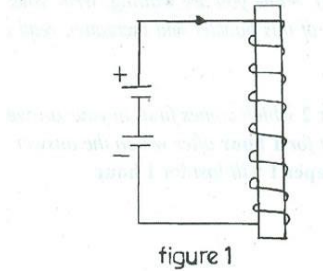
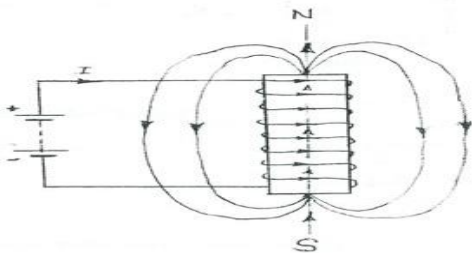


1. Figure 1 is a coil of wire wound on an iron core connected to a battery.



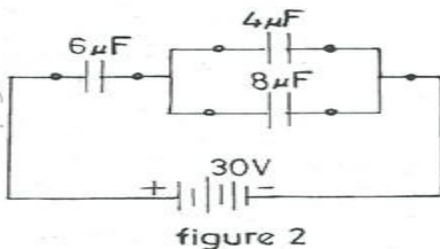
- (a) Sketch the magnetic field pattern of the current-carrying coil indicating its polarity.
- (b) State one rule for the determination of the polarity of the field in 1 (a).

### Expected Solution



- (b) The polarity of the field is determined either by the cork screw rule or by the right-hand grip rule.

2.



In figure 2 calculate the;

- (i) Equivalent capacitance;
- (ii) Total energy stored in the circuit;
- (iii) Charge in the 6μF capacitor;
- (iv) Potential difference across the 6μF capacitor.

### Expected Solution

- (i) Equivalent capacitance  $(C_{eq}) = \frac{6 \times 12}{6 + 12} = 4\mu F$
- (ii) Total energy stored  $= \frac{1}{2} CV^2 = 1.8 \text{mjoules}$
- (iii) Charge in the 6μF capacitor,  $Q = CV = 120\mu C$
- (iv) Potential difference across the 6μF Capacitor  $V = \frac{Q}{C} = 20V$

3. A balanced three-phase delta connected system has a line voltage of 415V and a line current of 20A. If the total load on the system is 6000W, calculate the:
- Load power factor;
  - Current in each phase;
  - Power delivered by each phase.

### Expected Solution

- (i) The load power factor; Power (P) =  $\sqrt{3}V_L I_L \cos \theta$ ;

$$\text{Power Factor} = \frac{P}{\sqrt{3}V_L I_L} = \frac{6000}{(1.7320 \times 415 \times 20)} = 0.418$$

- (ii) The current in each phase;  $I_P = \frac{I_L}{\sqrt{3}} = \frac{20}{\sqrt{3}} = 11.6A$

- (iii) Power per phase;  $= \frac{\text{Total Power}}{3} = \frac{6000}{3} = 2000W$  OR

$$\text{Power per phase,} = V_{ph} I_L \cos \theta = 415 \times 11.6 \times 0.418 = 2012.3W \text{ (In } \Delta \text{ connection, } V_L = V_{ph})$$

4. (a) Define coulomb.  
 (b) State the units of the following quantities;  
 (i) Resistance;  
 (ii) Potential difference.  
 (c) A dc motor supplied from 230V supply for 1hour consumes energy of 36mJ. Calculate;  
 (i) Power rating of the motor;  
 (ii) Current taken from the supply.

### Expected Solution

- (a) Coulomb (Q) = It; Is the quantity of a steady current of one ampere in one second.

- (b) (i) Resistance (Ohm -  $\Omega$ )                      (ii) Potential difference (Volt - V)

- (c) (i) Power rating of the motor =  $\frac{\text{Energy}}{\text{Time}} = \frac{36mJ}{3600} = 0.01mW$

$$(ii) \text{ Current taken from the supply} = \frac{\text{Power}}{\text{Voltage}} = \frac{0.01mW}{230v} = 0.043\mu A$$

5. (a) Define a generator.  
 (b) List the three parts of a dc machine.  
 (c) State;  
 (i) The part of a generator that enables it to produce a d.c. output;  
 (ii) Three methods of connecting field winding in a d.c. machine.

### Expected Solution

- (a) A generator is a machine that converts mechanical energy into electrical energy.

- (b) The three parts of d.c. machine;

- (i) Field windings      (ii) Armature      (iii) Commutator and its associated brush gear

- (c) (i) Commutator;

- (ii) (a) Series              (b) Shunt              (c) Compound              (d) Separately excited

6. (a) List four components of a power substation.  
 (b) State the function of any three components mentioned in 6(a)

## Expected Solution

(a) Substation components

(1) Transformer (2) Isolators (3) Fuses (4) Circuit breaker (5) Feeder (6) Contactor

(b) Explanation of any three listed above

(i) Transformer; it is used to step up or step-down voltage.

(ii) Fuse; it is used to break circuit on short circuit and overload.

(iii) Isolator; it is used to isolate the transformer from the system in case of a fault.

(iv) Feeder; feed the input and the output voltage of the transformer.

(v) Contactor; it is used for monitoring electrical quantities i.e. voltage or current in the system.

7. a. State the function of a damping force in measuring instruments.  
 b. State two methods by which damping force is achieved in measuring instruments.  
 c. State an advantage of a moving-coil measuring instrument over a moving-iron measuring instrument.

## Expected Solution

(a) Function of a damping force in a measuring instrument

The damping force causes the pointer to settle down to its final value without oscillation.

(b) Methods by which damping force is achieved in measuring instrument

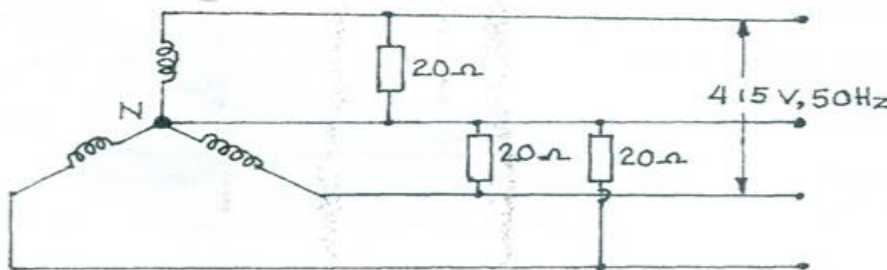
(i) Air dashpot damping (ii) Eddy current damping

(c) Advantages of moving-coil measuring instrument over moving-iron

(1) Uniform/linear scale (2) Not affected by stray magnetic field

(3) Higher sensitivity (4) Perfect damping achieved

8.



In the 3-phase star connected system, calculate the;

- a. Phase voltage;  
 b. Line current;  
 c. Total power

## Expected Solution

(a) Phase Voltage,  $V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{415}{\sqrt{3}} = 239.6V$

(b) In star connection,  $I_L = I_{ph}$ ;  $I_{ph} = \frac{V_{ph}}{R} = \frac{239.6}{20} = 11.98A$

(c) Total Power,  $P = \sqrt{3}V_L I_L \cos \theta = 1.7320 \times 415 \times 11.98 \times 1 = 8610.98W$

9. Table 1 shows the terminal of a 13A plug.

Table 1

Terminal	Colour of Wire	Symbol
Live		
Neutral		
Earth		

(a) Complete Table 1

(b) State two types of fault that occur in electrical installations.

### Expected Solution

(a)

Terminal	Colour of Wire	Symbol
Live	Brown/Red	L
Neutral	Blue/Black	N
Earth	Green/Yellow	E

(b) Types of fault that occur in electrical installations: (i) Short circuit (ii) Open circuit

10. State the function of the following used in distribution network:

- a. Substation;
- b. Busbar;
- c. Transformers;
- d. Feeder;
- e. Circuit breaker.

### Expected Solution

(a) Substation: It is a load center for receiving, transmitting and distributing electrical energy via power transformers.

(b) Busbars: These are the main bars or connections which offer convenient means of connecting switches and other equipment into various arrangements.

(c) Transformers: A transformer at the substation converts the incoming supply voltage to a lower or higher value which is fed either to the substation or distribution

(d) Feeder: This conducts power from a substation to load/consumer end.

(e) Circuit Breaker: An automatic device for interrupting the flow of current in an electric circuit as a safety measure.

11. (a) State two factors that affect the resistance of a metallic conductor.

(b) A  $1.5\text{mm}^2$  conductor is  $4500\text{m}$  long. If the resistivity is  $1.72 \times 10^{-8}\Omega\text{m}$ , calculate its resistance.

### Expected Solution

(a) Factors that affect the resistance of a metallic conductor

- (1) Temperature (2) Length (3) Cross-sectional area (4) Nature of material

$$(c) R = \frac{\rho l}{A} = \frac{1.72 \times 10^{-8} \times 4500}{1.5} = 51.6 \Omega$$

12. A series RL circuit has the following data:

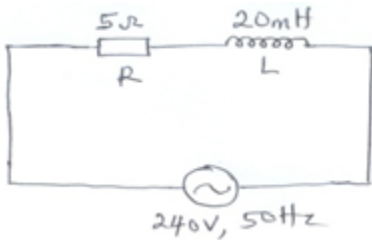
$R = 5 \Omega$ ;  $L = 20mH$ ; Supply voltage  $V = 240 V, 50Hz$ .

a. Draw the circuit diagram.

b. Calculate the:

- (i) Inductive reactance of the circuit;
- (ii) Impedance of the circuit.

**Expected Solution**



$$(b)(i) \text{ Inductive Reactance, } X_L = 2\pi fL = 100\pi(0.02) = 6.28 \Omega$$

$$(ii) \text{ Impedance, } Z = \sqrt{R^2 + X_L^2} = \sqrt{5^2 + 6.28^2} = 8.03 \Omega$$

13. A d.c. shunt-wound generator has armature resistance of  $0.125 \Omega$  and a shunt field resistance of  $60 \Omega$ . If the generator delivers  $100A$  at  $240V$ , calculate the:

- (a) Field current;
- (b) Armature current;
- (c) Generated e.m.f.

**Expected Solution**

$$a. \text{ Field current, } I_f = \frac{V}{R_f} = \frac{240}{60} = 4A$$

$$b. \text{ Armature Current, } I_a = I - I_f = 100 - 4 = 96A$$

$$c. \text{ Generated e.m.f, } e = V_t + I_a R_a = 240 + (96 \times 0.125) = 252V$$

14. A shunt motor has the following features:

Back e.m.f ( $E_b$ ) =  $220V$ ;

Field resistance ( $r_f$ ) =  $150 \Omega$ ;

Field current ( $I_f$ ) =  $1.5A$ ;

Supply current ( $I$ ) =  $31.5A$ .

Calculate the:

- (i) Terminal voltage;
- (ii) Armature resistance;
- (iii) Power output at the motor shaft.

**Expected Solution**

- (i) Terminal Voltage,  $V_t = I_f R_f$   
 $= 1.5 \times 150 = 225\text{v}$
- (ii) Armature resistance,  $R_a = \frac{V_t - E_b}{I_a}$   
 $I_a = I - I_f = 31.5 - 1.5 = 30\text{A}$   
 $R_a = \frac{225 - 220}{30} = 0.17\Omega$
- (iii) Power Output at the motor shaft  $= E_b I_a = 220 \times 30 = 6600\text{W}$

15. (a) State two devices of a moving-coil instrument.  
 (b) State two differences between an analogue meter and a digital meter

**Expected Solution**

(a) Devices of a moving coil instrument:

- (1) deflecting device (2) controlling device (3) damping device

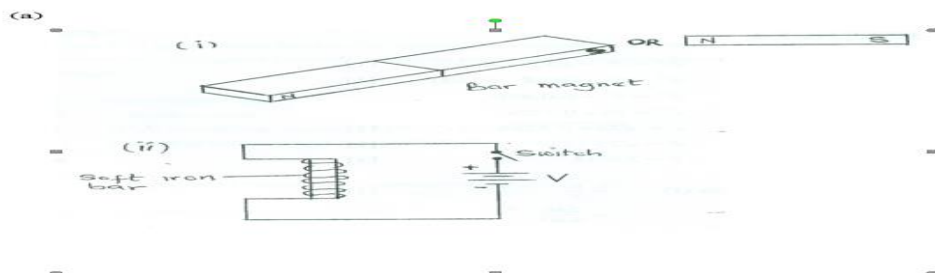
(b) Differences between an analogue and a digital meter are:

- (i) An analogue meter has a pointer and a scale while a digital meter has LCD or LED to display their values.  
 (ii) An analogue meter gives instantaneous values while a digital meter gives numeric values.  
 (iii) A digital meter is easier to read compared to an analogue meter.  
 (iv) An analogue meter has moving parts while a digital meter has static components.  
 (v) An analogue meter works on electromagnetic induction while a digital meter does not.  
 (vi) A digital meter is more expensive

16. (a) State two differences each between a bar magnet and an *electromagnet*  
 (b) Sketch and label the following:  
 (i) A bar magnet; (ii) An electromagnet.

**Expected Solution**

- (a) (i) A Bar magnet is a material which attracts ferrous metals.  
 (ii) Electromagnet needs external supply to function while bar magnet does not.  
 (iii) Bar magnet has permanent magnetism while that of electromagnet depends on the current in the coil.  
 (iv) The polarities of bar magnet are permanent while those of electromagnet can be changed.



17. (a) State three advantages of a ring distribution system of electrical supply.  
(b) State the two operating voltage levels for a transmission line.

**Expected Solution**

- (a) Advantages of a ring distribution system of electrical supply
- (i) Can use smaller supply cables than a radial distribution system.
  - (ii) Offers greater security of supply than a radial distribution.
  - (iii) More reliable
  - (iv) More efficient
- (b) The operating voltage levels for a transmission line are:
- (i) 132 kV
  - (ii) 330 kV

18. State three conditions for selecting cables to be used for installation.  
State two reasons for transmitting electricity by overhead conductors

**Expected Solution**

- (a) Conditions for selecting cables to be used for installation
- The current rating of the cable under defined installation conditions.
  - The type of installation project.
  - Environmental condition.
  - The type of load to be supplied.
- (b) Reasons for transmitting electricity by overhead conductors
- It is cheaper to install.
  - Easy to carry out maintenance.
  - Easy to detect fault.
  - It can transmit more power.
  - Cheaper to repair.
  - It is suitable for long distance transmission

19. (a) State three methods of starting a three-pole inductor motor.  
(b) State one application for each of the following single-phase induction motors:
- 1. Universal;
  - 2. Capacitor start.

