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: 2003**

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 main causes of accidents in a workshop is

A. students' lack of technical attitude

B. fatigue of students and the teacher

C. carelessness and ignorance

D. teacher's absence in the workshop

E. bad rules of the workshop

Correct answer: C. carelessness and ignorance

Reason: Most workshop accidents result from human negligence, not following safety rules, and lack of awareness of risks during operation of machines or tools.

(ii) The cable used for underground supply system is

A. vulcanised rubber insulated

B. mineral insulated metal sheathed

C. mineral insulated copper sheathed

D. armoured cable

E. PVC cable

Correct answer: D. armoured cable

Reason: Armoured cables are designed with a protective layer to withstand mechanical stress and environmental conditions underground.

(iii) The cable size and current rating of a domestic lighting circuit is

A. 1.5 mm^2 and 5 A

B. 2.5 mm^2 and 6 A

C. 2.5 mm^2 and 13 A

D. 3.5 mm² and 30 A

E. 1.5 mm² and 10 A

Correct answer: A. 1.5 mm² and 5 A

Reason: In standard domestic wiring, 1.5 mm² cable is recommended for lighting circuits with current ratings not exceeding 5 A for safety.

(iv) In a domestic electrical supply connection sequence, the following is supplied by the electric supply company (TANESCO):

A. Cut-out and energy meter

B. Earth leakage circuit-breaker and main switch

C. kWh-meter and main-switch

D. Main-switch and cut-out

E. Cut-out and main-switch

Correct answer: A. Cut-out and energy meter

Reason: TANESCO installs the energy meter for billing and a cut-out fuse to protect the connection before it enters the consumer unit.

(v) Polarity test is made in a new installation to ensure

A. all switches, fuses and circuit-breakers are in the live wire

B. all switches, fuses and circuit-breakers are connected to the neutral wire

C. earth wire is well connected to the live wire

D. all switches, fuses and circuit-breakers are electrically sound

E. all poles of all switches are connected to the live wire

Correct answer: E. all poles of all switches are connected to the live wire

Reason: Polarity testing confirms that switches are interrupting the live line and not the neutral, ensuring user safety during maintenance or disconnection.

(vi) The suitable type of switches for controlling one light or a group of lights from three different positions are

A. two 2-way switches and one 1-way 1-gang switch

B. two 2-way 1-gang switches and one intermediate switch

C. one 2-way 2-gang switch and one intermediate switch

D. two 2-way 2-gang switches and one 1-way 2-gang switch

E. two 2-way 2-gang switches and two 2-way 2-gang switches

Correct answer: B. two 2-way 1-gang switches and one intermediate switch

Reason: For control of a light from three different positions, the configuration must include two 2-way switches at the ends and one intermediate switch in the middle.

(vii) When measuring current, an ammeter is connected

A. in parallel with the load

B. in series-parallel with the load

C. in series with the load

D. in shunt with the load

E. either in series or in parallel with the load

Correct answer: C. in series with the load

Reason: Ammeter must be connected in series to measure the exact current flowing through the circuit.

(viii) The space factor for conduit installation is

A. 30%

B. 45%

C. 60%

D. 40%

E. 35%

Correct answer: C. 60%

Reason: The space factor, or the maximum permissible fill of conduits, is 60% to avoid overheating and allow easy pulling of wires.

(ix) A circuit is protected by a fuse of 5 A rating. If it has a fusing factor of 1.45 the minimum fusing current will be

A. 3.45 A

B. 6.25 A

C. 7.25 A

D. 10 A

E. 7.0 A

Correct answer: C. 7.25 A

Reason: Minimum fusing current = 5 A × 1.45 = 7.25 A. This is the minimum current needed to blow the fuse.

(x) Horse-power (HP) is a unit of real power. One HP is equal to

A. 1,000 W

B. 10,000 W

C. 746 W

D. 100 W

E. 647 W

Correct answer: C. 746 W

Reason: One mechanical horsepower is defined as 746 watts in SI units, commonly used for motor ratings.

2. State three factors which determine the resistance of a conductor.

The first factor is the length of the conductor. As the length of a conductor increases, its resistance also increases because electrons face more opposition to flow over a longer distance.

The second factor is the cross-sectional area of the conductor. A larger cross-sectional area offers more space for electrons to pass through, hence reducing the resistance. Conversely, a smaller area increases resistance.

The third factor is the material of the conductor. Different materials have different resistivities. Conductors like copper have low resistance due to high conductivity, while materials like iron have higher resistance because of greater opposition to electron flow.

