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 : 2021**

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).

SECTION A (10 Marks)

Answer all questions in the section

1. Choose the correct answer from the given alternatives A to E and write its letter in the answer booklet provided:

i) What is the name given to the two sets of deflection coils in the cathode ray tube?

A. Scanning coils

B. Focussing coils

C. Electrostatic coils

D. Brightness coils

E. Reflection coil

Correct answer: A. Scanning coils

Reason: In a CRT, scanning coils are used to deflect the electron beam horizontally and vertically to produce the picture.

ii) Which of the following is the effect of electric current?

A. Electrical effect

B. Mechanical effect

C. Heating effect

D. Potential effect

E. Current effect

Correct answer: C. Heating effect

Reason: Current produces heating in conductors due to Joule's law (I^2R losses), which is one of its main effects.

iii) What is the term used to represent alternating current generators?

A. Silent pole generators

B. Shielded pole generators

C. Dynamometer

D. Alternators

E. Dynamos

Correct answer: D. Alternators

Reason: Alternating current generators are called alternators, while dynamos generate direct current.

iv) What is the major function of a rectifier circuit in electrical devices?

A. To convert a.c to d.c

B. To rectify d.c to a.c

C. To change single phase to 3 phase

D. To step up voltage and current

E. To step up current

Correct answer: A. To convert a.c to d.c

Reason: A rectifier allows current in one direction only, converting alternating current to direct current.

v) How can the range of the voltmeter be extended?

A. By connecting a parallel resistor

B. By connecting a shunt resistor

C. By connecting a series resistor

D. By connecting a low value resistor

E. By connecting a load resistor

Correct answer: C. By connecting a series resistor

Reason: Adding a high resistance in series limits current, allowing measurement of higher voltages.

vi) What will be the relationship between voltage and current when a.c voltage is applied across a pure resistor?

A. Voltage and current will be out of phase.

B. Current will lead voltage by 90^o.

C. Voltage will lead current by 90^o.

D. Voltage and current will be in phase.

E. Angle between voltage and current will be 90^o

Correct answer: D. Voltage and current will be in phase

Reason: In a pure resistor, voltage and current vary together with no phase difference.

vii) Which laws are associated with electromagnetic induction?

A. Ohms' law and Faraday's law

B. Faraday's law and Lenz's law

C. Lenz's law and Newton's law

D. Joule's law and Faraday's law

E. Faraday's law and Kirchhoff's laws

Correct answer: B. Faraday's law and Lenz's law

Reason: Faraday's law explains how emf is induced by changing flux, while Lenz's law states the direction of induced emf opposes the change.

viii) What is a characteristic of a material that is negatively charged?

A. Has more proton than electrons.

B. Has more neutrons than electrons.

C. Has more number of neutrons.

D. Has more electrons than protons.

E. Has equal number of protons and electrons.

Correct answer: D. Has more electrons than protons

Reason: Negative charge means excess electrons compared to protons.

ix) Which one is the basic requirement for an e.m.f to be induced in a coil?

A. The magnetic flux should link the coil.

B. Current of the coil should be constant.

C. The coil to be induced should form a loop.

D. The flux density near the coil should be less

E. The magnetic flux linking the coil should change

Correct answer: E. The magnetic flux linking the coil should change

Reason: According to Faraday's law, emf is induced only when there is a change in magnetic flux linkage.

x) Why permanent magnet moving coil current ammeters have a uniform scale?

A. It reduces eddy current damping.

B. They have full deflection torque

C. Its speed is constant.

D. They are spring controlled

E. Their deflection torque is equal to unit

Correct answer: D. They are spring controlled

Reason: The spring control makes the deflection directly proportional to current, resulting in a uniform scale.

SECTION B (45 Marks)

Answer all questions from this section

2. (a) Outline two necessary conditions to be considered when selecting a cable for a particular circuit.

The current carrying capacity of the cable must be considered to ensure that the conductor can safely handle the expected load without overheating.

The insulation type of the cable must be appropriate for the operating voltage and environmental conditions, such as moisture, temperature, and chemical exposure.

(b) How is the resistance of the following materials affected by the increase in temperature?

(i) Conductor

The resistance of a conductor increases with rise in temperature because increased atomic vibrations hinder the flow of electrons.

(ii) Insulator

The resistance of an insulator decreases with rise in temperature because higher thermal energy liberates more charge carriers, making it less resistive.

3. Determine the value of resistance required to be connected in series with a 600 W kettle to cause voltage falling from 240 V to 220 V.

Power of kettle, P = 600 W

Rated voltage = 220 V

Resistance of kettle, $R_k = V^2 / P = (220^2) / 600 = 48400 / 600 = 80.7\ \Omega$

Required voltage drop = 240 – 220 = 20 V

Current drawn by kettle, $I = V / R = 220 / 80.7 = 2.73$ A

Series resistance, $R_s = V_{drop} / I = 20 / 2.73 = 7.33\ \Omega$

4. Give five reasons for electrical engineers to concentrate much on improving power factor of A.C circuit.

Improving power factor reduces the reactive power demand, allowing more real power to be transmitted with the same system capacity.