**Expected Solution**

- (a) Methods of starting a 3 phase inductions motor
- (i) Star – delta
  - (ii) Auto transformer
  - (iii) Direct on line
  - (iv) Rotor resistance starter
- (b) Application of single phase motors
- |                      |                           |                    |
|----------------------|---------------------------|--------------------|
| (i) Universal motor  | - Vacuum cleaner          | - Food mixers      |
|                      | - Domestic sewing machine | - Portable drills  |
| (ii) Capacitor start | - Ceiling fan             | - Compressors      |
|                      | - Refrigerators           | - Air conditioners |

20. (a) Define a *fuse*.  
 (b) List two types of *fuse*.  
 (c) State three reasons for earthing in an electrical installation.

### Expected Solution

(a) A fuse is a protective device for opening a circuit by means of a conductor designed to melt when an excessive current flow through it.

- (b) (i) Rewireable fuse (ii) Cartridge fuse  
 (iii) High breaking capacity (HBC) Fuse (iv) High rupturing capacity (HRC) fuses
- (c) (i) To protect equipment / appliances.  
 (ii) To prevent electric shock.  
 (iii) To prevent fire outbreak.

21. (a) Copy and Complete Table 1

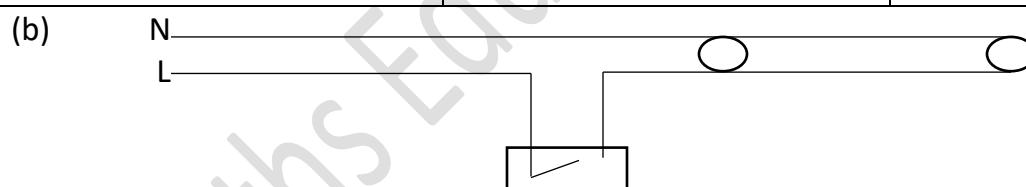
Size of PVC Insulated Cable	Current Carrying Capacity	Application
1.5mm <sup>2</sup>	15A	
2.5mm <sup>2</sup>	20A	

(b) Sketch a labeled wiring of two filament lamps connected in parallel, controlled by one-way switch. The supply is a 230 V through a fuse

### Expected Solution

(a)

Size of PVC Insulated Cable	Current Carrying Capacity	Application
1.5mm <sup>2</sup>	15A	Lighting
2.5mm <sup>2</sup>	20A	Socket outlet



22. (a) Define the term fuse  
 (b) State two methods of earthing an electrical installation.  
 (c) State the reason for the use of Earth leakage Circuit Breaker (E.C.L.B.) in an installation

### Expected Solution

(a) Fuse is defined as device for opening a circuit by means of a conductor designed to melt when excessive current flows through.

(b) Methods of Earthing

- (1) Plate earthing (2) Pipe earthing (3) Rod earthing (4) Strip or wire earthing

(c) Reasons for the use of ELCB

- (1) To reduce earthing impedance (2) To prevent electric shock



23. (a) State three (3) advantages for electrical transmission at high voltages.  
(b) State the voltage values of:  
(i) Single phase distribution;  
(ii) Three phase distributions.

### **Expected Solution**

- (a) Reasons for transmission at high voltages:  
(i) Standardization of frequency and voltages. (ii) Better voltage regulations  
(iii) Transmitting very large power over long distances (iv) Reduction of power loss  
(v) Reduction of transmission cost (vi) Improved rate of transmission
- (b) (i) Single phase - 240V  
(ii) Three phase - 415V
24. (a) Define final sub-circuit  
(b) List three final sub-circuits associated with domestic wiring.  
(c) State:  
(i) The difference between a cable and a conductor;  
(ii) One factor that must be considered in the choice of cable sizes for wiring.

### **Expected Solution**

- (a) Final sub-circuit is that circuit connected between electrical loads and live, neutral and earth points in Consumer Control Unit (CCU) for the purpose of supplying electrical energy to the load.
- (b) Final sub circuits associated with domestic wiring  
(i) Ring circuit  
(ii) Radial Circuit  
(iii) Lighting Circuit  
(iv) Heater Circuit  
(v) Motor Circuit
- (c) (i) Cable is a length of insulated single (solid or stranded) wire while conductor is the part of cable which offers very low resistance to the flow of current.  
(ii) Factors to be considered in the choice of cable size for wiring  
(1) Length of the cable (2) Current demand by its load (3) Cross sectional area  
(4) Ambient temperature (5) Environment
25. (a) State Faraday's law of electromagnetic induction.  
(b) State four factors that affect mutual inductance.  
(c) State four devices that use the principle of electromagnetic induction.

### **Expected Solution**

- (a) Faraday's law of electromagnetic induction states that whenever there is relative motion between a conductor and magnetic flux, an e.m.f. is induced in the conductor, the magnitude of which is proportional to the rate of change of the flux

- (b) Factors that affect mutual inductance
  - (i) Number of turns in each coil
  - (ii) Distance between the two coils
  - (iii) Permeability of the cores / core material
  - (iv) Amount of current in the coils
  - (v) Cross-sectional area of the conductor used.
- (c) Devices that use principle of electromagnetic induction
  - (i) Electric bell
  - (ii) Security alarm
  - (iii) Solenoid
  - (iv) Loudspeaker
  - (v) Buzzer
  - (vi) moving coil instrument
  - (vii) circuit breaker
  - (viii) Transformer
  - (ix) Electric machine
  - (x) electric fan
  - (xi) relays

26. The metal part of an electric kettle gives an electric shock when touched. State two

- (a) Possible causes of the problem;
- (b) Steps that should be taken in diagnosing fault;
- (c) Instruments that can be used for diagnosing the fault.

### **Expected Solution**

- (a) - Live conductor touching the frame of the kettle
  - Poor or improper earthing.
- (b) - Switch off the appliance
  - Unplug it from the supply
  - Test for earth continuity.
- (c) - Insulation resistance tester (megger tester)
- (d) - Ohmmeter.
  - Multimeter (ohm range).

27. State the regulation guiding the following with respect to installation of earthing:

- 1. Distance;
- 2. Cross section of earth continuity conductor;
- 3. Cross section of earth wire;
- 4. Electrodes;
- 5. Earth resistance.

### **Expected Solution**

Regulation with respect to earthing

- (1) Distance: The distance of the earth electrode from the installation at the premises should not be more than 1.5m.
- (2) Cross-section of earth continuity conductor: The size of the earth continuity conductor used in the circuit should not be less than  $2.5\text{mm}^2$ .
- (3) Cross-Section of earth wire: The size of the earth wire should be  $10\text{mm}^2$  or  $16\text{mm}^2$
- (4) Electrodes: The earth electrode should be electrically and mechanically strong and should be protected against corrosion. It should be of low resistance.
- (5) Earth resistance: The earth resistance should be between  $0.5\Omega$  to  $1\Omega$  maximum

28. State the function of the following components in electricity transmission systems.

- (i) Tower;
- (ii) Insulators;
- (iii) Conductors.

### Expected Solution

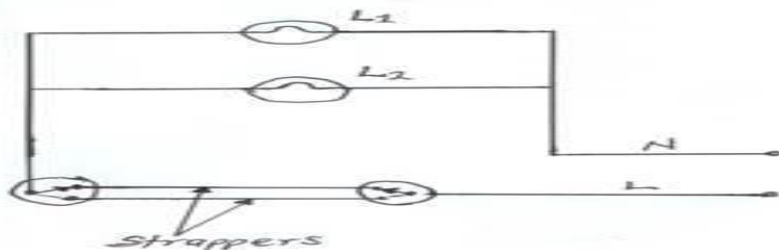
- (i) Tower: - It carries the high voltage transmission lines and keeps them separated from their surroundings and from each other.
- (ii) Insulators: – They are used for insulation purposes to:
  - avoid short circuit;
  - support conductors;
  - Conduct heat from conductors etc.
- (iii) Conductors: - They are used for the transmission of power or current from generating stations to points where the power is consumed through substations.

29. (a) State four methods of wiring.

(b) Draw a circuit diagram of two lamps connected in parallel and controlled by two 2-way switches.

### Expected Solution

- (a) Methods of wiring      - Conduit      - Surface      - Trucking      - Ducting
- (b)

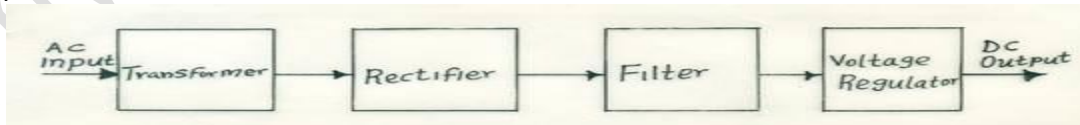


30. (a) State two types of rectifiers.

(b) Draw and label the block diagram of a stabilized power supply unit.

### Expected Solution

- (a) Types of rectifiers:      (1) half wave rectifier      (2) full-wave rectifier
- (b)



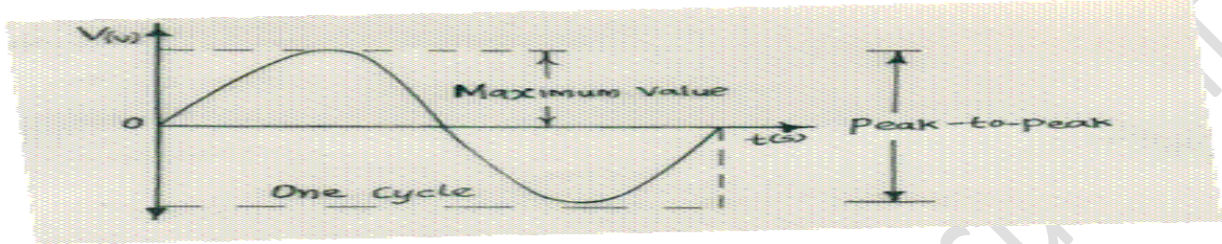
31. (a) Draw a sinusoidal waveform and indicate the following:

- (i) maximum value;
- (ii) peak-to-peak value;
- (iii) a cycle.

- (b) A 415V/240V single-phase transformer has a rated primary current of 200A. If the efficiency of the transformer is 95%, calculate its secondary current.
- (c) State two types of power generating stations

**Expected Solution**

(a)



$$(b) \varepsilon = \frac{I_s V_s}{I_p V_p} \times 100\%;$$

$$(c) 95 = \frac{240 \times I_s}{415 \times 200} \times 100;$$

$$I_s = 328.54A$$

32. (a) Define *resistance*.
- (b) The resistance of a conductor is 40Ω. If the cross-sectional area of the conductor is  $4 \times 10^{-6} \text{ m}^2$  and resistivity is  $1.783 \times 10^{-6} \Omega\text{m}$ , calculate the length of the conductor.

**Expected Solution**

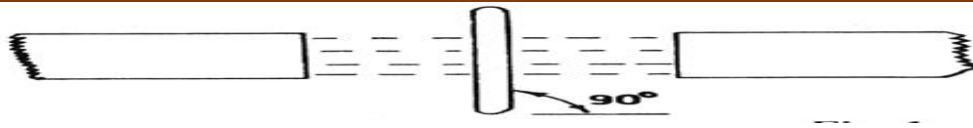
- (a) The property of a substance which offers an opposition to the flow of an electric current.
- (b)  $l = \frac{RA}{\rho} = \frac{40 \times 4 \times 10^{-6}}{1.783 \times 10^{-6}} = 89.736m$

33. (a) Explain how earth continuity test is carried out on an installation using low voltage transformer.
- (b) State the importance of earthing in an electrical installation.

**Expected Solution**

- (a) Earth continuity test is carried out in a given a.c. installation by
1. Connecting a low voltage transformer to the a.c. installation;
  2. Connecting an ammeter between secondary circuit of the transformer and a.c. installations;
  3. Energize the transformer;
  4. Read the value of current that flows through the secondary circuit of the transformer;
  5. Compare the value of current obtained in the above-mentioned step with 1.5A transformer rating of the a.c. installation.
- (b) Any one importance stated below: (1) to avoid electric shock (2) to avoid excess current

34. (a) State Lenz's law.
- (b) Fig. 1 shows a current-carrying conductor in a magnetic field.



The conductor in Fig. 1 has a length of 40cm and carries a current of 20A in a magnetic field of flux density of 0.8T. If the conductor moves at a velocity of  $30\text{ms}^{-1}$ , calculate the:

- (i) force acting on the conductor;
- (ii) induced e.m.f.

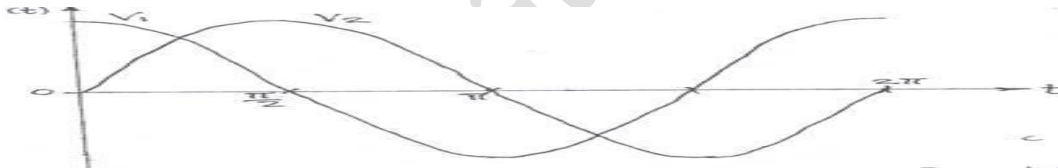
**Expected Solution**

- (a) Lenz's law states that the direction of an induced e.m.f. is always such that it tends to set up a current opposing the motion or the change of flux responsible for inducing that e.m.f.
- (b)  $B = 0.8\text{ T}$ ,  $I = 20\text{ A}$ ,  $L = 40\text{ cm} = 0.40\text{ m}$   $v = 30\text{m/s}$
- (i) Force  $F = BIl\sin\theta = 0.8 \times 20 \times 0.4 \times \sin 90^\circ = 6.4\text{ N}$
- (ii) E.m.f.,  $E = Blv\sin\theta = 0.8 \times 30 \times 0.40 \times \sin 90^\circ = 9.6\text{ V}$

35. (a) Sketch the sine waves of two voltages  $V_1$  and  $V_2$  with  $V_1$  lagging  $V_2$ .
- (b) The waveform of a voltage has a peak value of 4kV. Calculate the:
  - (i) Average value;
  - (ii) Rms value of the voltage

**Expected Solution**

(a)



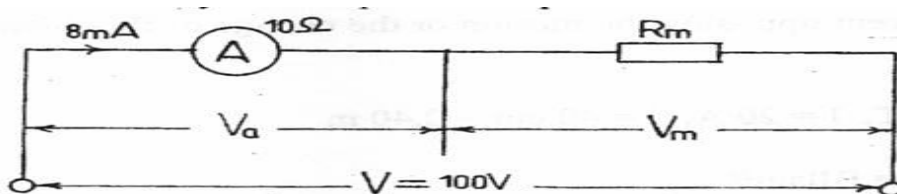
- (b) (i) Average value =  $0.637 \times \text{peak value} = 0.637 \times 4 \times 10^3 = 2.55\text{ kV}$
- (ii) R.m.s. value =  $0.707 \times \text{peak value} = 0.707 \times 4 \times 10^3 = 2.83\text{ kV}$

36. (a) Explain damping as applied to electrical measuring instruments.
- (b) A moving-coil instrument has a resistance of  $10\Omega$  with a f.s.d. of 8mA. With the aid of a sketch, calculate the value of a multiplier that will enable it read up to 100 V

**Expected Solution**

(a) In an electrical measuring instrument, the combination of the inertia of the moving system and the controlling torque of the spiral springs or of gravity gives the moving system a natural frequency of oscillation called damping.

