 2.3 A, which balances the 2.29 A load current.

16. (a) Define (i) rectifier, (ii) inverter, (iii) generator.

(i) Rectifier: A device that converts alternating current (a.c.) to direct current (d.c.).
(ii) Inverter: A device that converts direct current (d.c.) into alternating current (a.c.).
(iii) Generator: A machine that converts mechanical energy into electrical energy.

(b) Draw the circuit for a full wave single phase bridge rectifier. If a resistive load is connected in that circuit, draw the input and output voltage and current waveforms for two periods.

- The bridge rectifier consists of 4 diodes arranged in a bridge configuration, with the a.c. supply connected across one diagonal and the load resistor across the other.
- In each half cycle, two diodes conduct and direct current flows through the load in the same direction.
- The input waveform is a sinusoidal a.c. wave, while the output waveform is a pulsating d.c. with both halves of the input rectified.
- The current through the load resistor follows the output voltage, being pulsating d.c. with no reversal.