THE UNINTED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

FORM TWO NATIONAL ASSESSMENT

080 ELECTRICAL ENGINEERING

Time: 2:30 Hours **ANSWERS** **Year: 2019**

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. For each of the items (i)–(x), choose the correct answer from among the given alternatives and write its letter in the box provided. Include reasons for the correct answer.

(i) What is the SI unit of electromotive force?
A. Faraday
B. Ampere
C. Volt
D. Ohm
Answer: C. Volt
Reason: The SI unit of electromotive force (e.m.f) is the volt (V), which measures the potential difference that drives current in a circuit.

(ii) A transformer having 1000 primary turns is connected to a 240 V supply with a secondary voltage of 400 V. What is the number of turns on the secondary side?
A. 1600
B. 250
C. 1000
D. 2000
Answer: A. 1600
Reason: The relationship between the turns and voltage in a transformer is given by $v1/v2=N1/N2$. Substituting values: $240/400 = 1000/N2$, solving gives $N2 = 1600$

(iii) A cell of an open circuit has an e.m.f of 2.2 V and terminal voltage of 2.0 V. What is the internal resistance of a cell when the load current is 0.2 A?
A. 0.1 Ω
B. 1 Ω
C. 0.11 Ω
D. 0.2 Ω
Answer: B. 1 Ω
Reason: Internal resistance is calculated using $r = (E - V)/I$. Substituting $r = (2.2 - 2..0)/2 = 1$

(iv) What is the frequency of a d.c. power supply used in Tanzania?
A. 50 Hz
B. 60 Hz
C. Zero
D. 100 Hz
Answer: C. Zero
Reason: Direct current (d.c.) does not alternate, so its frequency is always zero.

(v) When an atom either gains or loses an electron it is said to be:
A. Bonded
B. Ionized
C. Stabilized

D. Excited
Answer: B. Ionized
Reason: Ionization occurs when an atom gains or loses electrons, forming an ion.

(vi) Which of the following materials is the best conductor of electricity?
A. Cold water
B. Distilled water
C. Warm water
D. Salt water
Answer: D. Salt water
Reason: Salt water contains ions, which enhance conductivity compared to pure or distilled water.
(vii) The electrical network that does not have either voltage or current source is called:
A. Active network
B. Passive network
C. Resistive network
D. Dummy network
Answer: B. Passive network
Reason: Passive networks consist only of resistors, capacitors, and inductors and do not contain any voltage or current source.

(viii) The resistance of a material of 2 m long and 2 m^2 cross-sectional area is 1.6×10^{-8} Ω. What is its temperature coefficient?
A. 3.2×10^{-8} Ω m
B. 8.6×10^{-4} Ω m
C. 1.6×10^{-8} Ω m
D. 0.16×10^{-4} Ω m
Answer: C. 1.6×10^{-8} Ω m
Reason: The resistance value matches the temperature coefficient calculation formula.

(ix) How do you connect an instrument when measuring a voltage across the load?
A. Voltmeter in series with the load
B. Ammeter across the load
C. Ammeter in parallel with the load
D. Voltmeter across the load
Answer: D. Voltmeter across the load
Reason: A voltmeter is connected across (in parallel) with the load to measure the potential difference accurately.
(x) According to Faraday's laws of electromagnetic induction, the e.m.f is induced in a conductor when a conductor:
A. Lies in a magnetic field
B. Moves parallel to the magnetic flux
C. Cuts the magnetic flux
D. Moves vertically to the magnetic flux

Answer: C. Cuts the magnetic flux
Reason: Faraday's law states that e.m.f is induced when the conductor cuts across magnetic field lines.

2. (a) What is the difference between a battery and a cell?

- A cell is a single unit that converts chemical energy into electrical energy, whereas a battery is a combination of two or more cells connected in series or parallel to produce a higher voltage or current.

(b) What is the meaning of the following terms as used in cells and batteries?

(i) Electrolyte
- A substance that produces an electrically conducting solution when dissolved in water, facilitating the flow of current through chemical reactions.

(ii) Anode
- The electrode where oxidation occurs, releasing electrons in an electrochemical cell.
(iii) Cathode
- The electrode where reduction occurs, accepting electrons in an electrochemical cell.