(b)



$$V = V_a + V_m = I(R_a + R_m)$$

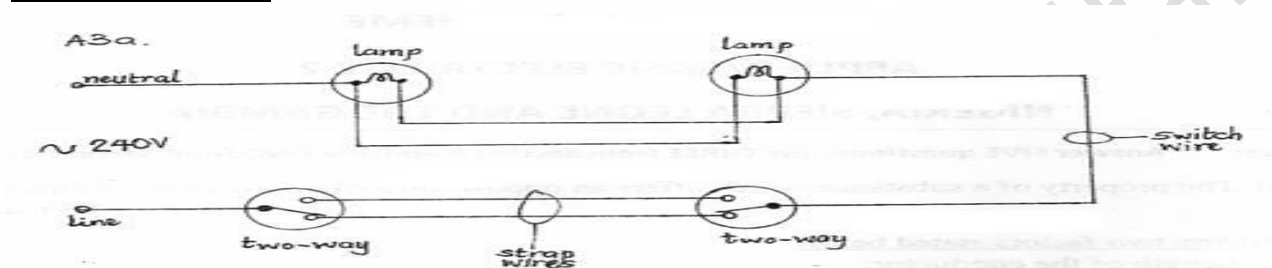
$$100 = 0.008 \times 10 + 0.008R_m$$

$$100 - 0.08 = 0.008R_m$$

$$R_m = 12490 = 12.49k\Omega$$

37. (a) Draw and label the circuit diagram of 2 two-way switches controlling two lamps in parallel.  
 (b) State the function of the following accessories: (i) switch; (ii) fuse.

## Expected Solution



- (b) (i) Switch – used to open and close electric circuit  
 (ii) Fuse – blow or open the circuit automatically when there is an overload etc.

38. (a) State any 3 precautions to be taken to avoid accident at an electrical installation work site;  
 (b) State two types of substation;  
 (c) Three differences between overhead and underground distribution systems.

## Expected Solution

(a) Any three precautions

- |   |   |
|---|---|
| 1. Do not misuse or interfere with equipment provided for health and safety | 3. Behave appropriately and with care   |
| 2. Adhere to safety precautions   | 5. Stay alert and avoid fatigue         |
| 4. Avoid over enthusiasm and foolishness                                    | 7. Work within your level of competence |
| 6. Do not use alcohol or drugs at work site                                 | 9. Dress appropriately                  |
| 8. Attend safety courses and read safety literature                         | 11. Use the right tool for each job     |
| 10. Take a positive decision to act and work safer                          |   |

(b) Any two substations listed below

- |            |                 |                 |
|------------|-----------------|-----------------|
| 1. Main    | 2. Transmission | 3. Distribution |
| 4. Outdoor | 5. Indoor       | 6. Generation   |

(c)

S/N	Overhead distribution system	Underground distribution system
1	It is easy to repair	Cannot be easily repaired
2	Fault can be detected easily	Fault cannot be easily detected
3	Has lower installation cost	Costly installation
4	Jointing is simple	Jointing is difficult
5	Maintenance not costly	Maintenance costly
6	Air insulation	Liquid and/or solid insulation

39. (a) List two essential devices of an analogue electrical measuring instrument;  
 (b) List two basic types of scale found in the instrument in 39(a)(i).

### Expected Solution

(a) Any two essential devices

1. Deflecting (or operating) device

2. Controlling device

3. Damping device

(b) 1. Linear scale

2. Non-linear scale

40. (a) Define the following terms: (i) Magnetic field; (ii) magnetic flux.  
 (b) A conductor of length 0.4m moves with a velocity of 2m/s at an angle to a magnetic field of flux density 0.9T. If an e.m.f. of 0.5V was induced in it, calculate the angle of movement of the conductor relative to the magnetic field.

### Expected Solution

(a) (i) Magnetic field is a region of space where magnetic effect is experienced.

(ii) Magnetic flux is the total number of lines of flux threading through a magnetic field.

(b)  $e = Blv \sin \theta$

$$\theta = \sin^{-1} \frac{e}{Blv} = \sin^{-1} \frac{0.5}{0.9 \times 2 \times 0.4} = 43.98^\circ$$

41. (a) List two protective devices that are used in an electrical installation.  
 (b) List four accessories in a conduit wiring system.  
 (c) State two reasons why a parallel circuit connection is preferred to a series connection in a wiring circuit.

### Expected Solution

(a) 1. Circuit breaker

2. Fuse

(b) Any four listed below

1. Inspection elbow

2. Inspection Tee box

3. Junction box

4. Solid elbow

5. Through box

6. Tee box

(c) Any two reasons stated below

(i) To have same voltage applied to all the loads

(ii) To enable any load to be disconnected without affecting other loads

(iii) Each load can draw its required current independent of the other loads

(iv) Fault in one circuit does not affect others.

42. (a) State Ohm's law.  
 (b) Calculate the resistance of a conductor that has a conductance of  $20\mu S$ .  
 (c) An electric heater consumes 2.16MJ when connected to a 240V supply for 30 minutes.  
 (i) Power rating of the heater; (ii) current taken from the supply.



## Expected Solution

(a) Ohm's law states that the current  $I$ , flowing through a metallic conductor is directly proportional to the potential difference across its ends provided temperature and all other physical factors are kept constant.

(b) Resistance,  $R = \frac{1}{G} = 50\text{k}\Omega$

(c) (i) Power rating of heater,  $P = \frac{\text{Energy}}{\text{Time}} = \frac{2.16\text{MJ}}{1800\text{s}} = 1200\text{ J/s} = 1.2\text{ kW}$

(ii) Current,  $I = \frac{P}{V} = \frac{1200}{240} = 5\text{A}$

43. (a) Explain briefly the basic principle of mutual induction in a transformer.  
 (b) List two factors that determine the induced e.m.f. in a transformer winding.  
 (c) Calculate the volts per turn for a transformer with primary turns of 1,100 when supplied with an alternating input of 110V.

## Expected Solution

(a) An alternating flux set up by the circuit in the primary coil links the secondary coil of the transformer thereby inducing an e.m.f. in the secondary coil. The primary and secondary coils are electrically separated but magnetically coupled.

(b) Any two factors listed below

- |   |                                       |
|---|---------------------------------------|
| 1. Number of turns in the winding                   | 2. Alternating current in the winding |
| 3. Alternating magnetic flux in the winding or coil | 4. Winding or coil inductance         |
| 5. Alternating flux in the winding or coil          | 6. Change of current in the coil      |
| 7. Change of flux in the winding or coil            |                                       |

(c) Volts per turn = 0.1 V/turn

44. (a) A d.c. shunt generator supplies a current of 28A at 400 V. The armature and field resistances are  $0.5\Omega$  and  $200\Omega$  respectively. Calculate the:  
 (i) field current;  
 (ii) armature current.  
 (b) Define the following with respect to alternating current:  
 (i) impedance;  
 (ii) reactance.

## Expected Solution

(a) Field current,  $I_f = \frac{V_t}{r_f} = \frac{400\text{V}}{200\Omega} = 2\text{A}$

Armature current.  $I_a = I_f + I_L = 28 + 2 = 30\text{A}$

- (b)(i) Impedance is the total opposition offered by an electric circuit to the passage of a.c.  
 (ii) Reactance is the opposition offered by a pure inductor or capacitor to the passage of a.c.

45. State the function of each of the following in a moving-coil instrument:

- (a) deflecting device;  
 (b) controlling device;



- (c) damping device;
- (d) measuring scale.

### **Expected Solution**

- (i) Deflecting device: causes the pointer of the instrument to move from its zero position.
- (ii) Controlling device: causes the moving system to rest at the required point.
- (iii) Damping device: causes the moving system to come to rest at the deflected position without any oscillation.
- (iv) Measuring scale: Is a calibrated surface which indicates the value of the quantity to be measured.

46. (a) Define the terms:

- (i) Earthing;
- (ii) Protective-earthing conductor.
- (b) List two protective devices used in an electrical installation.
- (c) State two advantages of high breaking capacity (HBC) fuse over rewirable fuse.

### **Expected Solution**

- (a) (i) Earthing is a method of connecting the neutral point of a supply to the general mass of earth.
- (ii) Protective earthing conductor is that which prevents hazard by keeping the exposed conductive surfaces of a device at earth potential.

(b) Any two stated below

- 1. Relay
- 2. Switchgear
- 3. Fuse

(c) Any two stated below

- 1. Circuit breaker (CB)
- 2. Miniature Circuit Breaker (MCB)

(c) Two advantages of HBC over rewirable fuse

- 1. Simple and easy installation
- 2. No maintenance required
- 3. No ageing effect
- 4. High breaking capacity
- 5. Extreme reliability
- 6. More secured
- 7. Low initial cost compared to rewirable fuse
- 8. Coordination and discrimination can be achieved to a high degree

47. (a) State two factors that affect the flux density of a magnetic core.

(b) A magnetic core has a coil of 500 turns wound on it. If a current of 5A is passed through it and the length of the core is 100cm, calculate the:

- (i) magneto-motive force;
- (ii) magnetizing force;
- (iii) magnetic flux density if the permeability of the core is  $16\pi \times 10^{-7} \text{H/m}$ .

### **Expected Solution**

(a) Any two of the factors stated below

- 1. Change in flux;
- 2. Change in cross-sectional area;
- 3. Change in permeability of the core;
- 4. Change in magnetizing force.

- (b) (i)  $m.m.f. = IN = 5 \times 500 = 2500AT$   
 (ii) magnetizing force,  $H = \frac{mmf}{length} = 2500 AT/m$   
 (iii)  $B = \mu H = 16\pi \times 10^{-7} \times 2500 = 0.0126T$

48. (a) State:

- (i) Faraday's law of electromagnetic induction;  
 (ii) one application of Faraday's law of electromagnetic induction.

(b) An a.c. generator has 10 poles. Calculate the number of:

- (i) Cycles generated in 1 revolution;  
 (ii) Revolutions per second required to generate a voltage at a frequency of 50 Hz.

**Expected Solution**

(a) (i) Faraday's law states that the magnitude of the e.m.f. induced in a circuit is proportional to the rate of change of magnetic flux through the circuit.

(ii) Electric bells, buzzers, telephone receivers, loudspeakers and relays.

(b) (i) A revolution is achieved when two poles give 1 cycle hence 10 poles will give 5 cycles

(ii)  $T = (\text{revolutions per second}) = 20ms$

49. (a) Explain briefly how an e.m.f. is induced in a conductor cutting magnetic flux.

(b) If an e.m.f. of 6V is induced in a coil when the current in an adjacent coil varies at a rate of 92A/s, calculate the value of the mutual inductance.

**Expected Solution**

(a) When a conductor (e.g. a wire) is moved through a magnetic field in such a way that it cuts the magnetic lines of force (i.e. magnetic flux), a voltage is induced in the conductor. An electric current will flow through the conductor if the two ends of the conductor are connected by a wire to form a circuit. Suppose the conductor has a length,  $L(m)$  and moves perpendicularly to the lines of flux in a uniform magnetic field of  $B(T)$  at a velocity of  $V(m/s)$ , then, in one second, the flux cut,  $E = Blv$

(b)  $E = Blv$

Mutual inductance,  $L = \frac{6v}{92A/s} = 65.22mH$

50. (a) Copy and complete Table 1.

Table 1

Type of instrument	Quantity measured with the instrument	Method of control	Method of damping
Moving - coil			
Moving - iron			

(b) State one application each of the following:

- (i) an ammeter  
 (ii) an ohmmeter.

## Expected Solution

(a)

Type of instrument	Quantity measured with the instrument	Method of control	Method of damping
Moving - coil	Current and voltage (d.c. only)	Hairsprings	Eddy current
Moving - iron	Current and voltage (d.c. and a.c.)	Hairsprings	Air

(b) (i) Ammeter application -Current measurement

(ii) Ohmmeter application – Impedance/Resistance/Insulation resistance measurement

51. (a) State one difference between the voltages generated by a single-phase and a three-phase synchronous generator.

(b) List four components of a high voltage overhead transmission system.

(c) State one advantage each of overhead and underground transmission systems.

## Expected Solution

(a)	Single-phase synchronous generator	Three-phase synchronous generator
	Constant	Varies
	230 V – series connection	Between 400 V and 230 V

(b) Any four of the items listed below

1. Steel towers

2. Glass/porcelain insulators

3. Aluminum conductors

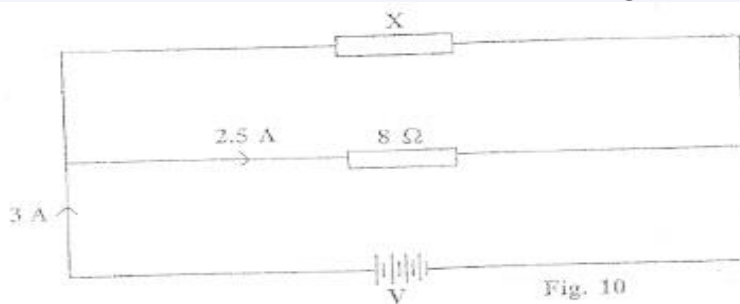
4. High voltage transformers

(c)

Overhead advantage	Underground advantage
Low investment costs	Long life expectancy
Less expensive maintenance	Reduced maintenance costs
	Service uninterrupted by storms
	Conserve valuable land
	Reduced fire-fighting hazards
	Prevention of accidents

52. (a) State one difference between an *electric circuit* and a *magnetic circuit*.

(b)



Calculate the:

(i) voltage across the parallel circuit;

(ii) current through resistor X;

(iii) value of X.

## **Expected Solution**

(a) In an electric circuit, insulation confines current to a definite path but in the magnetic circuit there is no known insulation and therefore not all flux is confined to one path.

(b) (i)  $8 \times 2.5 = 20V$  (ii)  $3 - 2.5 = 0.5A$  (iii) Resistor  $X = 20 / 0.5 = 40\Omega$

53. (a) Explain how the following works in a moving-coil meter:

(i) deflecting device;

(ii) control device.

(b) A moving-coil instrument gives a full-scale deflection with a current of  $30mA$  and a voltage of  $90mV$ . Calculate the value of a resistor be connected in series with the instrument so that it can be used to read 0-100

## **Expected Solution**

(a) (i) Deflecting device in a moving-coil works by the interaction of the field set up by the permanent magnet with the field set up by the current flowing through the coil.

