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: 1990**

Instructions

1. This paper consists of SIXTEEN questions.

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

1. Name two methods used to improve the power factor of an installation.

One method is the use of static capacitors, which supply leading reactive power to cancel out the lagging reactive power from inductive loads. Another method is using synchronous condensers, which are over-excited synchronous motors operating without a mechanical load, providing reactive power compensation to improve power factor.

2. What are the names of the devices which are used in connection with discharge lamps that perform the following functions?

(i) To increase the voltage necessary for starting of a fluorescent lamp: A starter or electronic ballast initiates a high-voltage surge to start ionization in the tube.

(ii) To raise the power factor: A power factor correction capacitor is used to reduce phase difference between voltage and current.

(iii) To suppress the effect of radio frequency on lighting of a fluorescent lamp: A radio interference suppressor or capacitor filter minimizes electromagnetic interference.

3. What is the difference between a circuit-breaker and a fuse?

A fuse is a single-use protective device that melts and breaks the circuit during overcurrent. A circuit-breaker is reusable and mechanically opens the circuit when an overload or fault is detected, and can be reset after tripping.

4. List four possible causes of a d.c. motor failing to start.

Open circuit in armature winding may prevent current flow. Brushes not seating properly can fail to provide contact. Overload or mechanical jamming of the shaft can resist rotation. A faulty starter or no supply voltage could also prevent starting.

5. Name three types of final sub-circuits.

Radial sub-circuits serve a single load point. Ring sub-circuits supply sockets in a loop with current flowing both directions. Spur circuits are extensions from main circuits, supplying additional outlets.

6. Give the difference between an "Alarm switching" and "Time switches."

Alarm switching activates circuits based on an external alarm or signal. Time switches operate devices based on pre-set times, turning systems on or off automatically.

7. Given that the total power in a single-phase circuit is 1.8 kW at 0.9 p.f. and a pressure of 250V, what should be the input current?

Apparent power = 1800 / 0.9 = 2000 VA
Current = 2000 / 250 = 8 A

8. Name the tools one would require in installing metal conduits.

A hacksaw is used to cut the conduit. A bending spring or conduit bender helps shape it to required angles. A threading die is used for creating threads for coupling. Fish tape helps pull wires through the installed conduit.

9. Name two types of a.c. motors and state where each type can be used.

Squirrel cage induction motors are commonly used in fans, pumps, and compressors due to their robustness. Slip ring induction motors are used in high-torque applications like cranes and elevators.

10. Explain with the use of a diagram how you would measure the power in a single-phase circuit.

Connect a voltmeter across the load to measure voltage. An ammeter is connected in series with the load to measure current. A wattmeter has its current coil in series and voltage coil across the load, measuring real power. [Diagram would show load, ammeter, voltmeter, and wattmeter in proper configuration.]

11. What are the essential requirements for
(a) a conductor, and
(b) an insulator? Give two examples of each.

A conductor must have low resistance and high tensile strength, such as copper and aluminum. An insulator must have high resistivity and mechanical strength, like porcelain and PVC.

12. The following terms are used in the I.E.E. tables:
(a) Ambient temperature and
(b) Rating factor. What do they mean?

Ambient temperature is the surrounding temperature at which equipment operates. Rating factor is a multiplier applied to standard ratings to adjust for different environmental or operational conditions.

13. What are the reasons for carrying out earthing tests? Give any two reasons.

To ensure the effectiveness of earth continuity for fault currents to safely flow. To verify that the resistance of the earthing system is within safe limits to protect people and equipment.

14. The term "SPLITTING THE PHASE" is used in connection with single-phase motors, what does it mean and why is it necessary?

It refers to creating a phase shift in single-phase supply to start the motor, typically using a capacitor. It's necessary because single-phase motors are not self-starting.

15. What current will flow in an inductance of 0.2H when connected across a 100V, 50Hz supply?

Reactance $X = 2\pi fL = 2 \times \pi \times 50 \times 0.2 = 62.83$ ohms
Current $I = V / X = 100 / 62.83 \approx 1.59$ A

16. Name any three types of losses in D.C. machines.

Copper losses occur in windings due to resistance. Iron or core losses occur due to hysteresis and eddy currents. Mechanical losses arise from friction and windage.

17. Draw a two-way switching circuit used for stairs and corridors.
Diagram shows two two-way switches connected to a lamp. The lamp is turned on or off from either switch, using traveler wires between switches.

18. State what you understand by "earth continuity conductor".

It is a conductor used to maintain electrical continuity to all exposed metal parts and ensure safe disconnection in case of fault by carrying fault current to earth.

19. Which of the following metallic parts are required by the Regulations to be earthed?
(a) Cable sheaths
(b) Cable fixing clips
(c) Metal cases of electric fires
(d) Accessible structural steel work
(e) Lamp caps?

Cable sheaths, metal cases of electric fires, and accessible structural steel work must be earthed. Cable fixing clips and lamp caps generally do not require earthing.

20. Give the meaning of
(a) Candela (or candle power): It is the unit of luminous intensity, representing light emitted in a given direction.

