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: 2010**

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 function of protective relay in a circuit breaker is to
A. react and stop voltage
B. close the contacts when actuating quantity reaches a certain predetermined value
C. interrupt current during the operation of the circuit breaker
D. provide additional safety in the operation of the circuit breaker
E. neutralize the effect of transient

Correct answer: B. close the contacts when actuating quantity reaches a certain predetermined value
Reason: A protective relay initiates tripping by closing its contacts when current or voltage reaches a set threshold.

(ii) Which portion of the transmission system does the fault occurs most frequently?
A. Transformer
B. Overhead lines
C. Alternators
D. Underground cables
E. Switch gears

Correct answer: B. Overhead lines
Reason: Overhead lines are exposed to environmental and mechanical damage, making them prone to faults.

(iii) Which of the following category of consumers can provide highest load factor?
A. A domestic consumer
B. A steel melting unit using arc furnace
C. A cold storage plant
D. A continuous process plant
E. An air compressor running continuously

Correct answer: D. A continuous process plant
Reason: Continuous process plants operate constantly, maintaining steady power consumption and thus high load factor.

(iv) A transformer with a fixed primary voltage is feeding a unity power factor load on the secondary side. How will the secondary terminal voltage behave when either inductor or capacitor is connected in parallel to the load?
A. Voltage will decrease when inductor is connected but will increase when capacitor is connected.
B. Voltage will increase when inductor is connected but will decrease when capacitor is connected.
C. Voltage will decrease when either inductor or capacitor is connected.
D. Voltage will increase when either inductor or capacitor is connected.
E. Voltage will remain constant either inductor or capacitor is connected.

Correct answer: A. Voltage will decrease when inductor is connected but will increase when capacitor is connected.
Reason: An inductor causes lagging current (drop in voltage), while a capacitor causes leading current (voltage rise).

(v) How much energy can be taken from a power supply?
A. As much as the consumers demand
B. Maximum demand
C. Basic load and peak load
D. A maximum of the installed capacity of generation
E. kWh generated in a year

Correct answer: D. A maximum of the installed capacity of generation
Reason: The energy that can be taken is limited by the capacity of the power generation system.

(vi) One of main reasons for conducting continuity tests on ring final circuit conductors is to
A. identify the opposite legs of the ring
B. ensure that the CPC is not continuous
C. ensure that interconnections in the ring do not exist
D. take a resistance measurement
E. ensure that CPC is continuous

Correct answer: E. ensure that CPC is continuous
Reason: Continuity tests ensure that the circuit protective conductor (CPC) is continuous throughout the ring.

(vii) Identify factors which decide the type of wiring system.
A. Flexibility, appearance, number of points, type of conductors
B. Type of building, flexibility, appearance, durability, cost, safety
C. Type of room, type of supply, size of fuse, cost changing
D. Conditions, installation conditions
E. Current rating, fixing factor, availability of accessories, cost, safety, durability, installation condition

Correct answer: E. Current rating, fixing factor, availability of accessories, cost, safety, durability, installation condition
Reason: These technical and environmental factors determine the suitable wiring system.

(viii) One can control a single bulb or a group of bulbs from two different positions by use of
A. two single-pole switches
B. one two-way switch and one single-pole switch
C. two one-way switches and an intermediate switch
D. two two-way switches
E. one intermediate switch

Correct answer: D. two two-way switches
Reason: Two-way switches allow control of one light from two different locations.

(ix) The purpose of interpoles in a d.c machine is to
A. raise reaction voltage of the commutating coils
B. oppose reactance voltage of the commutating coils
C. add armature reaction ampere turns
D. oppose armature reaction ampere turns
E. assist in reversal of current in the commutating coils

Correct answer: E. assist in reversal of current in the commutating coils
Reason: Interpoles improve commutation by inducing a voltage that aids in reversing current in the coils.