(ii) Control device ensures that the deflecting device returns to its zero position after measurement with the aid of the restoring force in the hair spring.

(b)  $I(\text{at f.s.d.}) = 0.030A$ ;  $V(\text{at f.s.d.}) = 0.090V$ ;  $V(\text{voltage across terminals}) = 100V$

Voltage across resistor =  $(100 - 0.090)V = 99.91V$ ;  $R_m = \text{resistance of multiplier}$

$$R_m = \frac{99.91}{0.030} = 3330.33$$

54. (a) (i) Define Trunking.

(ii) List three types of Trunking.

(b) State one purpose of polarity test in an installation.

(c) List two types of commonly used metal conduit.

## **Expected Solution**

(a) (i) Trunking is a system in which a bunch of cables are placed in a rectangular long run boxes with cover lids.

(ii) Types of Trunking

1. Tap-on Trunking      2. Floor Trunking      3. Busbar Trunking      4. Concrete Trunking
5. Plain-section      6. Skirting Trunking      7. Bench Trunking      8. Compactmented

(b) The purpose of polarity test in an installation is to ensure that:

- i. All single-pole switches are connected to the live conductor.
- ii. Live conductor to live terminal of socket, neutral terminal and earth to earth terminal of socket outlet.
- iii. Fuses protection are always on the live conductor.

(c) Types of commonly used conduit

1. Light gauge steel conduit      2. Heavy gauge steel conduit      3. Aluminium conduit
4. Copper conduit      5. Flexible conduit

55. (a) A coil of 300 turns is wound uniformly over a wooden ring having a mean circumference of 900mm and a uniform cross-sectional area of  $4 \times 10^{-4}m^2$ . If the current through the coil of

6A, calculate the:

- (i) magnetic field strength;
- (ii) flux density;
- (iii) total flux.

[Take  $\mu_r$  of wood = 1;  $\mu_o = 4\pi \times 10^{-7} H/m$ ]

### Expected Solution

Number of turns,  $n = 300$

Mean length,  $l = 900\text{mm} = 0.9\text{m}$

Cross-sectional area,  $A = 4 \times 10^{-4}\text{m}^2$

Current through coil,  $I = 6\text{A}$

(a) The magnetic field strength

$$H = \frac{NI}{l} = \frac{300 \times 6}{0.9} = 2000\text{N/m}$$

(b) The flux density,  $B = \mu_o \mu_r H$

$$= 4\pi \times 10^{-7} \times 1 \times 2000 = 8\pi \times 10^{-4}\text{T}$$

(c) Total flux,  $\phi = BA$

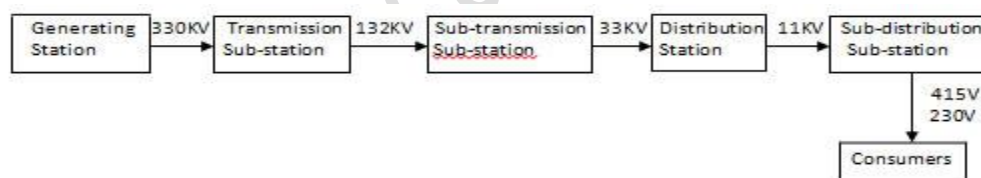
$$= 8\pi \times 10^{-4} \times 400 \times 10^{-6} = 1.005\mu\text{wb}$$

56. (a) Draw the layout diagram of high voltage overhead transmission system from generating station to the various consumers.

(b) List two main components of a transmission substation.

### Expected Solution

(a) Layout diagram of high voltage overhead transmission system from generating station to the various consumers.



(b) Any two of the following

- |                     |                       |                        |
|---------------------|-----------------------|------------------------|
| 1. Transformer      | 2. Voltage regulators | 3. Busbars             |
| 4. Circuit breakers | 5. Protective relays  | 6. High voltage fuses. |

57. (a) Define the following in terms of alternating current:

- (i) peak value;
- (ii) instantaneous value.

(b) A sinusoidal signal generated from an a.c. mains is represented by the expression

$$v = 5\sin 314t \text{ volts.}$$

Calculate its:

- (i) amplitude;
- (ii) r.m.s. value;
- (iii) peak-to-peak.

**Expected Solution**

(a)(i) Peak value - This is the maximum value attained by an alternating quantity over half a cycle.

(ii) Instantaneous value - This is the value of an alternating quantity at any instant of time.

(b) Given  $v = 5\sin 314t$  volts

Recall  $V = V_m \sin(\omega t)$  volts

(i) Amplitude ( $V_m$ ) = 5 volts

(ii) r.m.s. value =  $(0.707 \times 5) = 3.5$  volts

(iii) Peak-to-peak value =  $2 \times \text{Amplitude} = (2 \times 5) \text{ volts} = 10\text{v}$

58. (a) State one application of each of the following instruments:

(i) ohmmeter;

[ii] watt-hour meter.

(b) State the function of a choke in a fluorescent fitting.

(c) The coil of a loudspeaker has 20 turns and a diameter of 15mm. If the coil is placed in a magnetic field of flux density 0.8T, calculate the force produced when a current of 0.1A flows through the coil.

**Expected Solution**

(a)(i) Ohmmeter is used for measuring resistance / continuity test

(ii) Watthour meter is used for measuring energy consumed

(b) The function of a choke in a fluorescent fitting is to limit the current flowing in an a.c. cct.

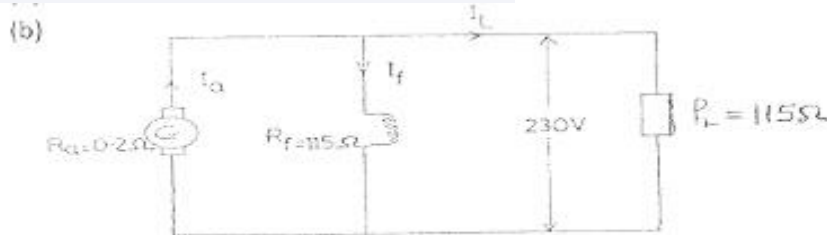
(c) Active length of the coil,  $L = n\pi D = 20\pi \times 0.015 = 0.94\text{m}$

Using  $F = BIL$

$= 0.8 \times 0.94 \times 0.1$

$= 0.075\text{N}$

59. (a) State two losses that occur in a d.c. machine.



From fig.8, calculate the : Fig. 8

From fig.8, calculate the:

(i) load current,  $I_L$

(ii) field current,  $I_f$

(iii) armature current,  $I_a$

(iii) generated *e.m.f.*

**Expected Solution**

(a) (Any two of the following)

- (i) Copper loss                      (ii) Frictional windage loss    (iii) Brush contact loss                      (iv) Iron loss

(b) Terminal voltage,  $V = 230V$

Power to the load,  $P_L = 1150W$

Armature resistance,  $R_a = 0.2\Omega$

(i) Load current  $= \frac{\text{Load Power}}{\text{Terminal Voltage}} = \frac{1150}{230} = 5A$

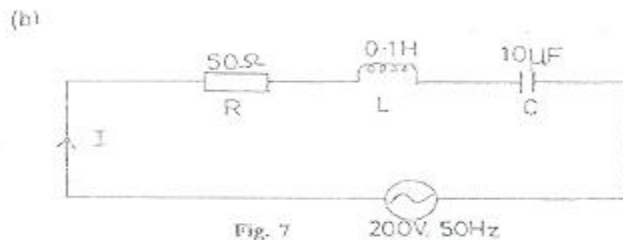
(ii) Field current  $= \frac{\text{Terminal Voltage}}{\text{field resistance}} = \frac{230}{115} = 2A$

(iii) Armature Current,  $I_a = I_L - I_f = 5A - 2A = 3A$

(iv) Generated e.m.f,  $E_b = V_t + I_a R_a$ ;  $E_b = 230 + (3 \times 0.2) = 230.6V$

60. (a) Define the following terms with respect to alternating current circuits:

- (i) inductive reactance;  
(ii) capacitive reactance;  
(iii) impedance.



- (i) resonant frequency;  
(ii) impedance at resonance;  
(iii) the current  $I$  at resonance.

**Expected Solution**

(a)(i) Inductive reactance is defined as the opposition offered to the flow of current in an a.c. circuit by an inductor.

(ii) Capacitive reactance is the opposition offered to the flow of current in an a.c. circuit by a capacitor.

(iii) Impedance is defined as the total opposition offered to the flow of current in an a.c. circuit

(b) (i)  $f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.1 \times 0.00001}} = 159.1Hz$

(ii)  $Z = R = 50\Omega$  at resonance

(iii) Current,  $I$  at resonance  $= \frac{V}{R} = \frac{200}{50} = 4A$

61. (a) Explain the cause of each of the following power losses in a transformer:

- (i) hysteresis loss;  
(ii) copper loss.

(b) State one application each of the following transformer:

- (i) single-phase transformer;
- (ii) three-phase transformer.
- (c) A transformer is connected to a 240V, 50 Hz *a.c.* supply. If the primary winding has 1800 turns and the secondary winding provides an output of 12V, calculate the number of turns in the secondary winding.

**Expected Solution**

- (a) (i) Cause of Hysteresis loss: This is the energy expended in causing the magnetization in a core in the form of heat.
- (ii) Cause of Copper loss: It is the heating of the conductors due to resistance of the coil.
- (b) (i) Applications of single-phase transformer are:  
Constant voltage application; impedance matching; protection; inverters; communication system, domestic appliances.
- (ii) Applications of three-phase transformer are:  
Power distribution system, 3-phase inverter communication system Power transmission  
Power distribution

(c)  $N_s = \frac{V_s N_p}{V_p}$

$$N_s = \frac{12 \times 1800}{240} = 90 \text{ turns}$$

62. (a) State:

- (i) two applications of a transformer;
- (ii) two functions of oil in a transformer.
- (b) A 40kVA three-phase transformer has a core loss of 400W and a full load copper loss of 400W. If the power factor is unity, calculate the efficiency of the transformer.

**Expected Solution**

- (a) (i) Any two correct applications  
step up and step down voltages; impedance matching
- (ii) 1. It cools the transformer.  
2. It provides electrical insulation between intervals of the live parts.

- (b) Iron losses = 400W
- Copper losses = 400W
- Total losses = 800W

$$\epsilon = \frac{\text{Power Output}}{\text{Power Output} + \text{Losses}} \times 100\% = \frac{40000}{40000 + 800} \times 100\% = 98.04\%$$

63. (a) Define resistivity.

(b) State the relationship between *resistivity* and *conductivity*.

(c) An aluminium cable of length 50m has a resistance of 0.067Ω. Calculate the:

- (i) Cross-sectional area;
- (ii) Conductivity.

[Take resistivity of aluminium to be  $2.84 \times 10^{-8} \text{m}$ ]



## Expected Solution

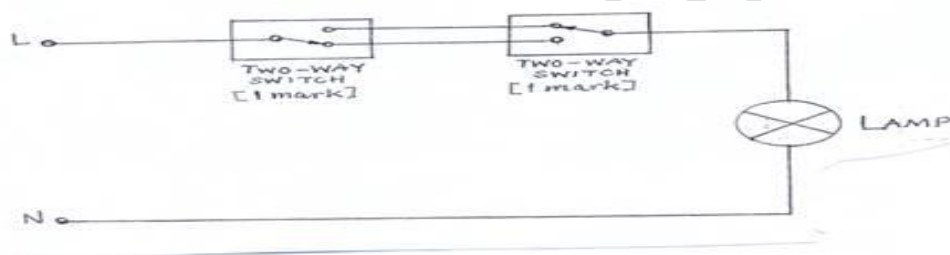
- (a) Resistivity is the specific resistance of a unit length of a material with a unit cross-sectional area. The S.I. unit of resistivity is  $\Omega\text{m}$   
 (b) Resistivity is the reciprocal of conductivity  
 (c) Length of the cable = 50m  
 Resistance of the cable = 0.067

(i) Cross sectional area,  $A = \frac{\rho L}{R} = \frac{2.84 \times 10^{-8} \times 50}{0.067} = 21.19 \text{mm}^2$   
 (ii) Conductivity,  $\sigma = \frac{1}{\rho} = \frac{1}{2.84 \times 10^{-8}} = 3.52 \times 10^7 (\Omega\text{m})^{-1}$

64. (a) State two methods of connecting 13 A socket outlets.  
 (b) Sketch a wiring diagram of a two-way system controlling a lamp in OFF position.

## Expected Solution

- (a) (i) Radial connection (ii) Ring connection  
 (b)



65. (a) List two types of wiring system.  
 (b) State two types of joint  
 (c) State two hazards that are associated with failure of earthing in an installation.  
 (d) List four conduit wiring accessories.

## Expected Solution

- (a) Any two correct types  
 - Surface concealed - Ducting - Trunking - Surface wiring  
 (b) Any two correct types  
 - Britannia - Tee - Married - Scar  
 (c) Any two correct hazards  
 - Electrical shock - Fire - Burn  
 (d) Any four conduit wiring accessories  
 - Adaptor - Elbow - Elbow bend - Brass bush - Inspection tee  
 - Saddle - Hook - Fastener - Junction boxes (circular, angle, twin, through)

66. (a) List two types of electrical measuring instrument.  
 (b) The coil of a moving-coil meter has a resistance of  $10\Omega$  and gives a full-scale deflection when a current of 20mA passes through it. Calculate the resistance required to enable the instrument to read up to:

- (i) 10 A;
- (ii) 10 V

## Expected Solution

(a) Any two of the instruments stated below

- |                |                |                    |                                |
|----------------|----------------|--------------------|--------------------------------|
| 1. Moving-coil | 2. Moving-iron | 3. Multimeter      | 4. Insulation Resistance Meter |
| 5. Ohmmeter    | 6. Wattmeter   | 7. Watt-hour meter | 8. Tachometer                  |

(b) (i)  $R_s = \frac{I_g R_g}{(I - I_g)} = \frac{0.02 \times 10}{10 - 0.02} = 0.02 \Omega$

(ii)  $R_m = \frac{V}{I_g} - R_g = \frac{10}{0.02} - 10 = 500 - 10 = 490 \Omega$

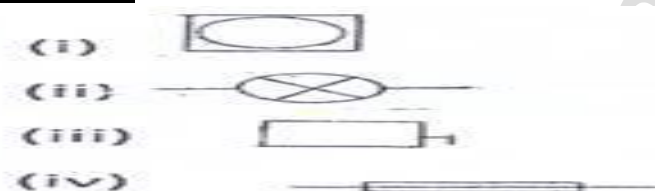
67. (a) Draw the symbol used to represent:

- i. energy metre;                      ii. lamp;                      iii. main switch;                      iv. fuse.

