THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

181 ELECTRICAL INSTALLATION

(For Both School and Private Candidates)

Time: 3 Hours **ANSWERS** **Year: 2012**

Instructions

1. This paper consists of SIXTEEN questions.

2. Answer all questions in section A and B and THREE questions from section C.

(i) The efficiency of d.c shunt generator is maximum when
A. magnetic losses are equal to mechanical losses
B. armature copper losses are equal to constant losses
C. field copper losses are equal to iron losses
D. variable losses are equal to copper losses
E. constant losses are equal to variable losses

Correct answer: E. constant losses are equal to variable losses
Reason: Maximum efficiency occurs when variable losses (like copper losses) equal constant losses (core, friction, etc.).

(ii) A d.c series motor should never be started on no load because
A. the field current is zero
B. the machine will run with less efficiency
C. the speed becomes dangerously high
D. it will take longer to accelerate
E. it will draw high armature current

Correct answer: C. the speed becomes dangerously high
Reason: With no load, there is very little opposing torque, so the motor speeds up uncontrollably.

(iii) The function of transformer oil in a transformer is to
A. provide insulation and cooling
B. provide protection against lightning
C. provide protection against short circuiting
D. lubricate the moving parts
E. insulate the moving parts of the transformer

Correct answer: A. provide insulation and cooling
Reason: Transformer oil acts both as an electrical insulator and as a coolant.

(iv) In thermal power plants, the pressure in the working fluid is developed by
A. condenser
B. super heater
C. feed water pump
D. economizer
E. boiler chimney

Correct answer: C. feed water pump
Reason: The pump increases the pressure of water before it enters the boiler for heating.

(v) A circuit breaker is a device for
A. correcting power factor

B. neutralizing the effect of transients
C. reducing power factor
D. interrupting current
E. neutralizing magnetic field effect

Correct answer: D. interrupting current
Reason: A circuit breaker automatically interrupts the current flow in case of fault.

(vi) Which type of power plant has the least running cost per kWh of energy generated?
A. Hydro-electric plant
B. Thermal power plant
C. Diesel power plant
D. Coal power plant

Correct answer: A. Hydro-electric plant
Reason: Once built, hydroelectric plants use water, which is free, hence low running costs.

(vii) The insulation resistance of cables is usually measured in terms of
A. ohms
B. kilowatts
C. kilovolts
D. kilowatt-hours
E. kilo-ohms

Correct answer: E. kilo-ohms
Reason: Insulation resistance is high and measured in kilo-ohms or mega-ohms.

(viii) The Wheatstone bridge can be used to measure
A. value of frequency
B. high value of current
C. high value of voltage
D. value of resistance
E. power

Correct answer: D. value of resistance
Reason: Wheatstone bridge is a precise instrument for measuring unknown resistances.

(ix) Overhead bus bar trunking is most suited to
A. high rise buildings
B. electric train railways
C. crossing highways and roads
D. industrial installations
E. laboratories and school workshops

Correct answer: D. industrial installations
Reason: Bus bar trunking is used in industries for efficient and flexible power distribution.

(x) The earthing fault loop impedance can be measured by the use of
A. continuity tester
B. insulation resistance tester
C. ohmmeter
D. RCD tester
E. phase – earth loop tester

Correct answer: E. phase – earth loop tester
Reason: This tester is specifically designed to measure the impedance of the complete earthing loop.

2. (a) Outline two insulation tests recommended by the I.E.E regulations that have to be carried out in a completed installation.
- Insulation resistance between live conductors and earth.
- Insulation resistance between line and neutral conductors.

(b) During a flash test, a voltage of 2 kV is applied to a cable with an insulation resistance of 5 mega-ohms. What will be the earth leakage current?
$I = V / R = 2000 / 5 \times 10^6 = 0.0004$ A = 0.4 mA

3. A primary cell with e.m.f of 1.5 V and internal resistance 0.2 Ω is connected to a circuit of 20 Ω resistance. Calculate the
(a) current flowing in the circuit
$I = E / (r + R) = 1.5 / (0.2 + 20) = 1.5 / 20.2 = 0.0743$ A

(b) current in the circuit if supplied from ten similar cells connected in series
$E = 10 \times 1.5 = 15$ V
$r = 10 \times 0.2 = 2$ Ω
R = 20 Ω
$I = 15 / (2 + 20) = 15 / 22 = 0.6818$ A

4. (a) Give two differences between a stranded conductor and a bunched conductor.
- Stranded conductor wires are laid uniformly in layers; bunched wires are twisted without order.
- Stranded conductor provides mechanical strength; bunched conductor offers higher flexibility.

(b) Why indicator boards are necessary in bell circuits?
They indicate the exact location from which the bell is pressed, especially useful in systems with multiple call points.