(x) Power factor of d.c series motor can be improved by
A. increasing the magnitude of inductance of field and armature
B. reducing the armature resistance to armature reactance
C. increasing the number of turns on armature winding
D. reducing the resistance required to armature reactance
E. decreasing the magnitude of reactance and armature winding

Correct answer: E. decreasing the magnitude of reactance and armature winding
Reason: Lowering reactance improves the alignment of voltage and current, thus improving power factor.

2. Define the following terms as used in electrical installation work:
(a) Earthing
Earthing is the process of connecting the metallic parts of electrical equipment to the ground so that in case of a fault, excess current flows safely into the earth. This protects users from electric shock and prevents equipment damage. It creates a low-resistance path for fault current, ensuring safety in electrical installations.

(b) Direct contact
Direct contact refers to the touching of live electrical parts such as conductors or terminals by a person. It usually occurs accidentally and can cause electric shock or serious injury. Direct contact is dangerous because the human body becomes part of the circuit, allowing current to flow through it.

(c) Fault current
Fault current is the abnormal current that flows through a circuit when there is a fault, such as a short circuit or earth fault. It is typically much higher than the normal operating current and can cause overheating, equipment damage, or fire if not interrupted quickly. Protective devices are used to detect and interrupt fault current.

(d) Protective relays

Protective relays are automatic devices used in electrical systems to detect abnormal conditions like overcurrent, under-voltage, or earth faults and initiate the operation of circuit breakers. They help isolate the faulty section of the system to prevent equipment damage and ensure safety of the entire network.

(e) Enclosed
Enclosed refers to electrical equipment or systems that are surrounded by a protective casing to prevent accidental contact with live parts. Enclosures also protect the equipment from external elements such as dust, water, or mechanical damage. They ensure both safety and durability in installations.

3. Draw a neat circuit diagram of two lamps controlled by two-way switches together with two intermediate switches (type I and type II).
[Explanation only since diagram cannot be drawn here]
The circuit should have two lamps with two pairs of two-way switches and a central intermediate switch in each line. The two-way switches are placed at the ends, while the intermediate switch is between them. Type I controls lamp 1 and Type II controls lamp 2. Each lamp can be switched on or off from three different positions.

4. What are the uses of the following tools?
(a) Revolving punch pliers
Revolving punch pliers are used to make clean and precise holes in soft materials such as leather, plastic, and rubber. In electrical installation, they are commonly used to punch holes in insulating boards or plastic boxes for wire entry or screw fitting.

(b) End cutting nippers
End cutting nippers are used to cut wires, nails, and small pins close to the surface. In electrical work, they are used to trim wire ends neatly, especially when working in tight spaces or when cutting cable ties.

(c) Pipe wrench
Pipe wrenches are used to grip and turn metal pipes and threaded fittings. In electrical installation, they are essential for tightening or loosening metallic conduits and fittings during conduit installations.

(d) Crimping pliers
Crimping pliers are used to permanently attach lugs or connectors to the ends of electrical wires by deforming the terminal around the wire. This creates a secure electrical and mechanical connection, commonly used in panel boards and circuit terminations.

5. (a) Why is it necessary to measure earth resistance?
It is necessary to measure earth resistance to ensure that the earthing system provides a low-resistance path for fault current to safely dissipate into the ground. Low earth resistance is crucial for effective operation of protective devices like fuses and circuit breakers during a fault.

Proper earth resistance measurement ensures that exposed conductive parts do not reach dangerous potential that could lead to electric shock.

Regular testing of earth resistance is required to maintain compliance with safety standards and regulations in electrical installations.

(b) Mention three tests required to be performed on any installation before putting it into service.
Insulation resistance test is conducted to check for leakage current and ensure that insulation between conductors and earth is adequate.

Continuity test is done to confirm that all protective conductors and bonding connections are complete and properly connected throughout the system.

Polarity test is carried out to verify that switches and protective devices are correctly connected in the live conductor and not in the neutral.

6. Explain briefly the five (5) main features of good protective devices.
A good protective device should be sensitive enough to detect faults like overcurrent, earth faults, or short circuits even at low levels before they become dangerous.