3. State three functions of a main-switch gear in an electrical installation.

The first function is to isolate the power supply. A main-switch gear provides a means of disconnecting the entire installation from the power source for maintenance or emergencies.

The second function is to protect the system from overloads. Main-switch gear is usually integrated with protective devices like fuses or circuit breakers to interrupt the circuit in case of excessive current.

The third function is to control the power flow. It acts as a central control point that allows or stops the supply of electricity to various sections of the installation.

4. Name three types of fuses used in the protection against excess current.

The first type is the rewirable fuse. This fuse contains a fuse wire which melts when current exceeds the limit, and can be rewired after blowing.

The second type is the cartridge fuse. It consists of a metal fuse element enclosed in a cylindrical ceramic or glass tube. It is disposable and used for accurate and fast protection.

The third type is the high rupturing capacity (HRC) fuse. It is designed to operate in high fault current conditions, offering high-speed interruption with greater safety and reliability.

5. Show how current and voltage are measured in an electric circuit. Illustrate your answer by means of a simple diagram.

Current in an electric circuit is measured using an ammeter, which is connected in series with the load to ensure the full current flows through it. Voltage is measured using a voltmeter, which is connected in parallel across the two points where the potential difference is required.

For example, if a circuit contains a resistor connected to a battery, the ammeter is placed in series with the resistor and battery, while the voltmeter is connected across the terminals of the resistor to measure voltage drop.

6. What is the purpose of the insulation resistance test in an electrical installation?

The purpose of the insulation resistance test is to ensure that the insulating material covering conductors is effective and free from faults such as cracks, moisture penetration, or aging that could lead to leakage currents, short circuits, or electric shocks. This test verifies that the installation is safe and prevents electrical hazards before it is energized.

7. State three methods of starting a 3-phase squirrel-cage induction motor.

The first method is the direct-on-line (DOL) starter. It connects the motor directly to full line voltage, used for small motors due to high starting current.

The second method is the star-delta starter. It initially connects the motor windings in a star formation for reduced starting voltage, then switches to delta once running.

The third method is the autotransformer starter. It uses an autotransformer to reduce the initial voltage applied to the motor during start-up, minimizing starting current and torque.

8. What is the function of a centrifugal switch in a single-phase a.c. motor?

The centrifugal switch in a single-phase a.c. motor is used to disconnect the starting winding from the circuit once the motor reaches a predetermined speed, usually around 70 to 80 percent of full speed. This action prevents the starting winding from overheating and ensures efficient running by allowing the motor to operate on the main winding alone.

9. Name three types of electrical power stations.

The first type is the thermal power station, which uses heat energy from burning coal, oil, or gas to generate steam that drives turbines connected to generators.

The second type is the hydroelectric power station, which converts kinetic energy of flowing water into mechanical energy using turbines, then into electrical energy using generators.

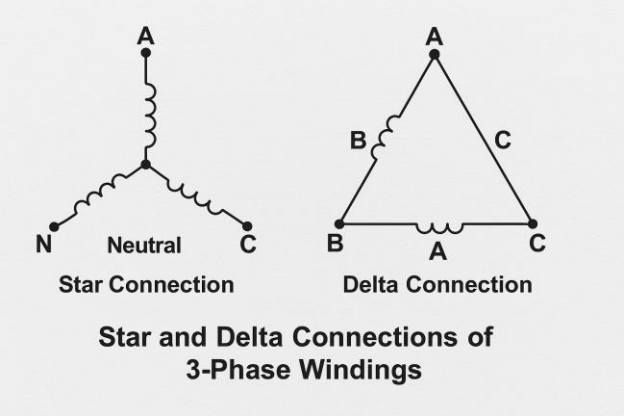
The third type is the nuclear power station, which uses heat generated from nuclear fission reactions to produce steam that powers turbines and generates electricity.

10. State two functions of a choke fitted in a low-pressure mercury vapour lamp.

The first function is to limit the current flowing through the lamp after ionization. Once the lamp starts, the choke maintains appropriate current flow to prevent damage.

The second function is to provide the high voltage pulse needed to initiate the discharge by inducing a voltage spike when the starter opens the circuit.

11. Show by means of a circuit diagram, the star and delta connections of a 3-phase windings of a transformer.



In a star connection, one end of each of the three windings is connected to form a neutral point, and the other ends are connected to the respective phase lines.

In a delta connection, the ends of the three windings are connected in a closed loop, forming a triangle, with each junction point connected to a phase line.