(b) State one function of each of the following in a substation:

- i. transmission transformer; ii. distribution transformer;                      iii. isolator;                      iv. fuse.

## Expected Solution



(b) (i) A transmission transformer (always step-up) receives electric power from a nearby generating facility and uses a large power transformer to increase the voltage for transmission to distant locations.

(ii) A distribution transformer steps down transmission or sub-transmission voltage to distribution voltage.

(iii) Isolator is used to open or close a circuit to enable maintenance or repair work to be done.

(iv) A fuse is used to protect circuit (transformer) and distribution line.

68. (a) Explain tolerance with respect to resistors.

(b) State the value of the following tolerance found on carbon resistors:

- (i) silver;                      (ii) Gold.

(c) Two resistors  $R_1 = 4 \Omega$  and  $R_2 = 5 \Omega$  are connected in series with a current of 5 A flowing through them. Calculate the:

- (i) Potential difference across each resistor;
- (ii) Total potential difference.

## Expected Solution

(a) Tolerance of a resistor defines the upper and lower limits within which the resistance of the resistor must be. This is the 4th colour-band of the colour-code and is expressed in %.

## BASIC ELECTRICITY FOR BEGINNERS

Colour code	Tolerance
Silver	$\pm 10\%$
Gold	$\pm 5\%$

- (b) (i) Potential difference across the  $4\ \Omega$  resistor =  $4 \times 5 = 20\text{ V}$   
 Potential difference across the  $5\ \Omega$  resistor =  $5 \times 5 = 25\text{ V}$   
 (ii) Total potential difference = p.d. across  $4\Omega$  + p.d. across  $5\Omega = 20\text{ V} + 25\text{ V} = 45\text{ V}$

69. (a) State the type of d.c. motor required for: (i) large starting torque; (ii) variable load.  
 (b) The armature resistance of a shunt motor is  $0.07\Omega$ . When the motor is connected across  $200\text{V}$  supply, it develops a back e.m.f. of  $179\text{V}$ . Calculate the:  
 (i) voltage drop across the armature circuit;  
 (ii) Armature current;  
 (iii) armature current at standstill.

### Expected Solution

- (a) (i) Series motor  
 (ii) Compound motor

(b) (i)  $E = V_t - I_a R_a$

The voltage drop across the armature is

$$E - V_t = I_a R_a = 200 - 179 = 21\text{ V}$$

(iii) Armature current at standstill,  $I_a = \frac{V_t}{R_a} = 2857.14\text{ A}$

70. (a) State two functions of substations in an electrical power system;  
 (b) List four main components of an overhead distribution system.

### Expected Solution

- (a) Any two of the functions listed below:

- Measuring transformers are located for protection
- For stepping up or down of system voltage
- For distribution of electrical power
- Control & Monitoring

- (b) Any four of the components listed below:

- Conductors
- Anchors
- Poles
- Cross arm

71. (a) State the function of commutator in a d.c. machine.  
 (b) Three applications of electromagnetism.

### Expected Solution

- (a) The function of the commutator in a d.c. machine is to provide

- (b) Any three of the following applications were acceptable:

- Electric bells
- Circuit breakers
- Electric fan
- Ignition assembly
- Transformer
- Contactor
- Solenoid
- Electric motor
- Buzzer
- Telephones
- Radio receivers
- Loudspeakers
- Relays

72. (a) State two differences between *primary cells* and *secondary cells*.  
 (b) A battery has a 9V output on an open circuit which drops to 8.5V with a load current of 1A. Calculate the:  
 (i) internal resistance of the battery;  
 (ii) power dissipated by the internal resistance.

**Expected Solution**

(a)

Primary cell	Secondary cell
Cannot be recharged	<u>Can be recharged</u>
<u>Irreversible chemical action</u>	<u>Reversible chemical action</u>

- (b) (i)  $I = \frac{E}{(R+r)}$  where  $r$  = internal resistance  
 $r = \frac{E}{I} - R = 9.0 - 8.5 = 0.50$   
 (ii) Power dissipated =  $i^2 r = 1^2 \times 0.5 = 0.5W$

73. (a) List two applications of a three-phase a.c. motor.



- (a) From the figure above, calculate the:  
 (i) turn ratio;  
 (ii) number of turns on the primary if the secondary has 100 turns;  
 (iii) current in the primary if the current in the lamp is 2A.

**Expected Solution**

(a) Lifts; Conveyors; Industrial air conditioners; Industrial drives.

(b)(i) Turns ratio =  $\frac{N_s}{N_p} = \frac{V_s}{V_p} = \frac{12}{240} = \frac{1}{20} = 1 : 20$

(ii)  $\frac{100}{N_p} = \frac{12}{240}; N_p = \frac{240 \times 100}{12} = 2000 \text{ turns}$

(iii)  $\frac{I_s}{I_p} = \frac{V_p}{V_s}; I_p = \frac{2 \times 12}{240} = 0.1A$

74. (a) State one factor that affects the resistivity of a conductor.  
 (b) A mild ring uniformly wound with a coil of 200 turns has a flux density of 1.6T when connected to a voltage supply. The ring has a cross sectional area of 500mm<sup>2</sup> and a mean circumference of 400mm. Calculate the:  
 (i) Reluctance of the steel ring;  
 (ii) Magnetizing current producing the flux.

$[\mu_r = 380; \mu_o = 4\pi \times 10^{-7} A/m]$

**Expected Solution**

- (a) (i) Length of the conductor (l)                      (ii) Cross sectional area of the conductor (A)  
 (iii) Resistance of the conductor (R)                      (iv) Conductor material

$$(b) (i) \quad s = \frac{L}{\mu_0 \mu_r A} = \frac{400 \times 10^{-3}}{380 \times 4\pi \times 500 \times 10^{-6}} = 1.68 \times 10^6 A/Wb$$

$$(ii) \quad F = \Phi S = B.A.S. = 1.6 \times 500 \times 10^{-6} \times 1.68 \times 10^6 = 1344A$$

$$I = \frac{F}{N} = \frac{1344}{200} = 6.72A/turns$$

75. (a) State one advantage and one disadvantage of a moving-coil instrument  
 (b) A capacitor has seven parallel plates separated by sheets of mica, 0.5mm thick and a relative permittivity of 6. The capacitor whose area of each plate is 500cm<sup>2</sup> is connected to a 400v supply

Calculate the:

- (i) capacitance of the capacitor;  
 (ii) charge in the capacitor.

$$\{\epsilon_0 = 8.85 \times 10^{-12} F/m\}$$

**Expected Solution**

- (a) Advantage

- High sensitivity
- Uniform scale
- Well shielded from stray magnetic field
- Low power consumption

- Disadvantage

- More expensive than moving-iron instrument
- Only suitable for d.c. currents and voltages
- Easily damaged

- (b) (i) Capacitance of the capacitor

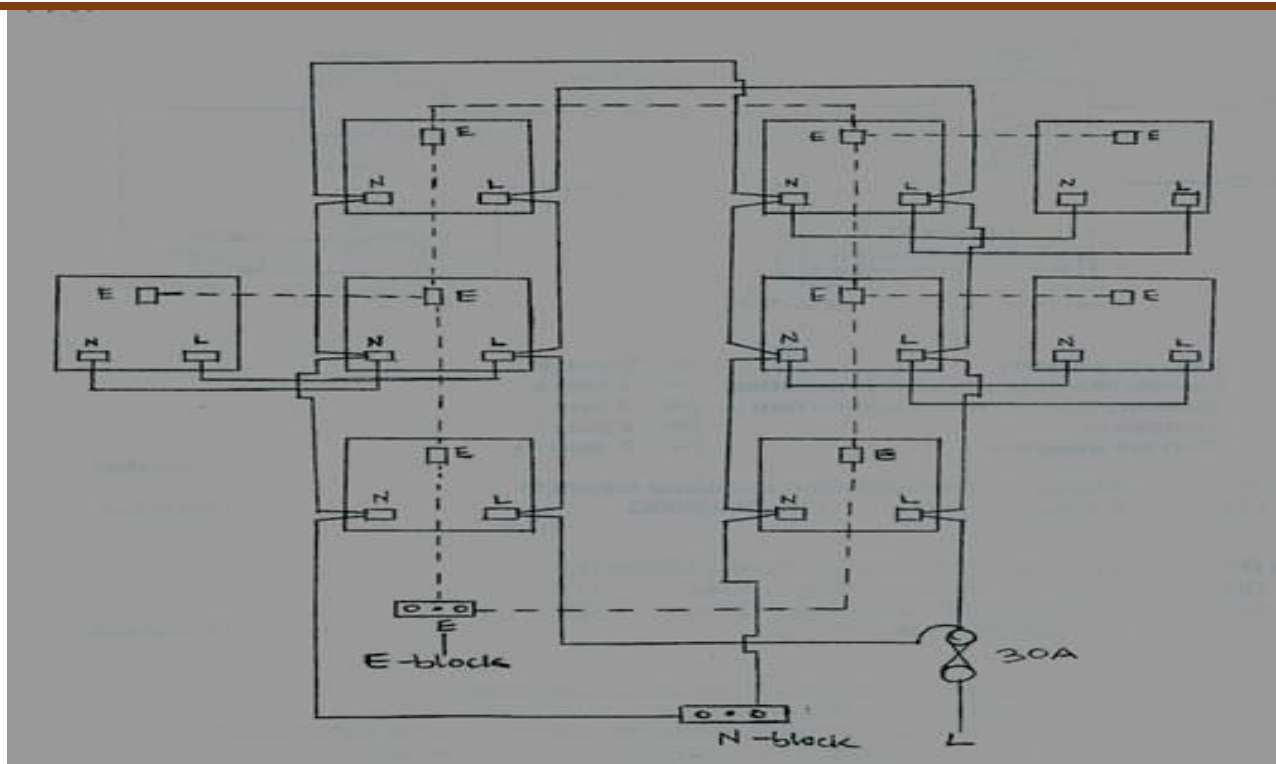
$$C = \frac{(n-1)\epsilon_0 \epsilon_r A}{d} = \frac{6 \times 8.85 \times 10^{-12} \times 6 \times 0.05}{0.0005} = 31.86nF$$

- (ii) Charge in the capacitor

$$Q = CV = 31.86 \times 10^{-9} \times 400 = 12.74\mu C$$

76. (a) (i) With the aid of a well labeled diagram, sketch a domestic ring circuit with 9 No. 13A socket outlets showing the recommended number of spurs.  
 (ii) What is the fuse rating for the circuit?  
 (iii) Give the standard cable size required for this installation.  
 (iv) What is the procedure for determining the number of spurs?  
 (b) (i) Define *domestic ring circuit* as specified in the IEE regulations.  
 (ii) State three requirements of the IEE regulations on domestic ring circuits.  
 (c) Copy and complete the table below (see full table in expected solution)  
 (d) (i) Give one reason why a capacitor is connected between fluorescent lamp terminals.  
 (ii) State two reasons why sodium lamps are used for street lighting.

**Expected Solution**

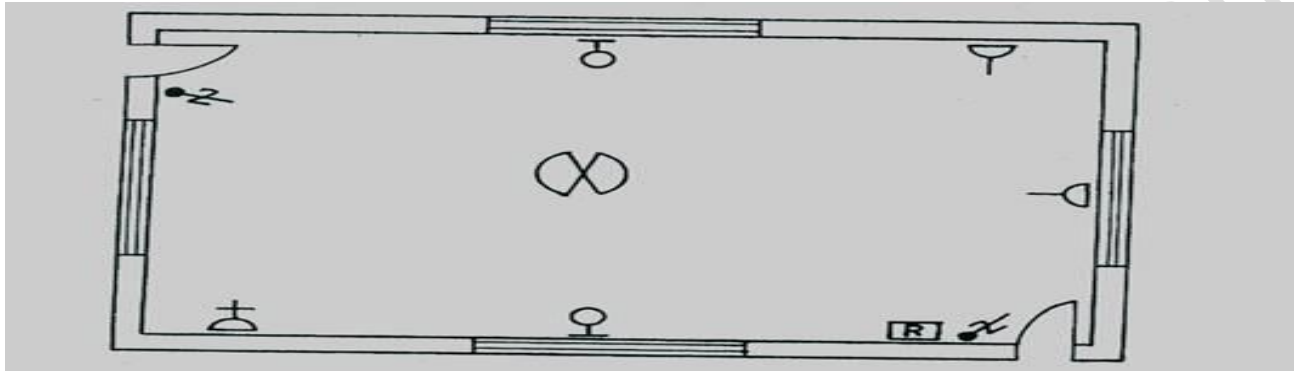


- (ii) 30A
- (iii)  $3 \times 2.5\text{mm}^2$  accept  $2.5\text{mm}^2$
- (iv) Total sockets divided by three
- (b) (i) Domestic ring circuit is defined in the IEE regulations as a final sub-circuit in which the current – carrying and earth-continuity conductors are connected in a form of a loop, both ends of which are connected to a single way in a distribution fuse board or its equivalent.
  - (ii) - Minimum cross-sectional area of  $2.5\text{mm}^2$  for P.V.C or T.R.S. cable.
  - Unlimited number of socket outlets allowed for floor area under  $100\text{m}^2$ .
  - Spurs should not be more than half the number of socket outlets on the ring circuit.
  - Fixed appliances must be protected by a local fuse
  - Fused 13A plug should be used at sockets outlets supplying portable appliances
  - 30A fuse should be used to protect the ring circuit.
- (c) Faults in fluorescent lamp circuit

S/N	SYMPTOM	POSSIBLE CAUSE
(i)	Fused blows when lamp is switched on	Short circuit in the wiring
(ii)	Lamp appears dead when switched on	No power supply/broken tube electrode/faulty starter/dead tube/dead choke
(iii)	Lamp makes repeated effort to start	Aging lamp/low voltage/faulty starter
(iv)	Lamp does not light but electrodes glow continuously	Faulty starter/faulty (R.I.S.) capacitor/aging tube/low voltage

- (d)(i) 1. To improve power factor (output) of the lamp  
2. To suppress radio frequency interference
- (ii) 1. It strikes immediately it is switched on  
2. It has warning effect  
3. It is very bright

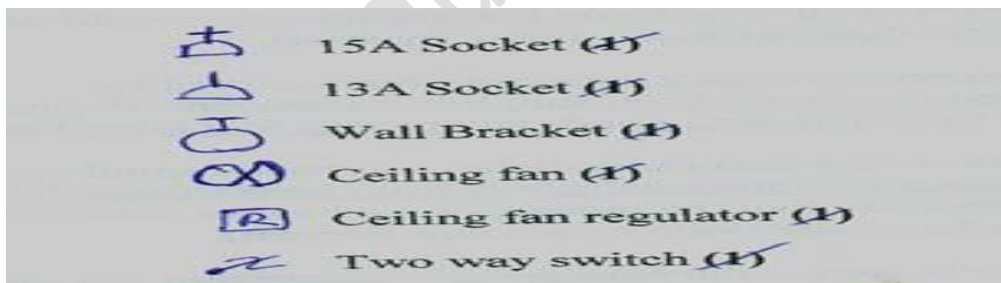
77. Study carefully the electrical layout of a living room as shown below. A surfacewiring system is to be used for the installation.