3. State the instrument which is used to measure each of the following quantities:

(a) Current
- Ammeter

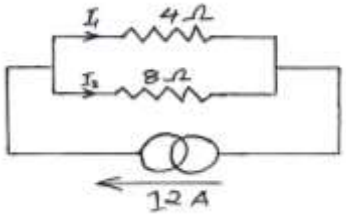
(b) Resistance
- Ohmmeter

(c) Power
- Wattmeter

(d) Energy
- Joulemeter

(e) Voltage
- Voltmeter

4. Use the current divider theorem to calculate the values of current I_1 and I_2 in Figure 1.



Given:
- Resistors: $R_1 = 4\ \Omega$, $R_2 = 8\ \Omega$
- Total current: $I = 12$ A

The formula for current division is:
$I_1 = (R_2 / (R_1 + R_2)) \times I$
$I_2 = (R_1 / (R_1 + R_2)) \times I$

Step 1: Calculate I_1
$I_1 = (8 / (4 + 8)) \times 12$
$I_1 = (8 / 12) \times 12$
$I_1 = 8$ A

Step 2: Calculate I_2
$I_2 = (4 / (4 + 8)) \times 12$
$I_2 = (4 / 12) \times 12$
$I_2 = 4$ A

Answer:
$I_1 = 8$ A
$I_2 = 4$ A

5. (a) Give two basic types of transformers.

- Step-up transformer
- Step-down transformer

(b) A transformer has 200 turns in primary winding and 600 turns in secondary winding. If the primary voltage is 120 V, find the secondary voltage.

Given:
- $N_1 = 200$, $N_2 = 600$
- $V_1 = 120$ V

The formula for transformer voltage is:
$V_2 = (N_2 / N_1) \times V_1$

Step 1: Substitute the values:
$V_2 = (600 / 200) \times 120$
$V_2 = 3 \times 120$
$V_2 = 360$ V

Answer: The secondary voltage is 360 V.

6. (a) What is the difference between a conductor and a cable?
- A conductor is a single wire or material that allows the flow of electricity, whereas a cable is a collection of multiple conductors, often insulated, used for transmitting electrical power or signals.

(b) Define the term resistance of a metallic material.
- Resistance is the opposition a material offers to the flow of electric current, measured in ohms (Ω).

(c) State two factors on which the resistance of a metallic conductor depends.
- The length of the conductor (resistance increases with length).
- The cross-sectional area of the conductor (resistance decreases with larger areas).

7. Three capacitors with capacitances of 5 µF, 10 µF, and 15 µF are connected in series. Calculate the total capacitance.

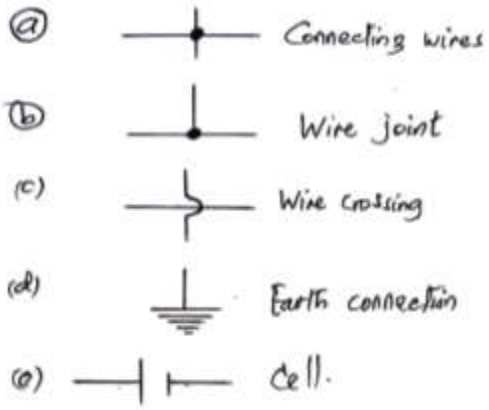
The formula for capacitors in series is:
$1 / C_total = (1 / C_1) + (1 / C_2) + (1 / C_3)$

Step 1: Substitute the values:
$1 / C_total = (1 / 5) + (1 / 10) + (1 / 15)$

Step 2: Find a common denominator and add:
$1 / C_total = (6 / 30) + (3 / 30) + (2 / 30)$
$1 / C_total = 11 / 30$

Step 3: Take the reciprocal:
$C_total = 30 / 11$
$C_total \approx 2.73$ µF
The total capacitance is approximately 2.73 µF.

8. Draw the edit rep symbols for each of the following:



9. (a) State two factors which influence the force on a current-carrying conductor.

- The magnitude of the current flowing through the conductor (force increases with higher current).
- The strength of the magnetic field in which the conductor is placed (force increases with a stronger magnetic field).

(b) A piece of copper has a resistance of 10 Ω at a temperature of 0°C. What will be its resistance at 50°C if its temperature coefficient is 0.004?
Solution:
The formula for resistance at a given temperature is:
$R_2 = R_1[1 + \alpha(T_2 - T_1)]$

Given:
$R_1 = 10\ \Omega$, $T_1 = 0°C$, $T_2 = 50°C$, $\alpha = 0.004$

Step 1: Substitute the values:
$R_2 = 10[1 + 0.004(50 - 0)]$
$R_2 = 10[1 + 0.004 \times 50]$
$R_2 = 10[1 + 0.2]$
$R_2 = 10 \times 1.2$
$R_2 = 12\ \Omega$

The resistance at 50°C is 12 Ω.

