THE UNINTED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

FORM TWO NATIONAL ASSESSMENT

080 ELECTRICAL ENGINEERING

Time: 2:30 Hours **ANSWERS** **Year: 2011**

Instructios:

1. this paper consists of sections A and B with total of eleven questions
2. answer all questions in section A. In section B answer all questions in either part I or part II depending on the area of your specialization.
3. All answers must be written in spaces provided.

1. Choose the correct answer and write its corresponding letter in the box provided:

(i) Electromagnetism is applied in:
A. Non-magnetic circuits
B. Atomic wiring systems
C. Electric bells and transformers (Correct Answer)
D. Electric lines and conveyor belts
Reason: Electromagnetism is fundamental in the operation of electric bells and transformers due to the induction of magnetic fields.

(ii) The unit of power is:
A. Ohms
B. Joule
C. Watt (Correct Answer)
D. Coulomb
Reason: Watt is the SI unit of power, defined as energy per unit time.

(iii) Gloves, safety belts, and fire extinguishers are considered as:
A. Circuit insulators
B. First aid tools
C. Protective devices (Correct Answer)
D. Semi-conductor materials
Reason: These items are used for personal protection in electrical environments.

(iv) In electrical works, a folding ruler is used for measuring:
A. Folded distances
B. Height from the ground floor to the roof
C. Short distances (Correct Answer)
D. Undetermined angles
Reason: A folding ruler is designed to measure short and precise lengths.

(v) The movement of electrons in a conductor is caused by:
A. A current in a conductor
B. An e.m.f. (Correct Answer)
C. An inductance
D. Equal potentials between the terminals
Reason: Electromotive force (e.m.f.) creates the potential difference that drives electrons in a conductor.

(vi) Two resistors, each having a resistance of 50 Ω, are connected in parallel. The equivalent resistance of the circuit is:
A. 25 Ω (Correct Answer)
B. 50 Ω
C. 100 Ω

D. 40 Ω
Reason: Parallel resistance is calculated using the formula:
$1/R = 1/R_1 + 1/R_2$.
Substituting, $1/R = 1/50 + 1/50 = 2/50$; $R = 25\ \Omega$.

(vii) A capacitor of 2 μF charged to a potential difference of 150 V is connected in parallel with an uncharged capacitor of 4 μF. What is the voltage existing in the combination?
A. 50V
B. 100V (Correct Answer)
C. 75V
D. 150V
Reason: The total charge is conserved, and the equivalent capacitance is used to calculate the final voltage.

(viii) The function of a rectifier is to:
A. Charge heat energy into electrical energy
B. Convert a.c. voltage into d.c. voltage (Correct Answer)
C. Convert d.c. voltage into a.c. voltage
D. Generate magnetic fields
Reason: Rectifiers are used to convert alternating current (a.c.) into direct current (d.c.).

(ix) One of the functions of a charged cell is:
A. Changes in colour of the plates
B. Changes specific gravity (Correct Answer)
C. Builds deposits on plates
D. Changes polarity
Reason: Specific gravity changes indicate the state of charge in cells, especially lead-acid batteries.

(x) Ohm's law does not apply to:
A. Conductors
B. Semi-conductors
C. Dielectrics
D. Semi-conductors and dielectrics (Correct Answer)
Reason: Ohm's law is valid for linear and ohmic materials but not for semiconductors or insulators.

2. (a) Define the following:

(i) Cable
A cable is a bundle of one or more wires covered with an insulating material, used to carry electrical power or signals between devices or locations.

(ii) Conductor
A conductor is a material that allows the flow of electric current, typically made of metals such as copper or aluminum due to their high electrical conductivity.

(iii) Insulator
An insulator is a material that resists the flow of electric current and is used to prevent electrical leakage or protect components. Examples include rubber and glass.

(b) (i) What is a transformer?
A transformer is an electrical device used to transfer electrical energy between two or more circuits through electromagnetic induction, often for stepping up or stepping down voltage levels.

(ii) A transformer is required to step down 1320 V to 240 V at 50 Hz. If the transformer needs to have 1.5 V per turn, calculate the number of turns on both primary and secondary windings.
Given:
Primary voltage (Vp) = 1320 V
Secondary voltage (Vs) = 240 V
Voltage per turn = 1.5 V

Primary turns (Np) = Vp / Voltage per turn
Np = 1320 / 1.5 = 880 turns
Secondary turns (Ns) = Vs / Voltage per turn
Ns = 240 / 1.5 = 160 turns

Answer:
Primary turns = 880
Secondary turns = 160

(c) Define the following terms:

(i) Cable
A cable is a bundle of electrical conductors enclosed within an insulating material, used to transmit electricity or communication signals.

(ii) Conductor
A conductor is a material that permits the flow of electric charge, typically made of highly conductive metals like copper or silver.