- (a) Prepare a key for the layout.  
(b) List the quantities of each of the fittings on the layout.  
(c) Sketch a labelled circuit diagram showing how the lamps in the layout can be controlled independently in parallel.

## Expected Solution

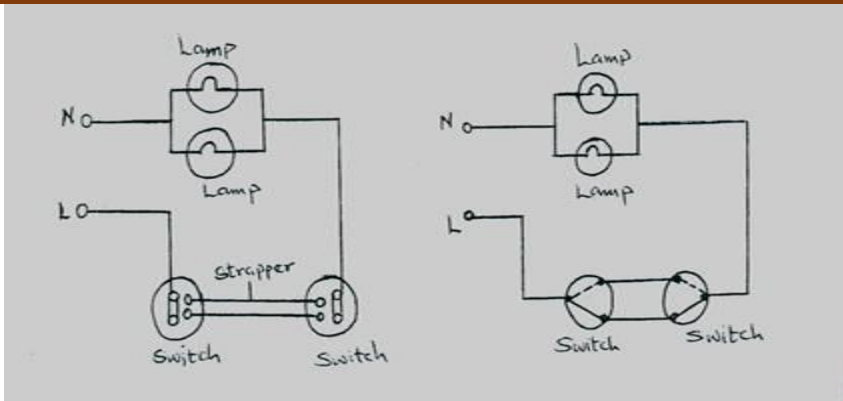
(a)



- (b)
- |                  |   |   |
|------------------|---|---|
| 15A socket       | - | 1 |
| 13A socket       | - | 2 |
| Wall bracket     | - | 2 |
| Ceiling fan      | - | 1 |
| Fan regulator    | - | 1 |
| Two-way switches | - | 2 |

(c)

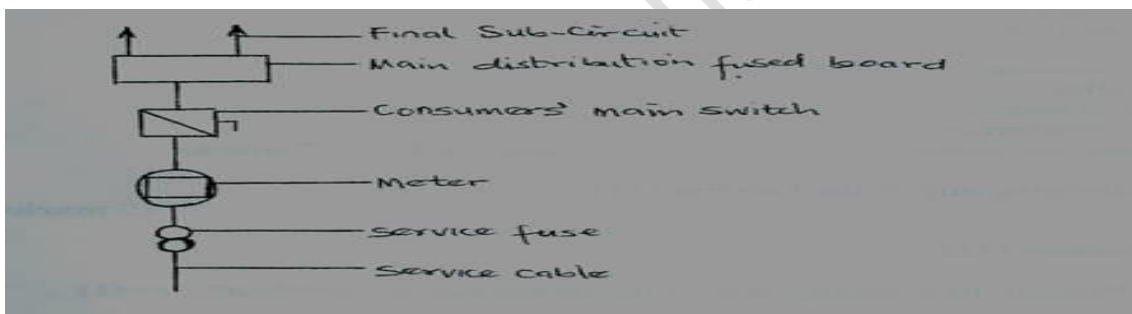




78. (a) (i) Define electrical cell.  
 (ii) State the two types of electrical cells.  
 (b) Sketch a line diagram showing the sequence of supply from the service cable of supply authority to a consumer's final sub-circuit.

### Expected Solution

- (a) (i) An electric cell is a device that converts chemical energy into electrical energy.  
 (ii) Primary Cell and Secondary Cell.  
 (b)



79. (a) Explain the following types of maintenance:  
 (i) preventive;  
 (ii) corrective.  
 (b) List four procedures for preventive maintenance of electrical machines and equipment.  
 (c) State the use of each of the following types of conduit boxes:  
 (i) End box; (ii) 4 – way box; (iii) 3 – way box; (iv) 2 way – box; (v) Back-entry box.  
 (d) With the aid of a well labeled diagram, illustrate the wiring diagram of a point of lamp controlled independently by two 2-way switches.  
 (e) (i) What is single phasing with reference to three phase motor?  
 (ii) List two types of earth leakage circuit breaker.  
 (iii) Give four reasons for installation of protective devices.

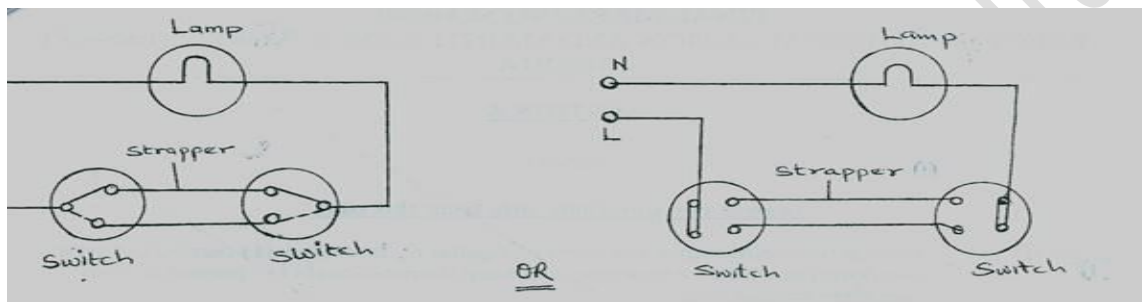
### Expected Solution

- (a) (i) Preventive maintenance is a form of regular maintenance carried out on a (working) machine or equipment to keep it operational / protect it from complete breakdown.

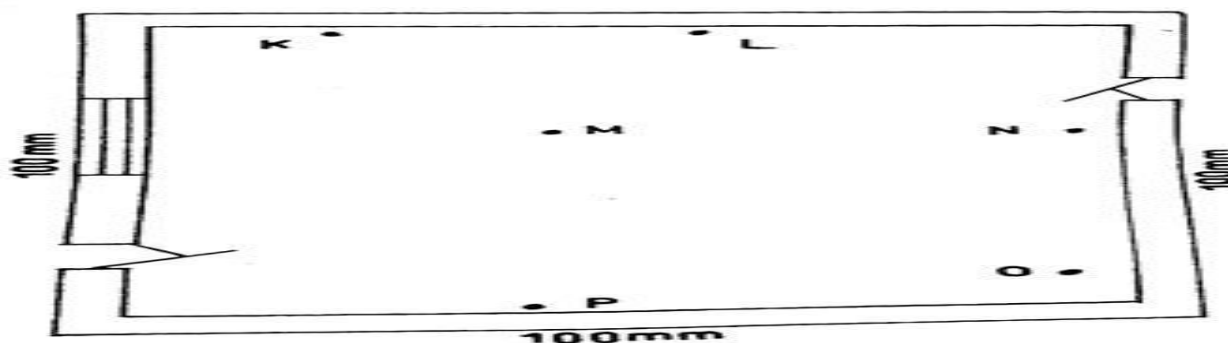


(b) - planning; - inspection - cleaning; - tightening;  
- lubricating - trouble shooting; - covering.

- (d)



80. (a) The diagram below shows the layout of a kitchen.



- |                       |                       |                              |
|-----------------------|-----------------------|------------------------------|
| I. cooker unit;       | II. 2-way switch;     | III. 13A socket outlet;      |
| IV. 15A socket outlet | V. incandescent lamp; | VI. 4-way MCB consumer unit. |

- (iii) State the correct cable size for each of the accessories in 80(a)(i)
- (b) Faults associated with contactor. (Complete table is provided under expected solution)
- (c) List four factors influencing earthing system.

## Expected Solution

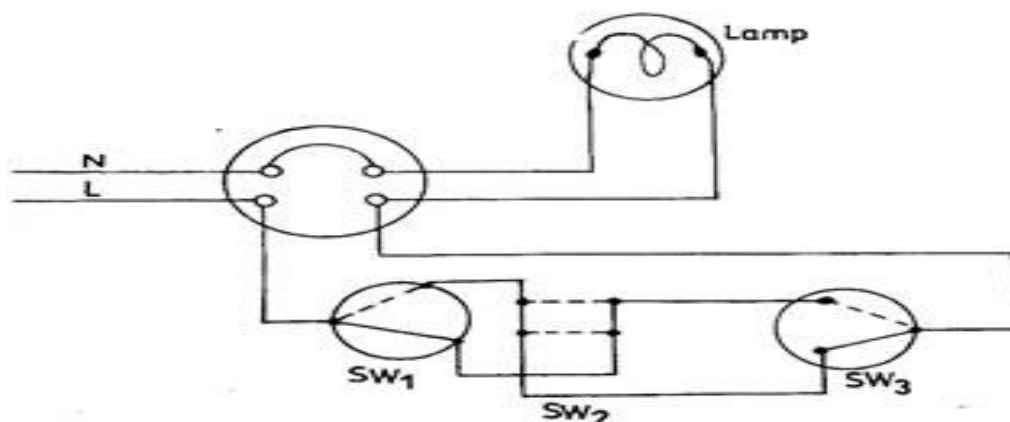
- (a) (i) Specification Layout – The layout is 10cm by 10cm square on the paper.
- (b) (ii) I - cooker unit – K; II - 2-way switch – N; III - 13 A Socket outlet - (L, P, O)  
 IV - 15A Socket outlet - (L, P, O) V - incandescent lamp -  
 VI – 4-way MCB Consumer unit - (4AO) [There must not be duplication of letters]
- (iii) I. Cooker unit - 4mm<sup>2</sup> II. 2-way switch - 1mm<sup>2</sup>/1.5mm<sup>2</sup> III. 13A socket - 2.5mm<sup>2</sup>  
 IV. 15A S/O - 2.5mm<sup>2</sup> V. Incandescent lamp – 1/1.5mm<sup>2</sup> VI. 4-way MCB
- (b) Faults Associated with Contactor

S/N	Causes	Fault
I	Contactor not energizing	Open circuit/short circuit coil/no supply
II	Circuit not completed after contactor is energized	Open circuit of the line conductors/high resistance on the contact
III	Contactor vibrating	Dirty contact
IV	Welded contacts of the contactor	partial contact/loose contact/excess current

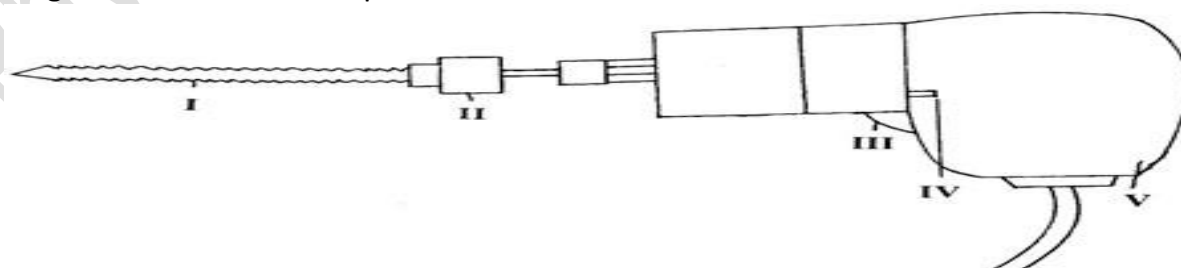
## (c) Four Factors Influencing Earthing System

1. Ambient temperature
2. Application/environment
3. Load current
4. Suitable voltage drop
5. Installation data
6. Short circuit current
7. Grouping
8. Type of sheath Deposition

81. (a)(i) The diagram below shows a circuit consisting of a lamp controlled by three independent switches.



- (ii) State one precaution to be taken while carrying out the installation in 91(a)(i).
- (b) The diagram below illustrates major equipment used in an electrical workshop. Study the diagram and answer the questions that follow.



- (i) Identify the equipment.

- (ii) Name the parts labeled I to V.
- (iii) State one function of the part labeled III.
- (iv) State three precautions to be taken while using the equipment during installation.

## **Expected Solution**

(a) (i)

Switch Position			Circuit Condition	Lamp Condition
SW1	SW2	SW3		
Up	Up	Up	Close	ON
Up	Up	Down	Open	OFF
Up	Down	Up	Open	OFF
Up	Down	Down	Close	ON
Down	Up	Up	Open	OFF
Down	Up	Down	Close	ON
Down	Down	Up	Close	ON

(ii) One Precaution to be Taken While Carrying out Installation in 81 (a)(i)

- I. Ensure that all connections are mechanically sound
- II. Ensure that there is no exposed conducting parts
- III. Ensure electrical continuity
- IV. Ensure usage of correct tools for the installation
- V. Observe colour coding

(b) (i) (Hand) drilling machine

(ii) I - drill bit

II – chuck

III – trigger

IV - forward and reverse switch

V - Grip/handle

(iii) The part labeled III is used for switching ON and OFF the machine

(iv) One precaution to be taken while carrying out installation in 81(a)

- (i) Remove chuck keys from drills prior to use
- (ii) Hold tools firmly and maintain good balance
- (iii) Secure the work in a holding device not in your hands
- (iv) Put on your safety wear while operating the equipment

82. (a) (i) Mention three parts of an electric cooker.

(ii) State two types of boiling plate found in an electric cooker.

(b) State the instruments used to measure the following quantities:

(i) current; (ii) voltage; (iii) diameter of a cable; (iv) resistance.

(c) (i) List four parts of a steel wire armoured cable.

(ii) State three characteristics of an MICC cable.

(d) Using a loop-in connection, draw a wiring diagram of three points of light, each controlled by three one-way switches.

(e) List four tools used in conduit installation.