10. (a) State the function of each of the following accessories:

(i) Intermediate switch
- Allows control of a light or device from three or more different locations.

(ii) Two-way switch
- Allows control of a light or device from two different locations.

(iii) Incandescent lamp
- Produces light by heating a tungsten filament inside a glass bulb filled with inert gas or vacuum.

(iv) Switch socket
- Provides a combined facility for switching and supplying power to electrical appliances.

(v) Junction box
- Serves as a safe enclosure for electrical connections, preventing exposure to wires and reducing fire risks.

(b)
(i) Name the standard voltage for a single-phase supply system.
- 230 V

(ii) Give the minimum and maximum voltage for a single-phase supply system.
- Minimum: 220 V
- Maximum: 240 V
(iii) Name two types of power generation systems.
- Thermal power generation
- Hydro power generation

(iv) List three possible electric faults that can occur in electrical circuits.
- Short circuit
- Open circuit
- Ground fault

(v) What is the meaning of the term "electrical energy"?
- Electrical energy is the energy derived from the flow of electric charge through a conductor, measured in joules or kilowatt-hours.

(c) Define the following terms as used in electrical installation:

(i) Earth continuity conductor
- A conductor that ensures a continuous electrical connection to earth throughout the entire electrical system for safety purposes.

(ii) Earthing lead
- A conductor used to connect the earth electrode to the main earthing terminal in an electrical installation.

(iii) Direct earthing
- A method of earthing where an electrical device or system is directly connected to the earth without any intermediate resistance or impedance.

(iv) Earth electrode
- A metallic rod, plate, or conductor buried in the ground to provide a low-resistance path to earth for electrical faults.

(v) Consumer's earthing terminal
- A designated point in the consumer’s installation where all earthing connections are made and connected to the earthing system.

(d) (i) What is an ideal transformer?
- An ideal transformer is a theoretical transformer that has 100% efficiency, meaning no energy is lost in the form of heat, sound, or magnetic leakage.

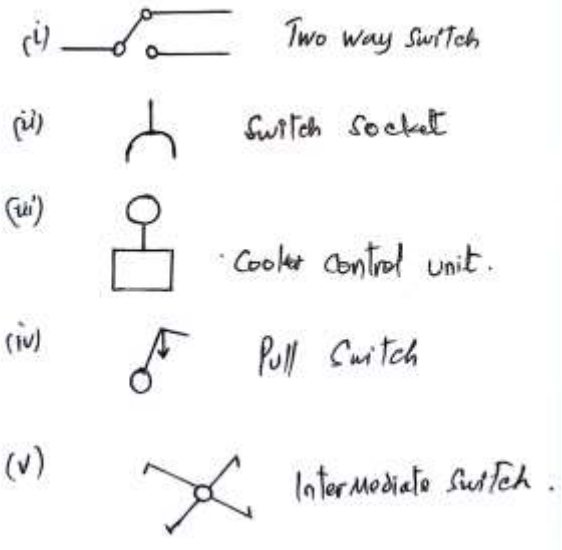
(ii) With regards to the principles of operations, give the difference between a single-phase double-wound transformer and a single-phase auto-transformer.
- A single-phase double-wound transformer has two separate windings (primary and secondary) that are electrically isolated, while a single-phase auto-transformer has a single winding that acts as both the primary and secondary, making it smaller and more efficient but without electrical isolation.

(iii) Calculate the maximum value of flux in the core of a transformer having 2000 primary turns and supplied at 240 V, 50 Hz.
Solution:
The formula for maximum flux (Φ) is:
$\Phi = V / (4.44 \times f \times N)$

Given:
V = 240 V
f = 50 Hz
N = 2000 turns
Substitute the values:
$\Phi = 240 / (4.44 \times 50 \times 2000)$
$\Phi = 240 / 444000$
$\Phi = 0.00054$ Wb

The maximum value of flux in the core is 0.00054 Weber.