It must be selective so that it isolates only the faulty section without disrupting the operation of the entire installation.

Speed is essential in a protective device to ensure that faults are cleared quickly to minimize damage and reduce the risk of fire or injury.

Reliability is critical as the device must function correctly whenever a fault occurs, under all environmental and electrical conditions.

It should be either resettable or easily replaceable after clearing a fault so that normal operation can be restored without difficulty.

7. List six (6) parts of a d.c generator.
Armature is the rotating part of the generator where electromotive force (emf) is induced due to the interaction of magnetic field and conductor.

Field windings produce the magnetic field required for the generation of emf. These are usually placed on the poles of the generator.

Commutator is a mechanical rectifier that converts the alternating emf induced in the armature windings into direct current output.

Brushes are made of carbon or graphite and maintain sliding electrical contact with the rotating commutator to transfer current.

Yoke is the outer frame of the generator which provides mechanical support and also carries magnetic flux.

Shaft is the rotating axis on which the armature is mounted and is driven by a prime mover like a diesel engine or turbine.

8. Explain briefly six (6) advantages of electric heating compared to other types of heating.
Electric heating is clean since it does not produce smoke, dust, or combustion gases, making it suitable for indoor and hygienic environments.

It offers high efficiency as nearly all the electrical energy is converted directly into heat with minimal losses.

Electric heating systems provide precise and easy control of temperature, making them ideal for industrial processes and domestic use.

They are silent in operation, as there are no moving parts or combustion, leading to a quieter environment.

Electric heating equipment is compact and easy to install, requiring less space compared to boilers and furnaces.

There is no need for storage or handling of fuel like coal or gas, reducing operational hazards and maintenance needs.

9. A consumer has the following connected loads: 10 lamps of 60 W each and 2 heaters of 1000 W each. His maximum demand is 1500 W. On the average, he uses 8 lamps for 5 hours a day and each heater for 3 hours a day. Find his total load, monthly energy consumption and load factor.
Total connected load = (10 × 60) + (2 × 1000) = 600 + 2000 = 2600 W or 2.6 kW

Daily usage:
Lamps = 8 × 60 × 5 = 2400 Wh = 2.4 kWh
Heaters = 2 × 1000 × 3 = 6000 Wh = 6 kWh
Total daily consumption = 2.4 + 6 = 8.4 kWh
Monthly energy consumption = 8.4 × 30 = 252 kWh

Load factor = Average load / Maximum demand
Average load = 252 / (30 × 24) = 0.35 kW
Maximum demand = 1.5 kW
Load factor = 0.35 / 1.5 = 0.233 or 23.3%

10. (a) What is an ideal transformer?
An ideal transformer is a theoretical transformer that has 100% efficiency, meaning there are no losses during energy transfer. It has perfect magnetic coupling, no core losses (hysteresis and eddy currents), no

winding resistance, and no leakage flux. The voltage and current ratios follow the turns ratio exactly, and it only serves to transform voltage or current levels without introducing losses.

(b) Mention two (2) types of losses that may occur in a transformer.
Iron losses occur in the core due to alternating magnetic flux and consist of hysteresis and eddy current losses. These are constant for a given voltage and frequency.

Copper losses occur in the winding resistance of the transformer and are proportional to the square of the load current. These losses generate heat and increase with load.

11. (a) Define the term 'grid'.
A grid is an interconnected network of electricity generation, transmission, and distribution systems that enables the transfer of electrical energy from power stations to consumers across a wide area. It allows for efficient, reliable, and flexible distribution of electricity by linking various power sources and users.

(b) Describe four (4) requirements which should be fulfilled for a system to be considered as a good system.
A good system must be reliable, ensuring continuous and uninterrupted supply of electricity even during peak demands or in the event of faults.

It must be efficient, meaning it should have minimal losses in transmission and distribution to reduce cost and improve performance.