5. (a) Name two types of protection which should be provided in a d.c motor starter.
- Overload protection
- No-volt release protection

(b) A 460 V direct current shunt motor, running on load has an armature resistance of 0.12 Ω. Calculate the value of the back e.m.f when the current in the armature is 150 A.
$E = V - I \times Ra = 460 - 150 \times 0.12 = 460 - 18 = 442$ V

6. (a) Give the name of the instruments for making the following tests:
(i) Insulation resistance test between conductors – Megger
(ii) Verification of polarity – Voltmeter

(b) The wire used to supply electricity to an electric iron through a socket has a cross-sectional area of 2.5 mm². What is the diameter of this wire?
$A = \pi d^2 / 4$
$d^2 = 4A / \pi = (4 \times 2.5) / 3.1416 = 3.183$
$d = \sqrt{3.183} = 1.78$ mm

7. (a) What is the armature reaction?
Armature reaction is the effect of the magnetic field produced by armature current on the main magnetic field in a machine, which can distort or weaken it.

(b) Give two effects of armature reaction magnetic fields.
- Distortion of the main field, reducing efficiency.
- Shifting of the neutral axis, leading to poor commutation.

8. A generating station has a connected load of 43,000 kW and a maximum demand of 20,000 kW. The average power being 7020 kW for the year. Calculate the load factor and demand factor for this case.
Load factor = Average load / Maximum demand = 7020 / 20000 = 0.351 = 35.1%
Demand factor = Maximum demand / Connected load = 20000 / 43000 = 0.465 = 46.5%

9. (a) Define regulation of a transformer.
Voltage regulation of a transformer is the change in secondary voltage from no-load to full-load expressed as a percentage of no-load voltage.

(b) The primary winding of a 25 kVA transformer has 200 turns and is connected to 230 V, 50 Hz supply. Calculate full load primary current.
I = Power / Voltage = 25000 / 230 = 108.7 A

10. Compare between neutral and earth wire (give three points):
- Neutral wire carries return current; earth wire does not normally carry current.
- Neutral is part of the electrical circuit; earth is a safety measure.
- Neutral is connected to the supply system; earth is connected to the ground for protection.

11. During electrical installation, metallic or plastic conduits can be used to accommodate a number of wires. Briefly explain three advantages of metallic conduit.
- Provides mechanical protection from impact and abrasion.
- Offers better grounding path, improving safety.
- Has higher resistance to heat and fire.

12. (a) Define the following terms:
(i) Simmerstat – A device used to regulate the heat of an electric heater by varying the current supply.
(ii) Moisture – Water in vapor or liquid form that can reduce insulation resistance and cause short circuits in electrical systems.

(b) A room has dimensions 4 m × 6 m × 2.5 m. Electric heaters are to be provided to produce an average temperature of 8°C. Calculate the rating of the heaters required, assuming two changes of air per hour and that 40% of their output is wasted.
Volume = $4 \times 6 \times 2.5 = 60\ m^3$
Air mass per hour = $60 \times 2 = 120\ m^3/h$
Density of air ≈ $1.2\ kg/m^3$ → mass = $120 \times 1.2 = 144\ kg/h$
Temperature rise $\Delta T = 8°C$
Specific heat of air = 1.005 kJ/kg°C
$Q = m \times c \times \Delta T = 144 \times 1.005 \times 8 = 1157.76\ kJ/h$
Convert to power: 1157.76 / 3600 = 0.3216 kW
If 40% wasted, useful power = 60%, so required power = 0.3216 / 0.6 = 0.536 kW

(c) A 2.0 mm^2 twin core cable feeds a heater which takes a current of 20 A. If the cable is 100 m long:
(i) Calculate the voltage drop in it and the p.d. across the heater if the supply voltage is 240 V.
Resistance of copper ≈ $0.0175\ \Omega \cdot mm^2/m$
Total length = 2 × 100 = 200 m
$R = 0.0175 \times 200 / 2.0 = 1.75\ \Omega$
Voltage drop = $I \times R = 20 \times 1.75 = 35$ V
P.d. across heater = 240 - 35 = 205 V

(ii) What must be the cross-sectional area of a replacement cable if the voltage drop is not to exceed 6 V?
$R = V / I = 6 / 20 = 0.3\ \Omega$
$R = \rho \times L / A \rightarrow A = \rho \times L / R = 0.0175 \times 200 / 0.3 = 11.67\ mm^2$

13. (a) Define the following terms:
(i) Utilization factor – The ratio of actual light output utilized to the total light output provided by the system.
(ii) Maintenance factor – The ratio of illumination maintained over time to the initial illumination level.

(b) Explain with the aid of a phasor diagram the meaning of the power factor in the alternating current circuit.

[Diagram expected: phasor showing voltage and current, angle θ between them, power factor = cosθ]
Power factor indicates the phase difference between voltage and current. It is the cosine of the angle between them.

(c) Electrical energy supplied at a poor power factor is more costly to the supply authority than the same energy supplied at or near unity power factor. Justify the statement by giving five reasons.
- Increases line losses due to higher current.
- Requires larger conductor sizes.
- Causes voltage drops in the system.
- Requires larger transformers and generators.
- Poor utilization of system capacity.