12. (a) Outline two types of tests carried out or applied in a new transformer in order to detect losses.

The insulation resistance test is conducted to determine the quality of insulation between windings and between windings and the core. It helps identify any weakness or deterioration in the insulation.

The winding resistance test is done to check for any abnormal resistance which may indicate poor connections or damage in the windings.

(b) By using circuit diagrams, show how the copper and iron losses are determined.

Copper losses are determined by measuring the current through the windings and using the resistance of the winding to compute I^2R losses. This is typically done under load conditions. Iron losses are measured by performing an open-circuit test where rated voltage is applied with the secondary open, and only core losses (eddy current and hysteresis) occur. The power measured gives the iron losses.

(c) State two methods of cooling transformers.

Oil immersion cooling uses mineral oil to absorb and transfer heat from the transformer core and windings. The heated oil circulates and transfers heat to the radiators or cooling surfaces.

Air blast cooling uses fans to blow air over the windings and core to remove excess heat. This is used in dry-type transformers where oil cooling is not applied.

13. (a) Outline three ways of transferring heat.

Conduction is the transfer of heat through a solid material from the hotter part to the cooler part due to particle vibration.

Convection is the heat transfer in fluids (liquids or gases) where the hot portion becomes less dense and rises while the cooler portion sinks, forming a circulation.

Radiation is the transfer of heat through electromagnetic waves without involving a medium, for example, heat from the sun.

(b) A domestic consumer requires an immersion heater for a tank containing 160 litres of water. The water has to be heated from 10°C to 50°C in three hours. If the efficiency of the heating system is 85%, calculate the nearest element size in kW. Take the specific heat capacity of water to be 4180 J/kg°C.

Mass of water = 160 litres = 160 kg

Temperature change = 50 - 10 = 40°C

Energy required = $mc\Delta T$

= $160 \times 4180 \times 40 = 26720000$ J

Useful energy output = 26720000 J

Efficiency = 85%

Total energy input = 26720000 / 0.85 = 31435294.12 J

Time = 3 hours = $3 \times 3600 = 10800$ s

Power = Energy / Time = 31435294.12 / 10800 = 2901.4 W

Element size = 2.9 kW

14. (a) Define armature reaction.

Armature reaction is the effect of the magnetic field produced by the armature current on the distribution of the main field flux in a machine. It can distort and weaken the main field, affecting performance and causing sparking at the brushes.

(b) The no-load voltage of a shunt generator is 230 V and on-load voltage is 220 V. The field and armature resistance are 100 Ω and 0.05 Ω respectively.

(i) Load current = (230 - 220) / 0.05 = 10 / 0.05 = 200 A

(ii) Armature voltage drop = 200 × 0.05 = 10 V

(iii) Armature current = Load current = 200 A

(iv) Field current = 220 / 100 = 2.2 A

15. (a) What precautions must be taken with respect to the load on a d.c. series motor?

A d.c. series motor must never be started without a load because its speed increases rapidly and uncontrollably under no-load condition, which may damage the motor.

(b) A d.c. motor connected to a 460 V supply has an armature resistance of 0.15 Ω.

(i) The value of back e.m.f. when armature current is 120 A:

V = E + IR

460 = E + (120 × 0.15)

460 = E + 18

E = 442 V

(ii) The value of armature current when the back e.m.f is 447 V:

460 = 447 + I × 0.15

13 = 0.15 I

I = 13 / 0.15 = 86.67 A

16. (a) Explain the reason of using high voltage for transmission and distribution of electric energy.

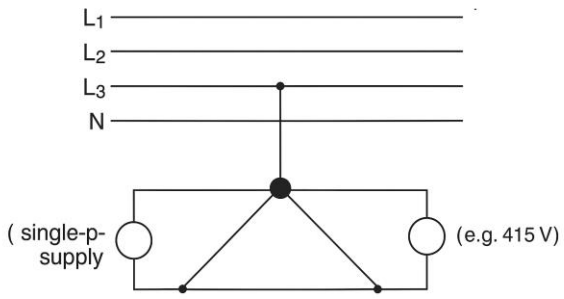
High voltage reduces the current for the same power transmission. Lower current reduces I^2R losses in the transmission lines, making the system more efficient and allowing for the use of smaller and lighter conductors.

(b) Draw a simple circuit diagram of a three-phase four-wire a.c. system showing:

(i) a star point

(ii) a single-phase supply (e.g. 240 V)

(iii) a three-phase supply (e.g. 415 V)



(i) a star point
(ii) a single-phase supply (e.g. 240 V)