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: 2005**

Instructions

1. This paper consists of SIXTEEN questions.

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

(i) For remote control of a direct on line contactor starter, start buttons are wired in
A series and stop buttons are also wired in series
B parallel and stop buttons are also wired in parallel
C series and stop buttons are wired in parallel
D parallel and stop buttons are wired in series
E series parallel to stop buttons

Correct answer: A
Reason: Start buttons must be wired in series to ensure all must be pressed for the circuit to operate, and stop buttons are also wired in series to ensure any stop button can break the circuit.

(ii) The ratio of the power to apparent power is used to find
A reactive volt ampere
B load factor
C power factor
D current ratio
E choke

Correct answer: C
Reason: Power factor is the ratio of real power (P) to apparent power (S), i.e. power factor = P/S.

(iii) The rotating field produced by the stator of a 3 phase induction motor travels at
A a speed above a synchronous speed
B a speed below a synchronous speed
C the same speed as the rotor
D a synchronous speed
E high speed

Correct answer: D
Reason: The stator produces a rotating magnetic field at synchronous speed, while the rotor lags behind in induction motors.

(iv) In a d.c motor, the back e.m.f. is given by
A $E = V - I_aR_a$
B $E = V + I_aR_a$
C $E = I_a - V$
D $E = V \times I_a - R_a$
E $E = V - I^2R_a$

Correct answer: A

Reason: The back emf E in a DC motor is given by subtracting the voltage drop across the armature resistance (I_aR_a) from the applied voltage V.

(v) A short circuit test in a transformer determines
A copper losses
B iron losses
C core losses
D mechanical losses
E power losses

Correct answer: A
Reason: Short circuit test is done with low voltage and rated current to measure copper losses in transformer windings.

(vi) A double wound transformer delivers 500 V to a load taking 500 kVA. The current taken by the load is
A 100 A
B 500 A
C 1000 A
D 5000 A
E 50 mA

Correct answer: B
Reason:
Power = Voltage × Current
Current = Power / Voltage = 500000 VA / 500 V = 1000 A

(vii) Balancing single phase loads on a three phase, four wire system ensures that
A minimal neutral current flows
B line voltages are all equal
C star point is maintained all the time
D circuit fuses operate efficiently
E current flows to neutral conductor

Correct answer: A
Reason: Balanced loads in a 3-phase 4-wire system result in minimal current in the neutral wire, improving efficiency and stability.

(viii) In a three phase star connected circuit, the ratio of line voltage ÷ √3 gives
A the voltage to neutral
B the voltage across two lines

C the permissible voltage drops
D neutral-earth voltage
E earth leakage voltage

Correct answer: A
Reason: In a star connection, line voltage = √3 × phase voltage. So, phase voltage (voltage to neutral) = line voltage / √3.

(ix) The permissible voltage drop on consumer's installation supplied by 110 V is
A 6 V
B 8.55 V
C 7.25 V
D 1.34 V
E 4 V

Correct answer: C
Reason: Permissible voltage drop is typically 6.5% of supply voltage. 6.5% of 110 V = 7.15 V ≈ 7.25 V.

(x) In an induction motor, the unit slip(s) is/are found by the expression
A S = (Ns - Nr) ÷ Ns
B S = (Nr - Ns) ÷ Ns
C S = (Ns - Nr) ÷ Nr
D S = (Ns - Nr) × Ns
E S = (Nr - Ns) ÷ Nr

Correct answer: A
Reason: Slip in an induction motor is defined as the ratio of the difference between synchronous speed (Ns) and rotor speed (Nr) to synchronous speed: S = (Ns - Nr)/Ns.

2. What is the difference between a flexible cable and a flexible cord?
A flexible cable is a heavy-duty cable made of multiple conductors, designed to carry higher currents and used in industrial applications. A flexible cord is a lightweight insulated cable used for household appliances and light-duty electrical devices.

3. What types and how many switches are required to control lights from four different stations?
To control lights from four different stations, you need two two-way switches and two intermediate switches. Two-way switches are placed at the ends, and intermediate switches are placed between them.

4. What are the reasons for fitting a protective switch-gear in an installation? State three (3) reasons.
To protect the circuit from overcurrent and short circuits.

To isolate faulty sections for safe maintenance.
To ensure safety of equipment and personnel by cutting off power during faults.

5. What are the methods of reducing stroboscopic effect? State three (3) methods.
Use twin lamp fittings with a phase displacement.
Use high-frequency electronic ballasts.
Use incandescent or LED lamps instead of fluorescent lamps.

6. Why do we get dim light from the series connected bulbs? State two (2) reasons.
The total voltage is shared among bulbs, reducing individual voltage.
Series connection increases resistance, reducing current through each bulb.

