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: 2007**

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 ratio of minimum breaking current over current rating is called
A. sensitivity factor
B. fusing factor
C. load factor
D. growth factor
E. power factor

Correct answer: B. fusing factor
Reason: Fusing factor is the ratio of minimum fusing current to the rated current. It indicates the margin between operating current and the current at which the fuse will melt.

(ii) A tong tester is an instrument used to measure
A. frequency
B. resistance
C. power
D. current
E. voltage

Correct answer: D. current
Reason: A tong tester (or clamp meter) is used to measure current flowing through a conductor without needing to make direct contact or disconnect the circuit.

(iii) The effect of an A.C motor stator winding having an open circuit fault is called
A. armature reaction
B. single phasing
C. split phasing
D. humming
E. short circuiting

Correct answer: B. single phasing
Reason: Single phasing occurs when one phase in a three-phase motor fails or opens, causing unbalanced operation, overheating, and potential damage.

(iv) A single phase motor designed to work on both A.C or D.C is called
A. series universal motor
B. shaded pole motor
C. split phase
D. capacitor start capacitor run
E. repulsion motor

Correct answer: A. series universal motor
Reason: A universal motor can operate on both A.C and D.C supplies and is commonly used in portable tools and appliances like mixers and vacuum cleaners.

(v) The battery/cell fitted in a multimeter is used only when measuring
A. voltages
B. power
C. resistance
D. inductances
E. current

Correct answer: C. resistance
Reason: The battery in a multimeter supplies a small voltage required to measure resistance by sending a current through the resistor and measuring the voltage drop.

(vi) The KVA input of a motor rating 4 KW and 3 KVAR is
A. 3 KVA
B. 4 KVA
C. 5 KVA
D. 7 KVA
E. 3.5 KVA

Correct answer: C. 5 KVA
Reason: $S = \sqrt{(P^2 + Q^2)} = \sqrt{(4^2 + 3^2)} = \sqrt{(16 + 9)} = \sqrt{25} = 5$ KVA

(vii) To reduce stroboscopic effects, discharge lamps may be connected
A. on one phase of a three phase supply
B. on all three phases of a 3 phase supply
C. without capacitor power factor improvement
D. with special filters
E. with a bank of capacitors

Correct answer: B. on all three phases of a 3 phase supply
Reason: Connecting lamps across different phases ensures that the light flickers are out of phase and cancel each other, reducing the stroboscopic effect.

(viii) For a completed electrical installation, the minimum insulation resistance test reading allowed is
A. 0.5 MΩ
B. 1.0 MΩ
C. 100 MΩ
D. Infinity
E. 2.5 MΩ

Correct answer: B. 1.0 MΩ
Reason: According to most standards, the minimum acceptable insulation resistance for a completed installation should not be less than 1 MΩ.

(ix) One of the main reasons for using a ringmain to feed a large distribution system is
A. supply reliability
B. spare stand by switch gear
C. consumer growth factor
D. less maintenance
E. higher voltage supply

Correct answer: A. supply reliability
Reason: A ring main system ensures power can be supplied from more than one direction, enhancing reliability and maintaining supply during faults or maintenance.

(x) The resistance of a conductor increases when
A. its length decreases
B. its area decreases
C. both area and length increases
D. its area increases
E. diameter increases

Correct answer: B. its area decreases
Reason: Resistance is inversely proportional to the cross-sectional area of a conductor. As area decreases, resistance increases.

2. What is the cable size and current rate for a circuit used for a radial circuit of the socket outlet?
For a radial socket outlet circuit, a common cable size used is 2.5 mm^2 copper conductor with PVC insulation. This size is suitable for carrying a current of up to 20 A when installed using the proper installation method and protected by a 20 A circuit breaker. It ensures safe operation for general-purpose socket outlets used in domestic and small commercial installations.

3. What is the purpose of performing insulation resistance test in a new installation?
The purpose of the insulation resistance test is to ensure that the insulation of electrical conductors is intact and free from any damage that could lead to leakage current or short circuits. It helps confirm that the insulation can withstand the system voltage without allowing current to flow between conductors or from conductors to the earth. This test guarantees safety and reliability before the installation is energized.

4. Find the synchronous speed of a 4 pole 3-phase motor operating at 380 V / 50 Hz.
Synchronous speed Ns is calculated using the formula:
$Ns = 120 \times f / P$
Where f = frequency = 50 Hz, P = number of poles = 4
$Ns = 120 \times 50 / 4 = 6000 / 4 = 1500$ rpm
Therefore, the synchronous speed of the motor is 1500 revolutions per minute.

5. Why do electricians perform continuity test in a new installation?

Electricians perform continuity tests to ensure that all conductors, especially the protective earth, are electrically continuous and correctly connected. This test verifies that there are no open circuits or broken wires, ensuring safety and effective operation of protective devices. It is a critical step before energizing the system.

6. Mention three (3) methods of starting a 3-phase squirrel cage induction motor.
Direct-on-line (DOL) starting applies full line voltage directly to the motor terminals, suitable for small motors.

Star-delta starting initially connects the motor windings in star to reduce starting voltage and current, then switches to delta for normal running.

Auto-transformer starting uses a transformer to reduce the initial voltage applied to the motor, thus limiting starting current and torque.

7. What are the recommended heights by I.E.E. regulations for the light switch and switch socket from the floor? (Write the height in centimetres)
According to I.E.E. regulations, light switches should be mounted at a height of 140 cm from the finished floor level. Switch sockets should be mounted at 30 cm above the floor in living areas and 100 cm in kitchens to avoid splash zones.