(iii) Insulator
An insulator is a material that restricts the free flow of electricity, ensuring safety and efficiency in electrical systems. Examples include plastic and ceramic.

(d) A PVC twin copper cable 50 m long has a total voltage drop of 8 V when it is carrying a current of 40 A. Calculate the cross-sectional area of the cable, given that the resistivity of copper is 1.7 μΩcm.

Voltage drop (V) = IR

Resistance (R) = ρL / A

Where:
ρ = resistivity of copper = 1.7 × 10^-8 Ωm
L = length of cable = 50 × 2 = 100 m (considering return path)
I = current = 40 A
V = 8 V

R = V / I = 8 / 40 = 0.2 Ω

From R = ρL / A:
A = ρL / R
A = (1.7 × 10^-8 × 100) / 0.2
A = 8.5 × 10^-6 m²

Cross-sectional area = 8.5 mm²

3. (a) List two materials used to produce wires for high-voltage transmission lines.
(i) Aluminum
(ii) Copper

(b) Mention two advantages of using clad-steel wires and high towers for high-voltage transmission lines.
(i) Clad-steel wires provide higher strength to withstand mechanical stresses.
(ii) High towers help reduce the risk of short circuits by maintaining a safe clearance between conductors and the ground.

(c) What is a fuse?
A fuse is a safety device designed to protect an electrical circuit from excessive current by breaking the circuit when the current exceeds a specific value, thereby preventing damage to equipment or fire hazards.

(d) Write three types of fuse.
(i) Cartridge fuse
(ii) Blade fuse
(iii) Resettable fuse

(e) Briefly describe three applications of heating effects of an electric current.

(i) Electric Heaters
Electric current is used to generate heat in devices such as room heaters, irons, and water heaters for domestic and industrial purposes.

(ii) Electric Lighting
The heating effect of current is used in incandescent light bulbs, where the filament is heated to emit light.

(iii) Soldering
The heating effect is applied in soldering irons, which use heat generated by current to melt solder for joining wires and components.

4. (a) Calculate the resistivity of aluminum wire if a length of 100 m aluminum conductor with a cross-sectional area of 4 mm² has a measured resistance of 0.07 Ω.

Formula:
Resistivity (ρ) = R × A / L
Where:
R = 0.07 Ω
A = 4 mm² = 4 × 10^-6 m²
L = 100 m

ρ = (0.07 × 4 × 10^-6) / 100
ρ = 2.8 × 10^-9 Ωm

Answer: Resistivity = 2.8 × 10^-9 Ωm

(b) Explain the term "Earth resistance."
Earth resistance refers to the resistance offered by the soil to the flow of electric current into the ground, which is a critical factor in ensuring the safety and effectiveness of electrical grounding systems.

(c) Design a lighting circuit of two lamps connected in series, with ratings of 60 W and 100 W.
To design a series circuit, both lamps are connected in a single path, sharing the same current. The total resistance and power distribution will depend on their ratings and the applied voltage.

(d) An electric heater is rated 240 V, 3.2 kW. Calculate the power output if the supply falls by 10%.

Given:
Rated voltage (V) = 240 V
Power (P) = 3.2 kW = 3200 W

New voltage = 240 - (10% of 240) = 240 - 24 = 216 V

Using the power formula:
P_new = P × (V_new / V)^2
P_new = 3200 × (216 / 240)^2
P_new = 3200 × 0.81
P_new = 2592 W

Answer: Power output = 2592 W

(e) What is "First Aid"?
First aid is the immediate assistance or treatment provided to an injured or ill person before professional medical help arrives, aimed at minimizing harm and stabilizing the individual's condition.

5. (a) Briefly explain the applications of a dimmer switch.
A dimmer switch is used to:
- Adjust the brightness of lights by varying the electrical power supplied to the bulb.
- Create a desired ambiance or mood lighting in residential, commercial, and theatrical settings.
- Save energy by reducing the power consumed by lighting systems.
- Extend the lifespan of light bulbs by operating them at reduced brightness.

(b) The specific resistance of platinum is 10.3 μΩ·cm. Calculate the length of a conductor made from platinum if its diameter is 0.548 mm. Assume resistance of platinum is 4 Ω.