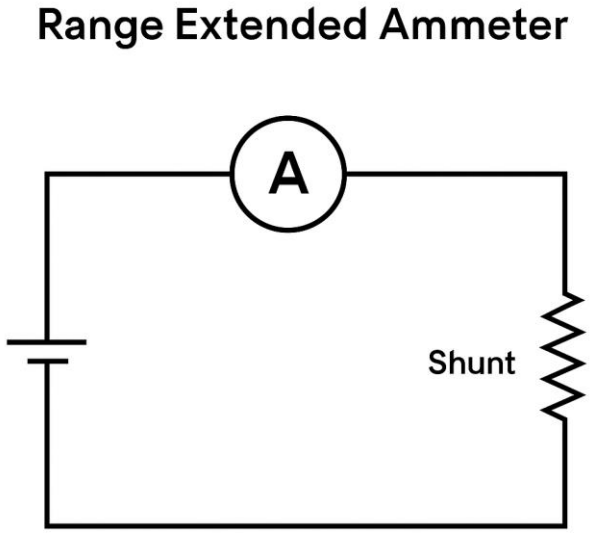
It should be flexible enough to handle load variations, integrate new technologies like renewable energy, and adapt to future expansions.

It must be safe for both equipment and personnel, with proper protection systems, grounding, insulation, and compliance with electrical standards.

12. (a) With the help of a diagram explain clearly how the ranges of a d.c ammeter and a d.c voltmeter can be extended.
To extend the range of a d.c ammeter, a low resistance known as a shunt is connected in parallel with the meter. This allows most of the current to bypass the meter, enabling it to measure higher currents than it could directly.

To extend the range of a d.c voltmeter, a high resistance known as a multiplier is connected in series with the meter. This limits the current entering the meter, allowing it to measure higher voltages without damaging the instrument.

A well-labeled diagram should show an ammeter with a parallel shunt and a voltmeter with a series resistor, indicating how total current or voltage is shared.



(b) A permanent magnet moving coil instrument gives a full scale deflection at 100 mV and 20 mA. Explain how the instrument can be used as:
(i) An ammeter of 0–100 A range.
Shunt resistance Rs = (Im × Rm) / (I - Im)
Rm = 100 mV / 20 mA = 5 Ω
Rs = (0.02 × 5) / (100 - 0.02) = 0.1 / 99.98 ≈ 0.001 Ω
So a very low resistance is connected in parallel to make it a 100 A ammeter.

(ii) Voltmeter of 0–200 V range.
Multiplier resistance R = (V - Vm) / Im = (200 - 0.1) / 0.02 = 199.9 / 0.02 = 9995 Ω
So a high resistance is connected in series to allow measurement of 200 V.

13. (a) Define the following terms as used in armature windings:
(i) Conductor
A conductor is a length of copper or aluminum wire placed in slots on the armature to carry current and produce the necessary electromotive force (emf) when the armature rotates in the magnetic field.

(ii) Turn
A turn refers to one complete loop of the conductor placed in the armature slots. It is the basic building unit of a coil, and many turns form a coil to produce adequate emf.

(iii) Coil
A coil is made up of several turns of wire. In a d.c machine, coils are placed in slots on the armature and are responsible for generating voltage when rotating in a magnetic field.

(iv) Winding
Winding is the complete interconnection of all coils and conductors in a defined pattern on the armature. It determines the electrical characteristics of the machine like voltage and current.

(b) A series generator of total resistance 0.5 Ω is running at 1000 r.p.m and delivering 5 kW at a terminal voltage of 100 V. If the speed is raised to 1500 r.p.m and the load is adjusted to 8 kW, find the new current and terminal voltage.
At 1000 r.p.m:
$P = 5000$ W, $V = 100$ V $\rightarrow I = P / V = 5000 / 100 = 50$ A
$E = V + Ir = 100 + (50 \times 0.5) = 125$ V
At 1500 r.p.m, speed ratio = $1500 / 1000 = 1.5$
$E_2 = 1.5 \times 125 = 187.5$ V
$P_2 = 8000$ W $\rightarrow I_2 = P / V = 8000 / V$
$V = E - I \times r \rightarrow V = 187.5 - 0.5I$
Substitute into power:
$8000 = I \times (187.5 - 0.5I)$
$8000 = 187.5I - 0.5I^2$
$0.5I^2 - 187.5I + 8000 = 0$
Solving: $I = 52.68$ A
$V = 8000 / 52.68 = 151.84$ V

14. (a) List three (3) methods of starting fluorescent lamps.
Using a starter switch (glow type starter) which preheats the filaments and provides a high voltage pulse to start the lamp.