8. What are the space factors of the following wiring systems?
(i) Trunking
Trunking systems typically use a space factor of 45%, meaning 45% of the internal area of the trunking should be filled with cables, and 55% left free for heat dissipation and future additions.

(ii) Conduit
For conduit systems, the space factor is limited to 40%. This ensures that cables can be easily installed and removed and that heat generated within the conduit does not build up excessively.

(iii) Ducting
Ducting space factor is generally set at 60% of the total cross-sectional area, leaving 40% for airflow and ease of installation and maintenance.

9. What is the effect of connecting a light switch in a neutral wire?
Connecting a light switch in the neutral wire is dangerous because it interrupts the return path instead of the live supply. The load (e.g., lamp) will still have a live supply even when the switch is off, creating a shock hazard during maintenance or replacement. Proper practice is to always switch the live wire to isolate the load fully.

10. How can you extend the range of an ammeter so as to measure high current?
The range of an ammeter can be extended by connecting a low resistance known as a shunt resistor in parallel with the meter. This allows a portion of the current to bypass the ammeter so that only a fraction

of the total current passes through the instrument. By calibrating the meter with the shunt, it can indicate much higher currents than it would normally handle.

11. Outline three (3) types of D.C. motors.
Shunt wound D.C. motor has the field winding connected in parallel with the armature. It provides constant speed under varying loads.

Series wound D.C. motor has the field winding in series with the armature. It offers high starting torque and is suitable for applications like traction.

Compound wound D.C. motor combines both series and shunt field windings. It offers a compromise between the constant speed of a shunt motor and the high torque of a series motor.
12. A shunt generator supplies 100 A at a terminal voltage of 200 volts. The prime mover is developing 32 HP. The shunt field resistance is 50 ohms, armature resistance is 0.1 ohms.
Find:
(a) Field current
$I_f = V / R_f = 200 / 50 = 4$ A

(b) Armature current
$I_a = I + I_f = 100 + 4 = 104$ A

(c) Electromotive force generated
$E = V + I_a \times R_a = 200 + 104 \times 0.1 = 200 + 10.4 = 210.4$ V

(d) Mechanical power input
$P_m = 32$ HP $= 32 \times 746 = 23872$ W

(e) Electrical power output
$P_{out} = V \times I = 200 \times 100 = 20000$ W

(f) The generator efficiency
$\eta = P_{out} / P_m \times 100 = 20000 / 23872 \times 100 = 83.76\%$

13.
(a) Mention two (2) types of losses available in a transformer, and the type of tests used to determine them.
Iron loss (core loss) is constant and determined by the open circuit test.
Copper loss is variable and determined by the short circuit test.

(b) In a 50 KVA transformer with iron losses of 500 W and full load copper losses of 800 W, determine at unit power factor the:
(i) Power input
$P_{in} = \text{Output} + \text{losses} = 50000 + 500 + 800 = 51300$ W

(ii) Efficiency
η = Output / Input × 100 = 50000 / 51300 × 100 = 97.47%

(c) If the power factor is changed into 0.8 lagging, what shall be the:
(i) Input power
P_{out} = 50000 × 0.8 = 40000 W
P_{in} = 40000 + 500 + 800 = 41300 W

(ii) Efficiency
η = 40000 / 41300 × 100 = 96.85%

14. A room 12 m by 7.5 m wide is to be lighted to an average intensity of 240 lux. The lamps to be used have an output of 30 lumens per watt and the coefficient of utilization of the room is 0.6.
If one lamp is rated 36 W, calculate the:
(i) Total lumens
Area = 12 × 7.5 = 90 m²
Lumens = Illuminance × Area = 240 × 90 = 21600 lumens

(ii) Total power
Useful lumens per watt = 30 × 0.6 = 18 lm/W
Power = Total lumens / lm per watt = 21600 / 18 = 1200 W

(iii) Number of lamps
Number = 1200 / 36 = 33.33 ≈ 34 lamps

15. A shunt motor takes 6 amperes on no load and runs at 750 rev/min. The resistance of shunt field is 110 ohms and of armature 0.25 ohms. When loaded, it takes a current of 52 amperes.
Calculate the:
(i) Field current
$I_f = V / R_f = 220 / 110 = 2$ A

(ii) Armature current at no load and at load
No load: $I_{a0} = 6 - 2 = 4$ A
Load: $I_a = 52 - 2 = 50$ A

(iii) Back e.m.f both at load and at no load
No load: $E_0 = V - I_{a0} \times R_a = 220 - 4 \times 0.25 = 219$ V
Load: $E = 220 - 50 \times 0.25 = 207.5$ V

(iv) Speed when loaded
$N_2 = N_1 \times (E_2 / E_1) = 750 \times (207.5 / 219) = 710.96 \approx 711$ rpm

16. Each phase of a 3-phase delta connected generator supplies a full load current of 100 A at a voltage of 240 V and a power factor of 0.6 lagging.
Find the:
(i) Apparent power
$S = \sqrt{3} \times V \times I = 1.732 \times 240 \times 100 = 4156.8$ VA = 4.157 kVA

(ii) Line current
In delta, line current = $\sqrt{3}$ × phase current = 1.732 × 100 = 173.2 A

(iii) Line voltage
In delta, line voltage = phase voltage = 240 V

(iv) Real power
$P = \sqrt{3} \times V \times I \times pf = 1.732 \times 240 \times 100 \times 0.6 = 2494.1$ W = 2.494 kW

(v) Reactive power
$Q = \sqrt{(S^2 - P^2)} = \sqrt{(4156.8^2 - 2494.1^2)} = \sqrt{(17274630.24 - 6220501.81)} = \sqrt{11054128.43} = 3323$ VAR = 3.323 kVAR