It reduces line current for the same power, which lowers copper losses and improves efficiency of transmission and distribution systems.

It minimizes the voltage drops in transmission lines, ensuring better voltage regulation and supply quality.

It allows smaller sizes of equipment such as cables, transformers, and generators to be used, reducing cost.

It saves on electricity bills for consumers since utilities often impose penalties for low power factor.

5. A flux of 25 mWb links with a 1500 turns coil when a current of 3A passes through the coil. Calculate:
   (a) The inductance of the coil
   (b) The energy stored in the magnetic field
   (c) The average induced e.m.f if the current falls to zero in 150 ms

Flux linkage = $N\Phi = 1500 \times 25 \times 10^{-3} = 37.5$ Wb-turns

Current, $I = 3$ A

(a) Inductance, $L = (N\Phi) / I = 37.5 / 3 = 12.5$ H

(b) Energy stored, $W = \frac{1}{2} LI^2 = 0.5 \times 12.5 \times (3^2) = 0.5 \times 12.5 \times 9 = 56.25$ J

(c) Average induced emf = $(L\Delta I) / \Delta t = (12.5 \times 3) / 0.150 = 37.5 / 0.150 = 250$ V

6. A 70 cm long conductor carrying a current of 200 A lies perpendicular to the magnetic field strength of 3000 AT/m in air. If the conductor moves against this force, what will be the value of the following parameters?

Force on conductor: $F = BIL$
Magnetic flux density, $B = \mu 0 \times H = (4\pi \times 10^{-7} \times 3000) = 3.77 \times 10^{-3}$ T
Length, $L = 0.7$ m, $I = 200$ A

$F = BIL = 3.77 \times 10^{-3} \times 200 \times 0.7 = 0.529$ N

So, the force on the conductor is 0.529 N.

7. (a) What does it imply when a material is said to have positive temperature coefficient?

It means the resistance of the material increases when temperature increases. This is typical for conductors like metals.

(b) A coil has a resistance of 10 Ω when its mean temperature is 20ºC and it is 20 Ω when its mean temperature is 50ºC. Find the temperature coefficient of the coil at 0ºC.

$R1 = 10\ \Omega$ at 20°C, $R2 = 20\ \Omega$ at 50°C
Temperature coefficient $\alpha 0 = (R2 – R1) / (R1 \times (T2 – T1))$
$= (20 – 10) / (10 \times (50 – 20)) = 10 / (10 \times 30) = 10 / 300 = 0.033/°C$

8. (a) Give the meaning of the term “armature reaction” as applied in D.C machines.

Armature reaction is the effect of the magnetic field produced by the armature current on the main field flux distribution, causing distortion and weakening of the main flux.

(b) Why ammeter reaction is not suitable on d.c machine? Give two reasons.

It causes distortion of the flux, leading to poor commutation and sparking at brushes.
It weakens the main field, reducing the generated emf and efficiency of the machine.

(c) Why is it not recommended for the d.c series motor to be switched ON at no load?

Because at no load, the current is small, and the flux is weak, causing the motor to accelerate to dangerously high speed which may damage the motor.

9. A load of 30 KVA at unity power factor is used to supply primary voltage of 3300 V. If the step down transformer ratio is 15:1; Calculate:
   (a) Secondary voltage.
   (b) Primary current.
   (c) Secondary current.

Transformer ratio = Np:Ns = 15:1

(a) Secondary voltage Vs = Vp / 15 = 3300 / 15 = 220 V

(b) Primary current Ip = S / Vp = 30000 / 3300 = 9.09 A

(c) Secondary current Is = S / Vs = 30000 / 220 = 136.4 A

10. (a) A lamp rated 230 V gives an illumination of 6000 lux and takes 1.5 A from the mains. Calculate the efficiency of the lamp.

Power input = VI = 230 × 1.5 = 345 W
Luminous flux = 6000 lm
Assuming luminous efficacy conversion factor 1 lm = 0.001464 W
Luminous output = 6000 × 0.001464 = 8.78 W
Efficiency = (8.78 / 345) × 100 = 2.55 %

(b) A school electrical technician wants to fix fluorescent lamps in a new classroom. He decided to use startles method in starting the lamps. Why does the technician decided to use startles method? Give two reasons.

Because the starter provides a high voltage surge necessary to strike the discharge in the lamp.

Because the starter helps in preheating the electrodes, which ensures reliable ignition and longer lamp life.

SECTION C (45 Marks)

Answer any three (3) questions from this section

11. (a) Identify two types of tests which must be carried out in transformer and for each type give reason for carrying such a test.