(d) (i) Briefly explain four factors which determine the value of coefficient of utilization of a new lighting scheme.
- Room surface reflectance
- Mounting height of luminaries
- Distribution characteristics of fittings
- Layout and spacing of lamps

(ii) A living room 6 m × 5 m to be illuminated with 100 W tungsten filament lamps to a level of 100 lm/m². The lamps have an efficiency of 10 lm/W. The coefficient of utilization is 0.8 and the maintenance factor is 0.7. How many 100 W lamps will be required?
Area = 6 × 5 = 30 m²
Total lumens needed = 30 × 100 = 3000 lm
Total output needed = 3000 / (0.8 × 0.7) = 5357.14 lm
Each lamp output = 100 × 10 = 1000 lm
Number of lamps = 5357.14 / 1000 = 5.36 → 6 lamps

14. (a) Mention five properties which must be possessed by transmission cable that is to be buried underground.
- High insulation resistance
- Moisture resistance
- Mechanical strength
- Chemical resistance
- Flexibility

(b) Underground system of an electric power transmission is better compared to overhead system. Justify the statement by giving six factors.
- Reduced exposure to weather hazards
- Less visual pollution
- Less risk of accidents
- Lower maintenance
- Better security against vandalism

- More reliable in densely populated areas

(c) Two conductors, one of copper and the other of iron, are connected in parallel and carry equal currents at 25°C. What proportion of current will pass through each if the temperature is raised to 100°C?
Given:
$\alpha c = 0.0043$ /°C, $\alpha Fe = 0.0066$ /°C
$Rc100 = Rc25(1 + \alpha c \Delta T) = R(1 + 0.0043 \times 75) = R \times 1.3225$
$RFe100 = R(1 + 0.0066 \times 75) = R \times 1.495$
Resistance is proportional to inverse current:
$Ic \propto 1 / 1.3225 = 0.756$
$IFe \propto 1 / 1.495 = 0.669$
Total = 0.756 + 0.669 = 1.425
Proportion of current:
Copper = 0.756 / 1.425 = 53%
Iron = 0.669 / 1.425 = 47%

15. (a)
(i) Enumerate four advantages of digital meter over analogue meter.
- Higher accuracy and resolution
- Easy to read (numerical display)
- Less parallax error
- Can store and transmit readings electronically

(ii) Mention four human errors which can be made during measurements.
- Parallax error when reading analogue scales
- Using the wrong range or scale
- Misconnecting leads or terminals
- Misreading the displayed value

(iii) Explain two ways in which human errors can be avoided.
- Use digital instruments with automatic ranging
- Proper training and adherence to standard procedures

(iv) Differentiate between accuracy and precision.
- Accuracy is the closeness of a measured value to the true value.
- Precision is the consistency or repeatability of measurements.

(b) A moving coil instrument has a resistance of 8 Ω and gives a full-scale deflection with a current of 5 mA.
(i) Calculate the value of a series resistor so that the instrument can measure up to a value of 100 V.
$V = IR \rightarrow Rtotal = V / I = 100 / 0.005 = 20000\ \Omega$
Series resistance = 20000 - 8 = 19992 Ω

(ii) Calculate the value of a shunt resistor so that the instrument can measure up to a value of 10 A.
Let Rs = shunt resistance
Is = 10 A, Im = 0.005 A, Rm = 8 Ω
Rs = (Im × Rm) / (Is - Im) = (0.005 × 8) / (10 - 0.005) = 0.04 / 9.995 = 0.004 Ω

(iii) In each case, show the circuit appropriately labeled.
[Diagram:
- For voltmeter: Series resistor with moving coil
- For ammeter: Shunt resistor in parallel with moving coil]

16. (a) A 3-phase load consists of three similar inductive coils each of resistance 50 Ω and inductance of 0.3 H. The supply is 415 V, 50 Hz and the load is star connected.
(i) Line current
$X_L = 2\pi fL = 2\pi \times 50 \times 0.3 = 94.25\ \Omega$
$Z = \sqrt{(R^2 + X_L^2)} = \sqrt{(50^2 + 94.25^2)} = \sqrt{(2500 + 8882.06)} = \sqrt{11382.06} = 106.6\ \Omega$
Phase voltage = 415 / √3 = 239.6 V
Iph = 239.6 / 106.6 = 2.25 A
Iline = Iph = 2.25 A

(ii) Power factor
$\cos\theta = R / Z = 50 / 106.6 = 0.469$

(iii) Total power
$P = \sqrt{3} \times V_L \times I_L \times \cos\theta = \sqrt{3} \times 415 \times 2.25 \times 0.469 = 758.1$ W

(b) In a series circuit containing pure resistance and a pure inductance, the current and the voltage are expressed as
$i(t) = 5\sin(314t + 2\pi/3)$
$v(t) = 15\sin(314t + 5\pi/6)$

(i) Impedance of the circuit
Impedance Z = Vm / Im = 15 / 5 = 3 Ω

(ii) Value of resistance
Phase difference $\varphi = (5\pi/6 - 2\pi/3) = (5\pi - 4\pi)/6 = \pi/6$
$\cos\varphi = R / Z \rightarrow R = Z \times \cos(\pi/6) = 3 \times \sqrt{3}/2 = 2.598\ \Omega$

(iii) Power factor
$\cos(\pi/6) = 0.866$