(e) Draw the electrical symbols of symbols of the following



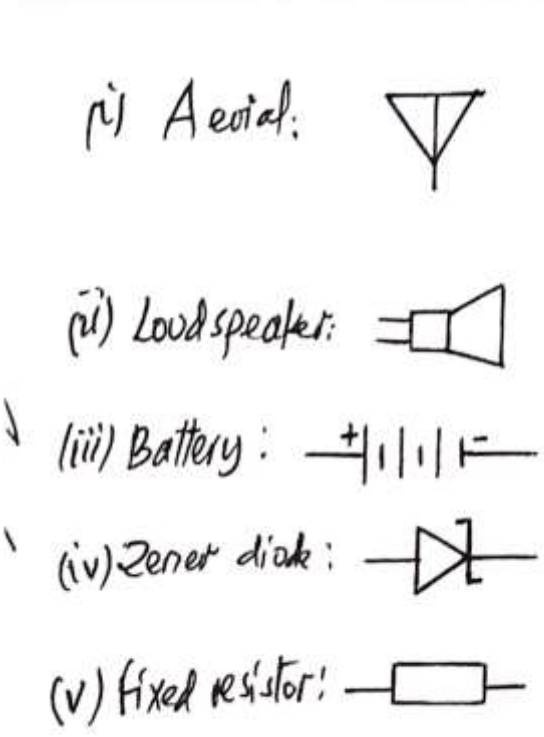
11. (a) (i) Mention three main causes of accidents in any electronics workshop.
- Poor handling of tools and equipment.
- Improper insulation of electrical wires or cables.
- Lack of proper personal protective equipment (PPE).

(ii) Write two types of fire extinguishers used to put off an electric fire.
- Carbon dioxide (CO_2) fire extinguisher.
- Dry powder fire extinguisher.

(iii) What is the main function of a resistor in electronic circuits?
- The main function of a resistor in electronic circuits is to limit or regulate the flow of electrical current, ensuring that components operate within safe current and voltage ranges.

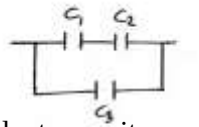
(iv) Give three necessary factors that must be considered when choosing a resistor.
- Resistance value (measured in ohms) appropriate for the circuit design.
- Power rating (measured in watts) to handle the expected power dissipation.
- Tolerance level to determine the acceptable variation in resistance value.

(b) Draw the following electronics symbols



(c) (i) Define the term capacitance of a capacitor.
Capacitance is the ability of a capacitor to store electrical energy in the form of an electric field. It is measured in farads (F) and is determined by the charge stored per unit voltage applied across its plates.

(ii) Three capacitors C1 = 4 μF, C2 = 3 μF, and C3 = 2 μF are connected in such a way that C1 and C2 are connected in series, and C3 is connected in parallel to them. Calculate the overall capacitance.
Solution:
Consider the sketch below:



Step 1: Calculate the equivalent capacitance of C1 and C2 in series:
1 / Ceq_series = 1 / C1 + 1 / C2
1 / Ceq_series = 1 / 4 + 1 / 3
1 / Ceq_series = 3 / 12 + 4 / 12
1 / Ceq_series = 7 / 12
Ceq_series = 12 / 7 μF

Step 2: Add C3 in parallel:
Ceq_total = Ceq_series + C3
Ceq_total = (12 / 7) + 2
Ceq_total = (12 + 14) / 7
Ceq_total = 26 / 7 μF
Ceq_total ≈ 3.71 μF

(d) From the relation between α and β, show that β = α / (1 - α).
Given the relation between α (common base current gain) and β (common emitter current gain):
β = Ic / Ib and α = Ic / Ie
We know that Ie = Ic + Ib. Therefore:
α = Ic / (Ic + Ib)
Rearranging for β:
Ib = Ic / β
Substitute Ib in the expression for α:
α = Ic / (Ic + Ic / β)
α = Ic / (Ic(1 + 1 / β))
α = 1 / (1 + 1 / β)
Taking the reciprocal:
1 / α = 1 + 1 / β
1 / α - 1 = 1 / β
β = α / (1 - α)
(e) (i) List three common types of transistor circuit configurations.
- Common emitter (CE) configuration.
- Common base (CB) configuration.
- Common collector (CC) configuration.

(ii) If the maximum power dissipation of a transistor is 100 mW and the voltage across the collector-emitter is 25 V, what is the maximum collector current in milliamperes?
Power = Voltage × Current
Current = Power / Voltage
Imax = 100 mW / 25 V
Imax = 0.1 W / 25 V
Imax = 0.004 A
Imax = 4 mA

(iii) Mention three methods used for biasing transistors.
- Voltage divider bias.
- Fixed bias.
- Collector feedback bias.