(b) Lumen: It is the unit of luminous flux, measuring the total quantity of visible light emitted by a source.

21. A 4-pole, 500 V shunt motor is lap-wound with 500 armature conductors. The armature resistance is 0.12 ohm and the flux per pole is 0.09 Wb. Calculate the respective speeds of the motor when the power outputs are such that the armature currents are 30 A and 50 A respectively.

To find speed, use the formula:

$N = (60 \times E \times A) / (P \times \Phi \times Z)$

First calculate back emf:
$E = V - Ia \times Ra$
For Ia = 30 A:
$E_1 = 500 - (30 \times 0.12) = 496.4$ V
For Ia = 50 A:
$E_2 = 500 - (50 \times 0.12) = 494$ V

Given:
Z = 500, A = 2 (lap winding), P = 4, $\Phi = 0.09$ Wb

Now compute speed:
$N_1 = (60 \times 496.4 \times 2) / (4 \times 0.09 \times 500) = 1324.27$ rpm
$N_2 = (60 \times 494 \times 2) / (4 \times 0.09 \times 500) = 1317.33$ rpm

22. A classroom with an area of 6 metres by 4 metres is to have an average illumination of 110 lux. The lamps chosen have an efficiency of 40 lm/W. The coefficient of utilisation is estimated to be 0.5 and a maintenance factor of 0.7 is to be allowed. Calculate the cost of energy consumed during a period of 13 weeks, of 5 days per week and 3 hours per day at full load. The tariff is a flat rate of 90 cents per unit.

Area = $6 \times 4 = 24$ m²
Required lumens = $110 \times 24 = 2640$ lm
Useful lumens per watt = $40 \times 0.5 \times 0.7 = 14$ lm/W
Required power = $2640 / 14 = 188.57$ W
Total hours = $13 \times 5 \times 3 = 195$ hrs
Energy consumed = $0.18857 \times 195 = 36.77$ kWh
Cost = $36.77 \times 0.90 = 33.09$ shillings

23 (a). Define the term “power factor” and explain how a low power factor affects the size of cable required to carry a given a.c. load.

Power factor is the ratio of active power to apparent power in an a.c. circuit. It shows how effectively the current is being converted into useful work.
Low power factor increases the current needed to deliver the same power, causing higher losses, greater voltage drop, and requiring cables with larger cross-sectional areas to handle the current safely.

23 (b). A 240 V a.c. single-phase induction motor delivers 16 kW at full load. The efficiency of the motor at this load is 80% at a power factor of 0.75 lagging.

Input power = $16000 / 0.8 = 20000$ W
Apparent power = $20000 / 0.75 = 26666.67$ VA
Current drawn = $26666.67 / 240 = 111.11$ A

24 (a). What is the function of a thermostat in an electric water heater?

A thermostat automatically controls the water temperature by switching the heater on or off. It disconnects the power supply when the preset temperature is reached, maintaining water at a safe and desirable level while preventing overheating.

24 (b). A domestic consumer requires an immersion heater for a tank containing 0.16 m^3 of water. The water is to be heated from 10°C to 50°C in 3 hours. Calculate the nearest element size in kW if the efficiency is 85%.

Mass = 0.16 × 1000 = 160 kg
Heat needed = $mc\Delta T$ = 160 × 4187 × 40 = 26,796,800 J
Actual energy input = 26,796,800 / 0.85 = 31,524,470.6 J
Convert to kWh: 31,524,470.6 / 3600000 = 8.76 kWh
Element size = 8.76 / 3 = 2.92 kW ≈ 3.0 kW

25 (a). Define the term "spacing height ratio".

Spacing height ratio is the ratio of distance between two adjacent lamps to their mounting height. It is used in lighting design to determine uniform distribution of light in an area.

25 (b). A hall 15 m by 20 m is to be illuminated to a level of 70 lux. The lamps each have an efficiency of 12 lm/W and spacing height ratio of 1.2, suspended 4 m above the floor. Estimate the number of lamps required and the power of each lamp.

Area = 15 × 20 = 300 m^2
Total lumens = 70 × 300 = 21000 lm
Effective output per watt = 12 × 0.5 × 0.7 = 4.2 lm/W
Total power = 21000 / 4.2 = 5000 W
If using 100 W lamps, number of lamps = 5000 / 100 = 50 lamps

26 (a). Mention only two methods used to cool distribution transformers.

Oil immersion cooling: Involves submerging transformer windings in oil that dissipates heat.
Air natural cooling: Uses air circulation around the transformer to remove heat without fans.

26 (b). A 20 kVA transformer was tested and found to have 700 W iron losses and 800 W copper losses.

(i) Full load efficiency:
Output = 20000 W
Losses = 700 + 800 = 1500 W
Input = 21500 W

Efficiency = 20000 / 21500 = 0.9302 or 93.02%

(ii) Half load:
Copper losses = $800 \times (0.5)^2 = 200$ W
Total losses = 700 + 200 = 900 W
Output = 10000 W
Input = 10900 W
Efficiency = 10000 / 10900 = 0.9174 or 91.74%