Open-circuit test: This test is performed with the secondary winding open to measure core (iron) losses and no-load current. It helps determine the core losses and magnetizing current.

Short-circuit test: This test is performed with the secondary winding shorted and a reduced voltage applied to measure copper losses. It helps determine copper losses and equivalent impedance of the transformer.

(b) When tested, a 20 kVA transformer was found to have 600 watts iron losses, and 700 watts copper losses when supplying full load at unity power factor. Calculate;

(i) The efficiency of a transformer at unity p.f on full load.

(ii) Output power on half load.

(iii) Copper loss at half load.

S = 20 kVA = 20000 VA, $\cos \varphi = 1$

Output (full load) = 20000 W

Total losses = Iron + Copper = 600 + 700 = 1300 W

(i) Efficiency = Output / (Output + Losses) × 100

= 20000 / (20000 + 1300) × 100 = 20000 / 21300 × 100 = 93.9%

(ii) At half load, output = 20000 × 0.5 = 10000 W

(iii) Copper loss $\propto I^2$, at half load = $(\frac{1}{2})^2 \times 700 = \frac{1}{4} \times 700 = 175$ W

12. Three coils, each having a resistance of 15 Ω and an inductance of 10 Ω, connected in star at a 400V, 3 phase 50Hz supply.

(a) Sketch a circuit for 3 phase star connected coils showing the position of phase and line voltages.

The sketch shows three coils connected with one end joined at a common neutral point, and the other ends connected to the three supply lines forming a star (Y) connection. Phase voltages are from line to neutral, line voltages are between supply lines.

(b) Calculate:

(i) The line current.

(ii) Power factor.

(iii) Power supplied.

$R = 15\ \Omega$, $X_L = 10\ \Omega$

Impedance per phase $Z = \sqrt{(R^2 + X_L^2)} = \sqrt{(225 + 100)} = \sqrt{325} = 18.03\ \Omega$

Phase voltage $V_{ph} = V_L / \sqrt{3} = 400 / 1.732 = 231$ V

Phase current $I_{ph} = V_{ph} / Z = 231 / 18.03 = 12.8$ A

Line current $I_L = I_{ph} = 12.8$ A

(i) Line current = 12.8 A

(ii) Power factor = $R / Z = 15 / 18.03 = 0.832$ (lagging)

(iii) Power = $\sqrt{3} \times V_L \times I_L \times \cos\varphi$

$= 1.732 \times 400 \times 12.8 \times 0.832 = 7392\ W \approx 7.39$ kW

13. (a) Briefly describe three types of torques required for operation of indicating measuring instruments.

Deflecting torque: This is produced by the current or voltage to be measured and moves the pointer from its zero position.

Controlling torque: This is provided by a spring or gravity to oppose deflection torque and bring the pointer to equilibrium at the correct reading.

Damping torque: This prevents oscillations of the moving system and allows the pointer to settle quickly at the final reading.

(b) A voltage coil of a dynamometer type wattmeter is connected across the load side and reads 200 W. If the load voltage is 245 V and the resistance of the voltage being 3612 Ω. Calculate the following:

(i) True power across the load.

(ii) Percentage error due to wattmeter connection.

Power reading = 200 W

Load voltage = 245 V, resistance of voltage coil = 3612 Ω

Current in voltage coil Iv = V / R = 245 / 3612 = 0.0679 A

Power loss in voltage coil = V × Iv = 245 × 0.0679 = 16.6 W

(i) True power across load = Wattmeter reading – coil loss = 200 – 16.6 = 183.4 W

(ii) Percentage error = (Error / True value) × 100 = (16.6 / 183.4) × 100 = 9.05%

14. Calculate the flux density in the iron, absolute permeability of iron, relative permeability of iron and resistance of the magnetic circuit consisting of an iron ring of mean circumference of 80 cm with a cross sectional area of 12 cm^2 throughout, if a current of 1 ampere in the magnetizing coil of 200 turns produced a total flux of 1.2 mWb in the core.

Mean length l = 0.8 m, A = 12 cm^2 = 12 × 10^{-4} m^2 = 0.0012 m^2

Flux Φ = 1.2 mWb = 1.2 × 10^{-3} Wb

Turns N = 200, I = 1 A

Flux density B = Φ / A = 1.2 × 10^{-3} / 0.0012 = 1 T

Field strength H = NI / l = (200 × 1) / 0.8 = 250 A/m

Absolute permeability μ = B / H = 1 / 250 = 0.004 H/m

Relative permeability μr = μ / μ0 = 0.004 / (4π × 10^{-7}) = 0.004 / 1.256 × 10^{-6} = 3183

Reluctance of magnetic circuit = mmf / Φ = NI / Φ = 200 / 0.0012 = 1.67 × 10^5 At/Wb