7. State three (3) types of fuses fitted in electrical switch gears.
Rewirable fuse
Cartridge fuse
High rupturing capacity (HRC) fuse

8. What is the purpose of a polarity test in a new installation?
To ensure that the live conductors are correctly connected to the appropriate terminals, especially switches and fuse holders, to avoid electric shock or faults.

9. Express two (2) laws of illumination by formula.
Illumination (E) = Luminous flux (F) / Area (A)
Illumination (E) = $I \cos \theta / r^2$, where I = luminous intensity, θ = angle, r = distance from the source

10. Differentiate the following electrical accessories:
(i) joint box
A joint box is used to join two or more cables together at one point, often buried or enclosed for protection.

(ii) junction box
A junction box is used to enclose wire connections to protect them and provide a safe enclosure for branching multiple electrical paths.

11. How can you reverse the direction of rotation of a 3-phase a.c. induction motor?
By interchanging any two of the three supply lines connected to the motor, which changes the phase sequence and reverses the direction of the rotating magnetic field.
12. A 60 kVA 1 phase transformer is immersed in a tank containing 2000 litres of insulating oil. The efficiency of a transformer at full load is 97%. Calculate the average rise in temperature of the oil in degrees Celsius after 3 hours of running at full load and unity power factor, assuming that 60% of the heat

energy loss in a transformer is expanded in heating oil. The specific heat capacity of oil is 2140 kJ/kgK. Density of oil is 879 kg/m³.

Transformer losses = (100% - 97%) = 3% of 60 kVA = 0.03 × 60000 = 1800 W
Heat used to heat oil = 60% of 1800 = 0.6 × 1800 = 1080 W
Energy in 3 hours = 1080 × 3 × 3600 = 11664000 J

Mass of oil = volume × density = 2000 L = 2 m³ × 879 = 1758 kg

Heat = mcΔT
11664000 = 1758 × 2140 × ΔT
ΔT = 11664000 / (1758 × 2140) = 11664000 / 3768120 ≈ 3.1°C

Average rise in temperature ≈ 3.1°C

13. The power input to a six pole, 3 phase, 50 Hz induction motor is 42 kW, the speed is 970 rev/min. The stator losses are 1.2 kW and the friction and windage loss is 1.8 kW. Calculate the:
(a) synchronous speed
Ns = 120f / P = 120 × 50 / 6 = 1000 rpm

(b) slip in percent
Slip = (Ns - Nr)/Ns × 100 = (1000 - 970)/1000 × 100 = 3%

(c) brake horse power
Rotor input = 42 - 1.2 = 40.8 kW
BHP = rotor input - friction and windage loss = 40.8 - 1.8 = 39 kW

(d) rotor copper loss
Rotor copper loss = slip × rotor input = 3/100 × 40.8 = 1.224 kW

(e) efficiency
Output = rotor input - rotor copper loss - mechanical loss = 40.8 - 1.224 - 1.8 = 37.776 kW
Efficiency = output/input × 100 = 37.776 / 42 × 100 ≈ 89.94%

14. A 220V shunt motor takes a total current of 30 amperes and runs at 500 rev/min. The shunt field resistance is 50 ohms and the armature resistance is 0.1 ohm. Calculate:
(i) field current
If = V/Rf = 220/50 = 4.4 A

(ii) armature current

Ia = I - If = 30 - 4.4 = 25.6 A

(iii) back e.m.f
Eb = V - Ia × Ra = 220 - (25.6 × 0.1) = 220 - 2.56 = 217.44 V

(iv) power input to the motor
Input power = V × I = 220 × 30 = 6600 W

15. A four-pole shunt generator with lap-connected armature supplies a load of 200 amperes at 100 V. The shunt field resistance is 50 ohms and armature resistance is 0.05 ohm. Calculate the:
(i) field current
If = V/Rf = 100/50 = 2 A

(ii) armature current
Ia = IL + If = 200 + 2 = 202 A

(iii) electromotive force generated if the voltage drop across brushes is 1.5 volts
E = V + Ia × Ra + brush drop = 100 + (202 × 0.05) + 1.5 = 100 + 10.1 + 1.5 = 111.6 V

(iv) power output generated
Output power = V × IL = 100 × 200 = 20000 W = 20 kW

16. The cost of electrical power to a consumer is Tsh. 600 per annum per kVA of maximum demand plus Tsh. 50 per unit. A consumer maximum demand is 450 kW at 0.72 P.F. lagging and his annual consumption is 720,000 kWh. Calculate the:
(i) kVA of maximum demand
kVA = kW / PF = 450 / 0.72 = 625 kVA

(ii) annual cost of maximum demand
Cost = 625 × 600 = 375000 Tsh

(iii) overall cost of the year
Energy cost = 720000 × 50 = 36000000 Tsh
Total cost = 375000 + 36000000 = 36375000 Tsh

(iv) average price per unit
Average price per unit = Total cost / units = 36375000 / 720000 = 50.52 Tsh/unit