Assignment - I

Q) Define temperature co-efficient of resistance. State its units and factors on which it depends.

Ans. i.) The temperature co-efficient of resistance is the ratio of change in resistance per °c to the resistance at t°c.

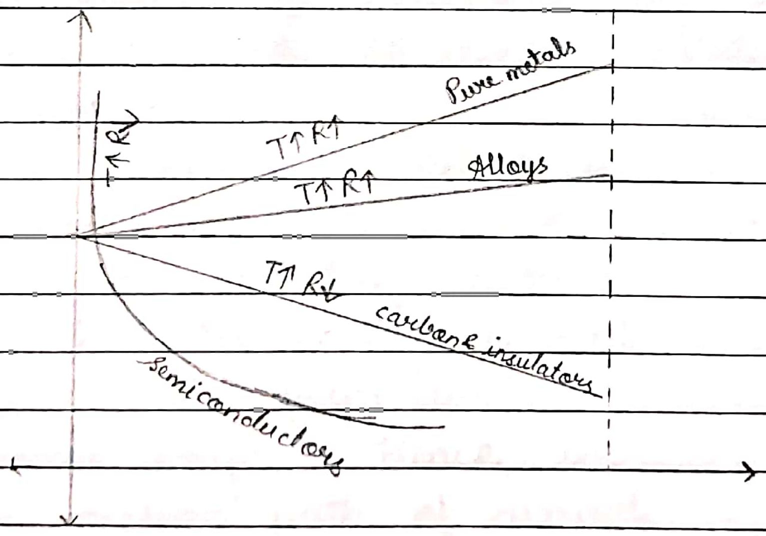
$$\text{Temperature coefficient of resistance } (\alpha) \text{ at } t^\circ c = \frac{\text{Change in resistance}}{\text{Resistance at } t^\circ c}$$

ii.) Its unit is $^\circ C^{-1}$

iii.) Temperature co-efficient of resistance depends on nature of the material used and on the temperature

Q2.) Define the effect of temperature on the resistance of various materials with help of graph.

Ans.



i.) For conductors as we increase temperature, resistance also increases. Thus showing positive slope. This is because at higher temperatures atoms in conductors vibrate more causing more collisions with moving electrons and creating obstacles for their flow, resulting in increased resistance.

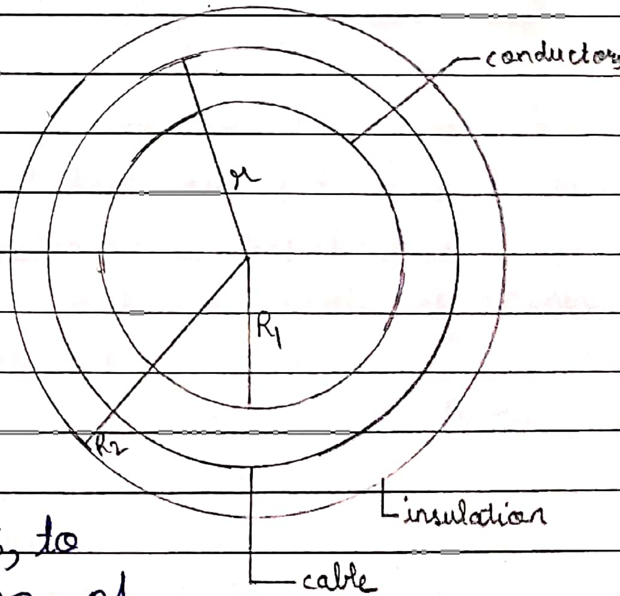
ii.) For semiconductors negative slope is seen as for increasing temperature, decreasing resistance is seen. This is due to the fact that semiconductor electrons can be excited from the valance band to conduction band with increase in thermal energy, creating more charge carriers and enhancing conductivity.

iii.) For carbon and insulators a very steep negative slope is seen, meaning their resistance drops significantly with increasing temperature. This is because as temperature increase insulating property breaks down cause more current to flow.