## Expected Solution

(a) (i) Three Parts of an Electric cooker

- |                          |                |                    |                       |
|--------------------------|----------------|--------------------|-----------------------|
| 1. Boiling plate element | 2. Grill plate | 3. Oven            | 4. Rotary switch      |
| 5. Thermostat            | 6. Timer       | 7. Indicating lamp | 8. Centrifugal switch |
9. warmer

(ii) Two Types of Boiling Plate Found in an Electric Cooker

- |                    |                       |
|--------------------|-----------------------|
| 1. Solid hot plate | 2. Radiant plate/ring |
|--------------------|-----------------------|

(b) Instrument used for Measuring Quantities

- |               |                  |                                |                 |
|---------------|------------------|--------------------------------|-----------------|
| (i) – Ammeter | (ii) – Voltmeter | (iii) - Micrometer screw gauge | (iv) - Ohmmeter |
|---------------|------------------|--------------------------------|-----------------|

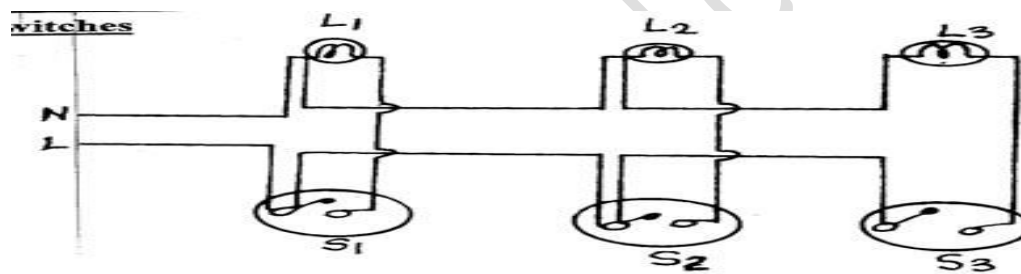
(c) (i) Four Parts of Steel Wire Armoured Cable

- |              |              |            |                          |           |           |
|--------------|--------------|------------|--------------------------|-----------|-----------|
| 1. Conductor | 2. Insulator | 3. Bedding | 4. Oil Impregnated paper | 5. Armour | 6. Sheath |
|--------------|--------------|------------|--------------------------|-----------|-----------|

(ii) Three Characteristics of an MICC cable

- |  |                           |  |
|--|---------------------------|--|
| 1. Higher current density                | 2. Hygroscopic            | 3. Ability to withstand high temperature |
| 4. Aesthetic                             | 5. Higher fire resistance | 6. High resistance to heat               |
| 7. High resistance to ionizing radiation |                           | 8. Does not deteriorate with age         |

(d)



(e) Four Tools Used in Conduit Installation

- |                  |                    |                 |                   |
|------------------|--------------------|-----------------|-------------------|
| 1. Bending block | 2. Bending machine | 3. Reamer       | 4. File           |
| 5. Stock and die | 6. Hacksaw         | 7. Fishing tape | 8. Bending spring |
| 9. Spanner       | 10. Hammer         | 11. Chisel      | 12. Pipe vice     |

83. (a) (i) State two types of electricity distribution networks.

(ii) Explain briefly the two types of electricity distribution networks stated in

(iii) List four materials used for overhead line installation.

(b) (i) State two causes of each of the following faults:

- I. the motor of an electrical appliance fails to start when switched on;
- II. a motor hums, but fails to start.

(ii) Suggest two remedies for each for the faults listed in 2(b)(i).

(c) Calculate the illumination on a working plane at a point 3m vertically below a lamp emitting 540cd.

(d) Name two fire-fighting equipment.

## Expected Solution

(a) Two types of electricity distribution networks are Radial and Ring main

(ii) Radial – feeders emanate from substation and feed specified areas only. Without return path of the source.

**Ring** – An electrical system in which distribution points are connected to the main supply in a continuous closed circuit/loop.

(iii) Four Materials used for Overhead line Installation

1. Stay wires      2. Flying stay      3. Insulator      4. Cross arm      5. Pole
6. Conductor      7. Lighting/surge arrester

(b) (i) I - Two Causes of faults in a motor of an electrical appliance that fails to start when switched on

1. No supply      2. Blown fuse      3. Centrifugal switch contacts open
4. Overhead relay open      5. Motor may be burnt      6. Open circuit on starter resistance
7. Open circuit on field winding.

II Two Causes of fault of a motor humming but fails to start

1. Mechanical overload      2. Open circuit in the starting winding      3. Low voltage
4. Open circuit in one of the three phases of a three-way phase motor
5. Faulty starting capacitor/device      6. Worn out bearings      7. Open Centrifugal switch

(ii) I. Two remedies for motor in an electrical appliance that fails to start when switched on

1. Restore supply      2. Change blown fuse      3. Change/replace centrifugal switch
4. Rewind burnt motor      5. Check and correct loose contact on starter resistance.
6. Correct the continuity of field winding      7. Check and close overhead relay.

II Two remedies for motor humming but fails to start

1. Check belt for alignment      2. Replace worn-out bearings
3. Check and restore supply voltage      4. Rewind starting winding
5. Open circuit windings      6. Check/ close centrifugal switch
7. Replace starting capacitor      8. Wash dirty bearings

(c)  $E = \frac{I}{d^2} = \frac{540}{3^2} = 60 \text{ lux}$

(d) Two Fire Fighting Equipment

- Fire extinguisher      - Sand pail/water & soap bucket/sand bucket
- Water hose      - Fire fighting vehicle      - Fire blanket

84. (a) (i) State five causes of accidents in a temporary electrical installation.

(ii) Name the three main types of maintenance carried out on electrical machines.

(b) (i) Explain briefly each of the following terms:

single phasing;  
electrical circuit.

(ii) State three requirements of IEE regulations on motors control.

(c) Sketch the British Standard (B.S.) symbols of each of the following electrical accessories:

(i) Two-way switch; (ii) intermediate switch; (iii) 13 A socket outlet.

### **Expected Solution**

(a) (i) Five Causes of Accidents in a Temporary Electrical Installation

1. Circuit fuse overrated      2. Cable run over sharp edges      3. Exposed metal parts
4. Lack of protective covering on switches/joint boxes
5. Use of cable without mechanical protection/bare conductors

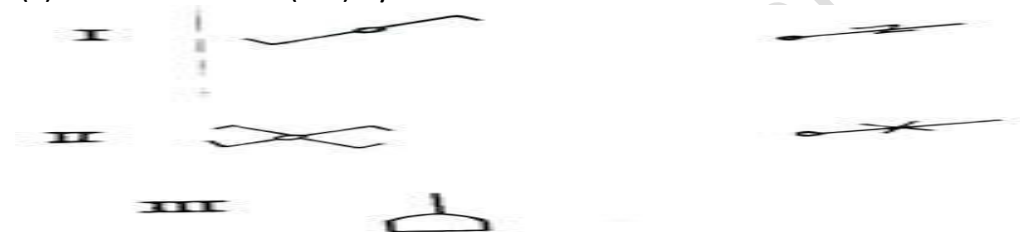
- ### (ii) Three Main Types of Maintenance Carried out on Electrical Machines

- (b) (i) - Single Phasing - Is the effect produced when an open circuit occurs on one of the lines/phases supplying 3-phase motor.

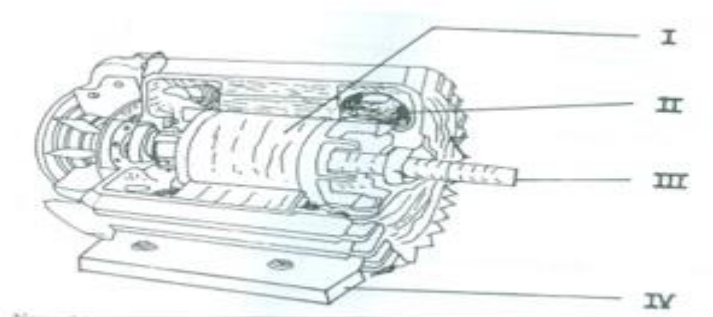
(ii) Three Requirements of IEE Regulations on motors Control

- Means of starting
- Means of stopping
- Means of protection against mechanical damage
- The control should be easily accessible to the operators
- Where the means of isolation is at a remote, an additional means of isolation shall be provided adjacent to the motor
- Means of protection against excess current
- Means of preventing automatic restarting

(c) British Standard (B.S) Symbols



85. The diagram below represents the longitudinal section of an a.c. motor. Study it and answer the questions that follow:



- Name the parts labeled I, II, III and IV.
- State one function of each of the parts labeled I, II, III and IV.
- Outline three steps to be taken in dismantling the motor.
  - List four tools needed to dismantle the motor.
- What would happen if the part labeled II got burnt?
  - Outline five steps in the procedure for rewinding a motor.
- Give two differences between an a.c. and a d.c. motor.
  - State two applications of a.c. motors.

### **Expected Solution**

(a) I- (Squirrel cage) rotor   II- stator winding   III- shaft   IV – feet / bed/ base plate

(b) Functions of The Labeled Parts

I - it is used to transmit / drive / move the motor forces to the output shaft

II - it is the part of the motor that receives current / that produces magnetic field / flux

III - it is used to drive the external load / it carries the bearing / fans

IV – it serves as a support to the motor / it gives the motor balance

(c) (i) Steps In Dismantling a Motor

- mark out the two end shields for easy identification
- loose the bolts / nuts
- gently tap the shaft from one end (with mallet / wood}
- remove the two end plates gently
- arrange the parts neatly to avoid loss / damage

(ii) Tools Needed To Dismantle a Motor

- centre punch
- spanner / allen key
- wooden hammer/mallet
- screw driver

(d) (i) The motor would not work/start/run

(ii) Steps in the Procedure for Rewinding a Motor

- take data of the winding (noting the connection, span and number of turns)
- take the cross-sectional area of the coil / winding
- remove the winding
- wash / clean the stator
- insulate the stator
- rewind the coil / wind using a former / winding machine
- insert the coil/ winding into the stator
- connect the coil / winding
- bind the coils / winding together
- apply varnish to the coil
- bake / dry the coil
- test again an

(e) (i) Differences Between an A.C. And a D.C. Motor

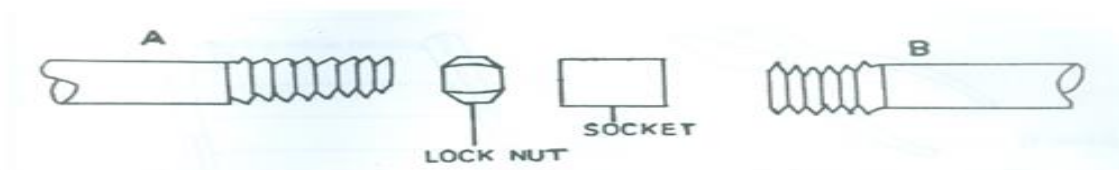


<b>a.c. motor</b>	<b>d.c. motor</b>
uses a.c. current	uses d.c. current
speed is controlled by varying the frequency	Speed is controlled by varying the armature winding current
simple starting method	complicated starting method
start on no load	start on load
No brushes and commutator	do have brushes and commutator
More rugged	less rugged
not used for stable operations	used for stable and precise operations
has varying voltage/current	has constant voltage/current
travels longer distance	travels shorter distance
has greater power	has less power

(ii) Applications of A.C. Motors

- Saw milling machines
- Electric fans
- Compressors in refrigerators / a.c. compressors
- Washing machines

86. (a) The diagram below illustrates two pieces of threaded conduits (A and B), a locknut and a socket. Study the diagram and answer questions that follow.



- (i) Reproduce the diagram showing the parts coupled together.
  - (ii) Where is this type of coupling used?
  - (iii) Why is it important to ensure that the socket is tightened firmly to the part labeled B?
- (c) Study the electrical workshop tools illustrated below and answer the questions that follow



- (i) Identify X, Y and Z.
  - (ii) State one use of each of X, Y, Z.
  - (iii) Suggest five ways of maintaining electrical tools.
- c. Identify three possible causes of each of the following faults in an a.c. motor:
- (i) Motor fails to start;
  - (ii) Overheating while running



### Expected Solution

a(i)



- (ii) - steel/metal conduit system of wiring
- (iii) - To prevent mechanical damage of the conduit
- To avoid loosening of the locknut from socket

b. (i) Electrical Workshop Tools

X – (Pair of) pliers

Y - screw driver

Z – hammer

(ii) X - It is used for holding / gripping / twisting / cutting (cables)

Y - It is used for driving screw in and out

Z - It is used for driving in nail

(iii) Ways of Maintaining Electrical Tools

- keep in dry place / keep away from moisture
- keep clean after use
- keep them in their proper boxes / racks
- use a particular tool for the job it is meant for / do not use wrong tools for a job
- oil/grease/ lubricate tools
- sharp/grind tools when blunt

c. (i) Motor fail to Start

- Failure of supply/no supply
- Short circuit
- Open circuit in control gear
- Incorrect setting of over – current releases
- Faulty centrifugal switch
- Open circuited fuse

(ii) Motor overheating while running

- overloading
- Single phasing / supply voltage not available in one of the three terminals
- Short circuit
- worn bearing
- ground/earth fault

87. (a) (i) State four precautions to be taken in charging a battery.

(ii) Give two differences between primary and secondary cells.

(iii) Explain briefly how a damaged socket can be replaced.

(b) (i) List four types of measuring instrument used in an electrical workshop.

(ii) State one use of any of the instruments listed in 87 b(i)

(iii) Explain briefly how electric current can be measured in a circuit.

## **Expected Solution**

### (a) (i) Precautions In Charging A Battery

- the battery charging room must be well ventilated
- ensure correct polarity of battery
- always add acid to water ( not water to acid )
- protective clothing / hand gloves should be used
- vent plugs must be removed before charging
- metals in the charging room should be painted to avoid corrosion
- no naked light (of any form) should be allowed in the charging room
- ordinary tap water should not be used for topping up the battery
- switch off charger before fixing the battery

### (ii) Differences Between Primary And Secondary Cells

<b>Primary cell</b>	<b>Secondary cell</b>
it is not rechargeable	it is rechargeable
it is cheap	it is expensive
it has short life span	longer life span
lower voltage	higher voltage
It has local action	no local action
It has polarization	no polarization
mostly use for portable appliances	used for less portable appliances

### (iii) Replacement of a Damaged Socket

- switch off / cut off supply
- remove / unscrew the damage socket
- connect a new socket with the live connected to the live, neutral to neutral and earth to earth
- screw the new socket firmly and turn on the supply

### b. (i) Types of a Measuring Instrument

- Ammeter    - voltmeter    - ohmmeter    - tachometer    - photometer    - micrometer screw gauge
- Hydrometer- multimeter    - watt meter    - megger                      - tape rule / measuring tape / ruler
- Wheatstone bridge            - potentiometer                      - Vernier calipers

### (ii) Uses of Measuring Instruments

Ammeter - used for measuring current

Hydrometer - used for measuring specific gravity of electrolytes

Voltmeter - used for measuring voltage

Multimeter - used for measuring current/voltage/resistance

Ohmmeter - used for measuring resistance

Tachometer - used for measuring speed of rotation

Megger - used for measuring very high resistance

Photometer - used for measuring illumination

Measuring tape/ruler/tape rule - used for measuring length / breadth / distance

Micrometer screw gauge/standard wire gauge - used for measuring diameter of wires

Wheatstone bridge - measuring resistance

Potentiometer - measuring voltage

Vernier calipers - used for measuring diameter of wires

(iii) Measuring Electric Current in A Circuit

- Identify the component terminal to be measured
- Break/open the circuit
- Insert an ammeter in series with the circuit to the meter's two points of break and select the correct range

88. (a) (i) Define the term illumination.  
(ii) List three factors that would affect the illumination of a room.
- (b) (i) State two types of conduit gauge.  
(ii) Outline five steps in the procedure for threading metal conduits.  
(iii) List four types of saddles used in metal conduit work.