Given:
Specific resistance (ρ) = 10.3 × 10^-6 Ω·cm = 10.3 × 10^-8 Ω·m
Diameter (d) = 0.548 mm = 0.548 × 10^-3 m
Radius (r) = d / 2 = 0.274 × 10^-3 m
Resistance (R) = 4 Ω

Formula:
$R = \rho \times (L / A)$, where $A = \pi r^2$

Rearranging for L:
$L = R \times A / \rho$

$A = \pi r^2 = \pi \times (0.274 \times 10^{-3})^2 = 2.356 \times 10^{-7}\ m^2$

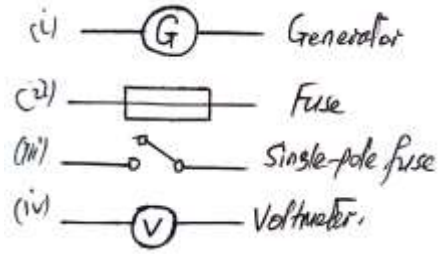
$L = (4 \times 2.356 \times 10^{-7}) / (10.3 \times 10^{-8})$
L = 9.15 m

Length of conductor = 9.15 m

(c) (i) Define the term "Ampere."
Ampere is the unit of electric current in the International System of Units (SI), defined as the amount of electric charge flowing through a conductor in one second.

(ii) Briefly explain how electric power is obtained.
Electric power is obtained by converting energy from various sources such as coal, natural gas, nuclear, wind, and solar into electrical energy using power generation systems. The power is then distributed through the grid to end users.

6. (a) Sketch a neat symbol for each of the following:
(i) Generator
(ii) Fuse
(iii) Single-pole switch
(iv) Voltmeter



(b) What is the importance of rectification?
Rectification is important as it converts alternating current (AC) into direct current (DC), which is essential for powering electronic devices and charging batteries.

(c) Why are resistors used in electronic circuits?
Resistors are used to:
- Control the flow of electric current and protect components from damage.
- Divide voltages in a circuit to meet specific design requirements.
- Act as load components in testing and measuring instruments.

(d) A moving coil instrument of resistance 5 Ω gives a full-scale deflection with 0.015 A. Calculate the resistance of a resistor connected in parallel to allow the instrument to read up to 2 A.

Given:
$R = 5\ \Omega$, $I1 = 0.015$ A, $I2 = 2$ A
Parallel resistance formula:
$1/R_{total} = 1/R + 1/R_p$
Current ratio:
$I1/I2 = Rp/(R + Rp)$
Solving for Rp:
$Rp \approx 0.038\ \Omega$
Resistance of the parallel resistor = $0.038\ \Omega$

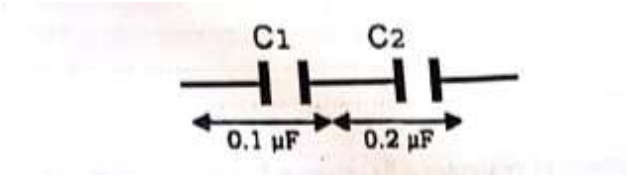
7. (a) What is electric field intensity?
Electric field intensity is the force experienced per unit charge at a point in an electric field. It is expressed as:
$E = F / Q$
where E is the electric field intensity, F is the force, and Q is the charge.

(b) Briefly explain the factors that affect the capacitance of a capacitor.
- Area of the plates: Increasing the surface area of the plates increases the capacitance because more charge can be stored.
- Distance between the plates: Reducing the distance between the plates increases the capacitance as the electric field strength becomes stronger.
- Dielectric material: The type of material between the plates affects the capacitance, as materials with higher dielectric constants allow more charge to be stored.

- Temperature: Changes in temperature can alter the dielectric properties of the material, affecting the capacitance.

(c) Write down the recommended electric solder.
The recommended electric solder is typically a combination of tin and lead, such as 60/40 solder (60% tin and 40% lead), or lead-free solder for modern applications.

(d) In the figure below, calculate the voltage across C1.



Given:
C1 = 0.1 μF
C2 = 0.2 μF

For capacitors in series:
1/C_total = 1/C1 + 1/C2
1/C_total = 1/0.1 + 1/0.2
C_total = 0.067 μF

Voltage division rule:
Voltage across C1 = (C_total / C1) × Total Voltage

(Provide the total voltage to complete the calculation.)

8. (a) Write the colour code for the following resistances:
(i) 60 kΩ: Blue, Black, Orange
(ii) 40 Ω: Yellow, Black, Black
(iii) 25 kΩ: Red, Green, Orange
(iv) 72 kΩ: Violet, Red, Orange
(v) 120 Ω: Brown, Red, Brown

(b) What is a tunnel diode?
A tunnel diode is a highly doped semiconductor diode with a negative resistance region in its current-voltage characteristic, allowing it to operate at very high speeds. It is used in oscillators, amplifiers, and high-frequency applications.

(c) What is meant by “impedance in a transformer”?
Impedance in a transformer refers to the opposition to alternating current due to both resistance and reactance in the windings and the magnetic core.

(d) Write down the importance of impedance in a transformer.

- It limits the fault current during short circuits, protecting the transformer and connected systems.
- It affects voltage regulation by determining how much the output voltage changes with varying load conditions.
- Impedance matching ensures maximum power transfer between the transformer and connected devices.