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: 2006

Instructions

1. This paper consists of SIXTEEN questions.
2. Answer all questions in section A and B and THREE questions from section C.

(i) Which one of the following methods is used to improve the low power factor in a large installation?
A. Changing one of the phases
B. Installing a new motor
C. Installing a synchronous motor
D. Connecting a number of resistors in series with loads
E. Connecting a number of resistors parallel with a loads

Correct answer: C. Installing a synchronous motor
Reason: A synchronous motor can operate at leading power factor and is used to compensate lagging reactive power from inductive loads, thus improving overall power factor.

(ii) Fuse is a protective device fitted in an electrical installation in order to
A. decrease the electrical current
B. maintain continuity
C. measure insulation resistance
D. protect installation against excess current
E. protect electrical short-circuit

Correct answer: D. protect installation against excess current
Reason: A fuse melts when excessive current flows, thereby breaking the circuit and preventing damage due to overheating or fire hazards.

(iii) The open circuit test in a transformer is used to determine .... losses.
A. copper
B. eddy
C. mechanical
D. core
E. hysteresis

Correct answer: D. core
Reason: An open circuit test measures the no-load loss of a transformer, which consists of core losses (hysteresis and eddy current losses).

(iv) Which one of the following arrangements represent 2 supply sequences of residential houses as recommended by TANESCO? Service line,
A. cut out, ELCB, main switch, kWh-meter
B. EL.CB, cut out, kWh meter, main switch
C. cut out, kWh meter, EL.CB, main switch
D. EL.CB, kWh meter, main switch, cut out
E. kWh meter, EL.CB, cut out, main switch

Correct answer: C. cut out, kWh meter, EL.CB, main switch

Reason: This sequence ensures proper flow of energy metering, protection, and user control. TANESCO recommends the sequence for safety and accurate metering.

(v) Earthing in electrical installations means
A. connection of tool to neutral wire
B. missing of one phase to power supply
C. connection of installation to general mass of the earth
D. connection of installation to gravitational force
E. connection of wires to the ground

Correct answer: C. connection of installation to general mass of the earth
Reason: Earthing is the connection of electrical systems to the earth to ensure safety by directing fault current safely into the ground.

(vi) When measuring voltage across the bulb/light, the voltmeter should be connected
A. in parallel with bulb/light
B. in series with bulb/light
C. horizontal to the bulb/light
D. immediately after the bulb
E. perpendicular to bulb/light

Correct answer: A. in parallel with bulb/light
Reason: Voltage is always measured in parallel across two points. To measure the voltage across a bulb, the voltmeter must be connected in parallel.

(vii) Why do we carry a polarity test in a new installation?
A. To check if insulation resistance is durable
B. To check if all switches, circuit breakers and fuses are connected to a live wire
C. To check if the earthing system is effectively earthed
D. To ensure that there is no open circuit
E. To check if the new installation is stable

Correct answer: B. To check if all switches, circuit breakers and fuses are connected to a live wire
Reason: Polarity test ensures that switches and protective devices are correctly connected to the live wire, so they can effectively disconnect supply in case of faults.

(viii) What is synchronous speed?
A. motor speed
B. speed of a revolving magnetic field
C. rotor speed
D. stator speed
E. motor and rotor speed

Correct answer: B. speed of a revolving magnetic field
Reason: Synchronous speed is the speed at which the magnetic field in a rotating machine revolves, and it depends on frequency and number of poles.

(ix) What is first Aid?
A. First Aid box with medicine
B. First Aid Kit
C. Temporary measure or service given to a victim of an accident before seen by a skilled person
D. Permanent treatment given to a victim of an electrical accident
E. Aid given to injured people

Correct answer: C. Temporary measure or service given to a victim of an accident before seen by a skilled person
Reason: First aid is immediate assistance given to someone injured or suddenly ill before professional medical help is available.

(x) Express 1 kWh into mega joules –
A. 3.6 MJ
B. 1.6 MJ
C. 3.6 kJ
D. 3600 MJ
E. 360 J

Correct answer: A. 3.6 MJ
Reason: 1 kWh = 1000 W × 3600 s = 3,600,000 J = 3.6 MJ

2. Mention three (3) different types of D.C. motors.
Shunt wound D.C. motor has the field winding connected in parallel with the armature. It operates at nearly constant speed regardless of the load, making it suitable for applications such as lathes and fans.

Series wound D.C. motor has the field winding in series with the armature. It produces very high starting torque and is used in applications like cranes and electric trains.

Compound wound D.C. motor combines both shunt and series windings, offering a balance of torque and speed regulation. It is used in elevators and conveyors.

3. What is the size of a power factor in a pure capacitive circuit?
The power factor of a pure capacitive circuit is zero but leading. This is because in a pure capacitive circuit, the current leads the voltage by 90 degrees, and the cosine of 90° is zero.

4. Name three (3) methods of reducing stroboscopic effect.
Using multiple lamps powered from different phases of a three-phase supply helps reduce flickering by smoothing the overall light intensity.

Employing high-frequency electronic ballasts instead of conventional chokes increases the flicker frequency beyond human perception.

Using incandescent or LED lighting in conjunction with discharge lamps reduces the flicker visibility due to their continuous light emission.

5. Distinguish the following electrical accessories:
(a) Junction box
A junction box is an enclosure that houses wire connections, protecting them and preventing short circuits or fire. It allows safe branching of conductors.

(b) Joint box
A joint box is used specifically to connect two lengths of cable, typically underground or within walls, where extension or repair is needed. It does not allow branching like a junction box.