Using an electronic ballast which controls the starting and running conditions of the lamp more efficiently and eliminates flickering.

Using instant start circuitry that provides a high voltage immediately without preheating the filaments.

(b) With the help of a well labeled circuit diagram, explain the working principle of a low pressure mercury vapour lamp (fluorescent lamp).
The fluorescent lamp contains mercury vapor and an inert gas inside a glass tube. When voltage is applied, electrons flow through the gas and collide with mercury atoms, emitting ultraviolet (UV) light. The UV light strikes the phosphor coating on the inside of the tube, converting it into visible light. A ballast regulates the current while the starter assists in initiating the arc.

(c) Draw a circuit of domestic consumer's control unit and state the cable sizes you would use for each circuit.
The control unit includes a main switch, earth leakage circuit breaker (ELCB), circuit breakers for lighting (1.5 mm^2 cable), socket outlets (2.5 mm^2 cable), and cooker or water heater circuit (4 mm^2 cable). Each circuit is individually protected and connected through suitable MCBs.

15. (a) Explain briefly three (3) disadvantages of low power factor.
Low power factor increases the current drawn for the same amount of power, leading to larger conductor sizes and increased copper losses.

It causes higher voltage drops in the distribution system, reducing voltage regulation and efficiency of the supply system.

Electricity suppliers charge penalties to consumers with low power factor, increasing operating costs.

(b) The cost of electrical power to a consumer is Shs 1,300 per month per kVA of maximum demand plus Shs 131 per unit. A consumer's maximum demand is 450 kW at 0.72 power factor and his monthly consumption is 60,000 kWh.
(i) Calculate the overall cost per unit.
Demand in kVA = 450 / 0.72 = 625 kVA
Cost of demand = 625 × 1300 = 812,500
Cost of energy = 60,000 × 131 = 7,860,000
Total cost = 812,500 + 7,860,000 = 8,672,500
Cost per unit = 8,672,500 / 60,000 = 144.54 per unit

(ii) Give one (1) method by which the consumer could reduce the cost of his power while taking the same number of units.
The consumer can install power factor correction capacitors to improve the power factor and thus reduce the kVA maximum demand charges.

16. (a) Mention three (3) factors which determine a well designed lighting scheme.
The required level of illumination based on the nature of work being performed is a key factor to ensure proper visibility and productivity.

The uniformity of lighting across the area without causing glare or dark spots affects visual comfort and aesthetics.

The efficiency and positioning of lamps, including spacing, mounting height, and type of luminaire used, determine the effectiveness of the lighting design.

(b) A hall 30 m long and 12 m wide is to be illuminated, and the illumination required is 50 lm/m². Calculate the number of lamps required in each unit. Take depreciation factor of 1.3 and utilization factor of 0.5.
Area = 30 × 12 = 360 m²
Lumens required = 360 × 50 = 18,000 lm
Total lumens needed = 18,000 × 1.3 / 0.5 = 46,800 lm

Using lamp types:

100 W = 1615 lm → 46,800 / 1615 = 29 lamps
200 W = 3650 lm → 46,800 / 3650 = 13 lamps
300 W = 4700 lm → 46,800 / 4700 = 10 lamps
500 W = 9950 lm → 46,800 / 9950 = 5 lamps
1000 W = 21,500 lm → 46,800 / 21,500 = 2.2 lamps ≈ 3 lamps
So number of lamps depends on wattage chosen.