### **Expected Solution**

a. (i) Illumination is the density of luminous flux falling on a working plane / working area

(ii) Factors Affecting Illumination

- light output from lamp/types of lamp
- height of the fitting/lamp
- spacing of the fittings
- floor area of the room/working plane of the room
- colour of the wall /ceiling

b. (i) Types of Conduit Gauge

- Light gauge
- Heavy gauge

(ii) Procedures for Threading Metal Conduits

- measure the length(s) to be threaded
- cut the metal conduit
- taper the end of the conduit with file / reamer
- lubricate the part to be threaded
- press the stock and dies on the conduit and start threading
- reverse the threading half way
- clean the end of the thread after completion

(iii) Types of Saddles

- spacer bar
- distance bar
- multiple saddles
- (girder) clips
- hospital saddle
- crampet

89. (a)(i) List four sources of danger to an electrician in an electrical workshop.

(ii) State two causes of electric shock.

(iii) State three procedures for rescuing a victim of electric shock.

- (b) Draw a well-labeled diagram to illustrate the wiring of two points of light in parallel controlled by a one-way switch.
- (c) List five tools used for surface wiring in electrical installation work.
- (d)(i) Define the following terms:
- I earthing
  - II earth electrode.
- (ii) Calculate the current flowing through a circuit of voltage 12V and resistance  $3\Omega$ .

### **Expected Solution**

a. (i) Sources of Danger in an Electrical Workshop

- Ineffectiveness of earth continuity conductor
- Use of cable without mechanical protection / bare conductor
- Use of cable without proper insulation / damaged insulation
- working on live conductors
- use of unearthed brass / unskirted lamp holders
- Lack of protective covering on switches / boxes
- Cable run over sharp edges
- Water and chemical
- Overloading of circuit
- Use of wrong tools
- Non-insulated tools
- Horseplay
- Lack of safety wear
- Moving machinery
- Poor ventilation/illumination
- Slippery floors

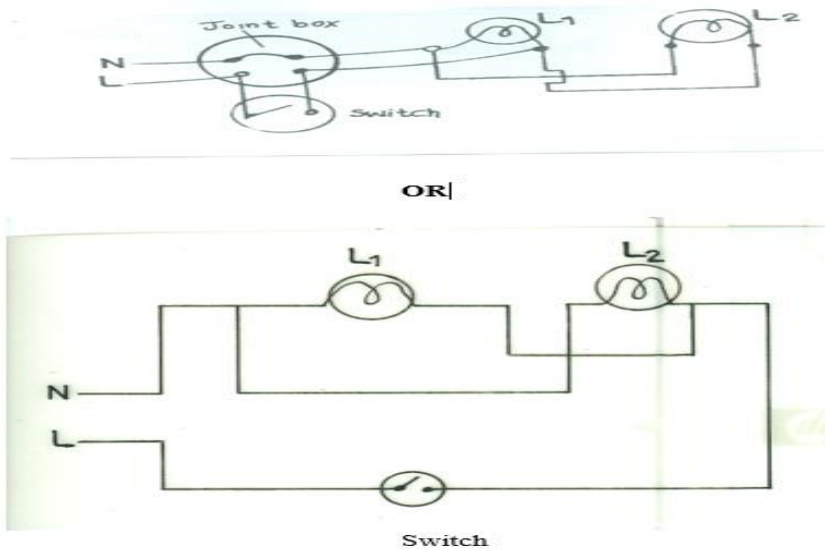
(ii) Causes of Electric Shock

- Wet hands
- Walking bare footed
- Frayed cables / incorrect jointing of cables
- Un-insulated / badly made connections
- Use of cable without mechanical protection
- Unprotected or unearthed socket outlets/plugs
- Poor or broken earth connections

(iii) Procedures for Rescuing an Electric Shock Victim

- Switch off the source of current / supply (before attempting to remove the casualty)
- Remove any obstructions to breathing
- Pull off the person by his clothing / using an insulated material
- Carry out artificial respiration
- Send for a doctor / medical help

b. Illustration of A Two Points of Light



### c. Tools for Surface Wiring

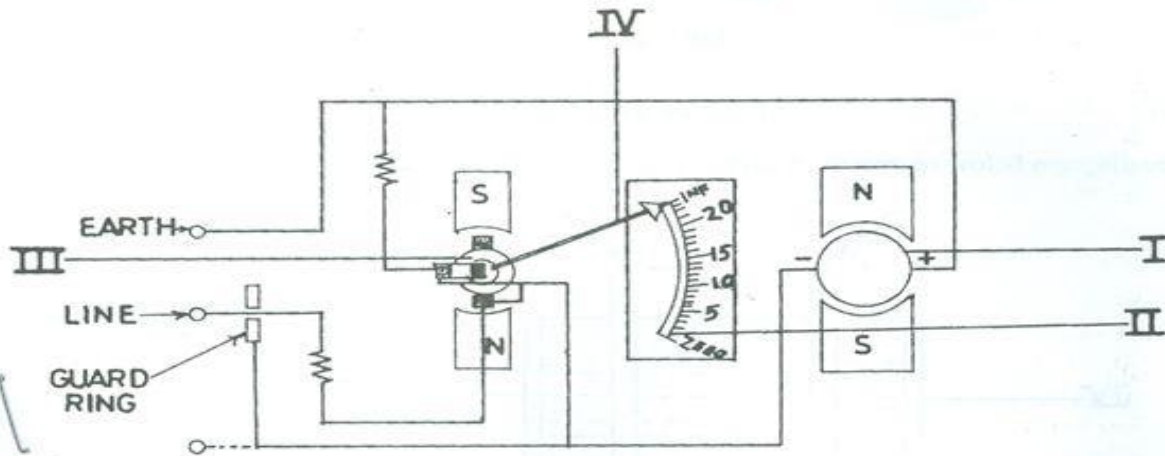
- hammer
- knife
- raw plug
- saw
- pliers
- screw driver
- neon tester / test lamp
- gimlet
- stripper
- measuring tape
- plumb line
- chisel

- d. (i) I - it is the connection of an electrical installation to the general mass of the earth  
II - it is the conductor connected to the earthing lead and buried in the ground

(ii) 
$$I = \frac{V}{R} = \frac{12}{3} = 4A$$

90. (a)

5. The circuit diagram below represents a megger insulation tester.



- (i) Name the parts labeled I, II, III and IV.
- (ii) State one function of each of the parts named in (a)(i)
- b. (i) What is the minimum reading for this instrument when used in measuring insulation resistance?
- (ii) Give two applications of this instrument.
- (iii) State two precautions that should be taken in using this type of testing instrument.
- c. Outline four steps in the procedure of operating this type of testing instrument

### **Expected Solution**

(a) (i) Parts of Megger insulation tester labeled I, II, III, and IV

I – Generator

II – Scale

III – Ohmmeter

IV- Pointer

(ii) Function of the parts

I - the generator is used to generate current to the ohmmeter

II - the reading is taken from the scale

III - ohmmeter is used to measure the quantity/value of resistance

IV - the pointer indicates the value measured

(b) Minimum reading of megger insulation tester

(i) 1 MΩ (between conductors) OR 0.5MΩ (between conductor and general mass of earth)

(ii) Applications of Megger Insulation Tester

- The instrument is used to measure the insulation resistance between poles
- It is used to measure insulation resistance between live conductor and earth of the installation

(iii) Precautions to be taken when using megger insulation tester

- Ensure that all loads are removed before commencing testing with the instrument
- When generating voltages, care should be taken not to touch the lead to avoid shock
- The lead of the megger should not be short circuited to avoid damaging the instrument.
- The handle of the Megger should be handled with care so that the voltage being generated should be gradual.

- (c) Steps in procedure of operating megger insulation tester
  - ensure that all loads are removed before commencing testing with the instrument
  - wind the generator to generate voltage
  - take the readings from the scale
  - interpret the reading taken

- 91 (a) (i) Define *first-aid*.  
(ii) Outline four steps in the procedure of administering artificial respiration.
- (b) (i) Define *maintenance factor* in relation to illumination.  
(ii) List three types of lamps used for street lighting.
- (c) (i) Define cable.  
(ii) List four types of cables based on their constructional features.
- (d) Explain briefly how the current rating of a cable is affected by the ambient temperature.  
(i) State two methods of joining electrical conductors.  
(ii) Explain briefly any one of the methods stated in (d)(i).

### **Expected Solution**

- (a) (i) First-aid is the treatment given to an accident victim before taken him/her to the hospital.  
(ii) Procedure of administering artificial respiration
  - clean the victim's mouth to remove any particle/foreign material
  - position the victim on the floor with the head tilted backward
  - take a deep breath
  - place your mouth on the victim's mouth
  - blow air into victim's lungs/mouth/nostrils until chest expands
  - repeat the process several times until the victim starts breathing professional arrives.
- (b) (i) Maintenance factor  
This is a loss in light output due to lamp ageing and dirt on the lamps/fittings.  
(ii) Lamps used for street lighting
  - High pressure mercury vapour lamp
  - Sodium discharge lamp
  - LED light
  - High intensity discharge lamp
- (c) (i) A cable is defined as a length of insulated conductors OR A cable is defined as two or more conductors each provided with its own insulation.  
(ii) Types of cable based on their constructional features
  - Polyvinyl chloride (PVC)
  - Lead sheathed
  - Vulcanized India-rubber insulated (V.R.I)
  - Tough-rubber-sheathed (T.R.S)
  - Mineral insulated/MICC/MISC
  - Polychloroprene (P.C.P. or neoprene)
  - Paper insulated lead-covered

- Heat resisting, oil-resisting and flame-retardant (H.O.F.R)
- Armoured cable

(iii) How current rating of a cable is affected by ambient temperature

As temperature increases, the surrounding air increases, the resistance of the cable increases hence the current rating of the cable decreases vice versa.

(d) (i) Methods of joining electrical conductors

- Mechanical method
- Soldering method
- Welding method

(ii) - Mechanical method - This is done by using connector blocks/bolt and nut. It is a manual way of joining.

- Soldering method - This is the process of joining conductors using heat/soldering bits.

- Welding method - This involves the use of flames from gas in joining conductors.

92. (a) (i) List three types of electrical tests for domestic installations.  
(ii) Why is it important to conduct electrical tests in domestic installations?  
(iii) Name three instruments used for conducting tests in electrical installations.
- (b) (i) Define *a.c.* motors.  
(ii) Give two applications of an *a.c.* motor.
- (c) State three reasons for the installation of protective devices

### **Expected Solution**

- (a) (i) Types of electrical tests for domestic installations
- polarity test
  - insulation resistance test
  - earthing test
  - continuity (ring circuit) test
- (ii) Importance of electrical tests in domestic installation
- to ensure that the installation is properly done
  - to detect fault
  - to correct fault
  - to certify that the installation is fit/ safe for use
  - to prevent hazard, malfunction and breakdown of domestic equipment/installation
- (iii) Instruments for conducting test in Electrical Installation
- insulation resistance tester/megger
  - bell set tester
  - ohmmeter
  - electrician phase tester
  - testing lamp
  - avometer/multimeter
  - voltmeter
  - testing screw driver
  - ammeter



- (b) (i) A.C. motor is a device which converts electrical energy into mechanical energy.  
(ii) Application of A.C. motor
  - water pumps
  - blenders
  - ceiling fans
  - grinders
  - air condition fans
  - a.c. compressor
  - drilling machine
  - milling machine
- (c) (ii) Reasons for installation of protective devices
  - To prevent earth leakage
  - To prevent electric shock
  - To prevent excess current
  - To prevent low voltage
  - To prevent damage by fire
  - To maintain continuity of supply
  - To isolate the consumer installation from the main supply
  - To prevent lightening

93. (a) (i) What is corrective maintenance?  
(ii) State one disadvantage of corrective maintenance.  
(iii) List three types of electrical machine enclosures.
- (b) State the use of each of the following types of conduit fittings:  
(i) elbow joint;  
(ii) male and female bushing;  
(iii) locknut;  
(iv) couplers.
- (c) State three requirements of IEE regulations on conduit installations.
- (d) (i) List three pieces of information contained on the name plate of a three-phase machine.  
(ii) List three constructional features of a *d.c.* machine.  
(iii) State two possible causes of low voltage output of an *a.c.* generator.

### **Expected Solution**

- (a) (i) Corrective maintenance is the type of maintenance / repairs carried out on a machine / device / equipment to put it into use after a breakdown / damage has occurred OR This is the type of maintenance done after an installation has been damaged to restore it to active installation.
- (ii) Disadvantages of corrective maintenance
  - Stoppage / delay of work
  - It is expensive / costly
  - It wastes time / it is time consuming
- (iii) Types of electrical machine enclosures

- Pipe ventilated
- Drip-proof
- Screen protected
- Totally enclosed
- Flame proof
- Open type

### (b) Uses of named conduit fittings

Elbow joint - It is used to link / connect pipes at an angle

Male and Female Bushing - It is used to link the pipes / conduit to the back entry boxes / looping boxes / joint boxes

Locknut - It is used to hold conduit firmly in place

Coupler - It is used to join two lengths of conduit / pipes

### (c) IEE regulations on conduit installations

- Conduit must be erected before cables are drawn into it
- The space factor must not exceed 40%
- Extra low and low voltage cables must not be installed in the same conduit
- Conduit installed in a damp environment must have water resistance finishing
- All exposed metals must be bonded
- All joints must be mechanically sound and electrically continuous
- It is essential that the whole of the conduit system be efficiently earthed
- All burrs must be removed to prevent abrasion
- Proper precautions must be taken against corrosion
- PVC conduit must not be used where the ambient temperature exceeds 60°C

### (d) (i) Information on the name plate of a three-phase machine

- Supply / Rated voltage
- Frequency
- Horse power
- Speed
- Winding connection
- Current rating
- Manufacturer's name and address

### (ii) Constructional features of a d.c. machine

- Eye bolt
- Pole shoe
- Main pole
- Field winding
- Inter-pole
- Commutator
- Armature (windings)
- Yoke

### (iii) Causes of low voltage output of an a.c. generator

- Low speed
- Faulty A.V.R
- Lost of residual magnetism