6. Outline two (2) losses available in a transformer.
Core loss (iron loss) occurs in the magnetic core of the transformer due to alternating magnetic flux. It includes hysteresis and eddy current losses and is constant under all loading conditions.

Copper loss occurs in the transformer windings due to the resistance of the copper conductors. It varies with the square of the load current.

7. How can you reverse the direction of rotation of a three-phase induction motor?
To reverse the direction of rotation, interchange any two of the three supply phase connections. This will reverse the rotating magnetic field, thus changing the motor’s rotation direction.

8. What is cable size and current rate of a lighting circuit?
A lighting circuit commonly uses a cable size of 1.5 mm^2 copper conductor. This cable is suitable for carrying up to 10 A of current, which is typically protected by a 10 A MCB.

9. A fuse rated at 20 A has a fusing factor of 1.5. Calculate the current required to blow the fuse.
Fusing current = Rated current × Fusing factor
= 20 A × 1.5 = 30 A
Therefore, 30 A is required to blow the fuse.

10. Outline two (2) types of instrument transformer and application of each one.
Current Transformer (CT) is used to step down high current levels to a lower, measurable value for use in metering and protection systems.

Potential Transformer (PT) is used to step down high voltage to a lower, safe voltage for measuring instruments and relays in high-voltage circuits.

11. Calculate the supply voltage of a heater element rated 2.5 kW and absorbs a current of 10.5 A.
$P = V \times I$
$V = P / I = 2500 W / 10.5 A = 238.1 V$
The supply voltage is 238.1 volts.

12. A moving coil meter has a resistance of 5 Ω and a full scale deflection of 25 milliamps. Calculate the:
(a) Resistance required to enable the meter to be used as a voltmeter to measure up to 20 V.
$V = I \times (R + r)$
$20 = 0.025 \times (R + 5)$
$R + 5 = 20 / 0.025 = 800$
$R = 800 - 5 = 795 \Omega$

(b) Resistance required to enable the meter to be used as an ammeter to measure up to 5 A.
$I_{total} = 5 A, I_{meter} = 0.025 A$
$I_{shunt} = 5 - 0.025 = 4.975 A$
Using current division:
$R_{shunt} = (r \times I_{meter}) / I_{shunt} = (5 \times 0.025) / 4.975 = 0.125 / 4.975 = 0.0251 \Omega$

13. A 400 V shunt generator has full load current of 100 A and stray losses of 1.5 kW. Armature and field resistances are 0.2 Ω and 250 Ω. Calculate:
(a) Field current
$I_f = V / R_f = 400 / 250 = 1.6 A$

(b) Armature current
$I_a = I_L + I_f = 100 + 1.6 = 101.6 A$

(c) Total power losses
Armature loss $= I_a^2 \times R_a = (101.6)^2 \times 0.2 = 10322.56 \times 0.2 = 2064.51 W$
Field loss $= V \times I_f = 400 \times 1.6 = 640 W$
Total losses = Armature + Field + Stray = 2064.51 + 640 + 1500 = 4204.51 W

(d) Input and output power
Output power $= V \times I_L = 400 \times 100 = 40000 W$
Input power = Output + Total losses = 40000 + 4204.51 = 44204.51 W

14. An electric kettle is required to heat 100 litres of water from 10°C to the boiling point in 5 minutes. The supply voltage being 230 V, and the efficiency of the kettle is 78 percent. Taking the specific heat capacity of water as 4.187 kJ/kg°C, calculate the:
(a) Energy used
Mass = 100 litres = 100 kg
$\Delta T = 100 - 10 = 90°C$
Energy $= mc\Delta T = 100 \times 4.187 \times 90 = 37683 kJ = 37683000 J$

(b) Resistance of heating element

Input energy = Output / Efficiency = 37683000 / 0.78 = 48311538.5 J

Time = 5 min = 300 s

Power = Energy / time = 48311538.5 / 300 = 161038.5 W

$P = V^2 / R$, $R = V^2 / P = 230^2 / 161038.5 = 52900 / 161038.5 \approx 0.328\ \Omega$

(c) Size of an element to be marked in W

Power = 161038.5 W

This is the input power, so the element should be rated approximately 161 kW.

15. (a) What is an ideal transformer?

An ideal transformer is one that has no losses. It means 100% efficiency where all the input power is transferred to output without any core (iron) or copper (winding) losses.

(b) 75 kVA Transformer has a step-down ratio of (2:1) with 2400 primary turns and a primary voltage of 7.2 kV. Calculate:

(i) Volts per turn

$V_{per\_turn} = V_p / N_p = 7200 / 2400 = 3$ V/turn

(ii) Secondary voltage

$V_s = V_p$ / Turns ratio = 7200 / 2 = 3600 V

(iii) Secondary turns

$N_s = N_p$ / Turns ratio = 2400 / 2 = 1200 turns

(iv) The primary and secondary currents

Apparent power S = 75 kVA

$I_p = S / V_p = 75000 / 7200 \approx 10.42$ A

$I_s = S / V_s = 75000 / 3600 \approx 20.83$ A

16. A room 12 m by 7.5 m is to be illuminated to an average intensity of 240 lux. The lamp efficiency is 30 lumens per watt and the coefficient of utilization of the room is 0.6 and maintenance factor is 0.8.

Calculate the:

(a) Total lumens

Area = $12 \times 7.5 = 90\ m^2$

Lumens = Illuminance × Area = 240 × 90 = 21600 lumens

(b) Total power required

Effective lumens per watt = 30 × 0.6 × 0.8 = 14.4

Power = Total lumens / effective lumens per watt = 21600 / 14.4 = 1500 W

(c) The number of lamps if each lamp is rated at 100 W

Number of lamps = 1500 / 100 = 15 lamps