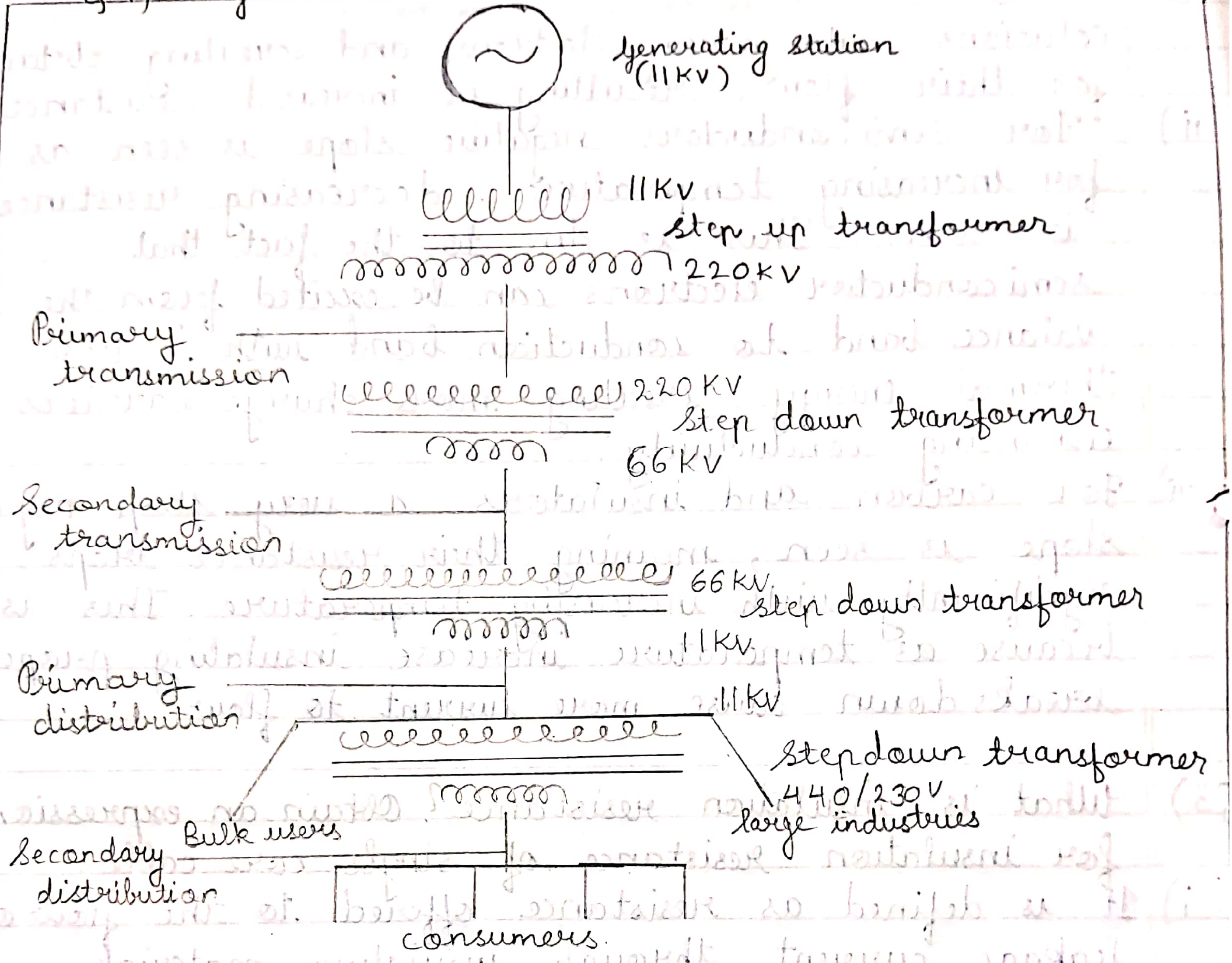
Q3.) What is insulation resistance? Obtain an expression for insulation resistance of single core cable.

Ans. i) It is defined as resistance offered to the flow of leakage current through insulating material.

ii Figure shows cable which is insulated with the help of layer of insulating material in such cables leakage current flows rapidly from centre towards surface. Hence, the cross section path of current is not constant but changes continously through length. Thus, to calculate resistance of a cable section of radius (r) and small thickness thickness (dr) from the cable.



Q4) Diagram



Electrical Power System (Single line diagram)

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Q4.) Draw a layout of a typical power system and explain in brief the stages involved in the transmission of electrical power from the generating station to consumer premises

Ans. i) Generation :- Electricity is generated at power plants at a lower voltage.

ii) Step Up Transformer :- Voltage is increased for efficient long-distance transmission.

iii.) Transmission lines :- High voltage lines carry electricity over large distances.

iv.) Step down Transformer :- Voltage is reduced near cities or industrial areas.

v.) Distribution Lines :- Medium-voltage lines deliver power to local areas.

vi.) Distribution transformer :- Voltage is further reduced for safe consumer use.

vii.) Consumer premises :- Electricity reaches, homes, businesses, and industries.

Each step ensures efficient and safe power delivery from the plant to the consumer.

Q5.) A single core cable has its diameter as 5cm. The resistivity of conductor insulator are $1.73 \times 10^{-8}\ \Omega m$ and $8 \times 10^{12}\ \Omega m$ respectively. Calculate resistance of conductor and insulation for a cable of 100m.

Ans. Given :- diameter of cable $(d) = 5cm$

resistivity of conductor $(\rho_c) = 1.73 \times 10^{-8}\ \Omega m$

resistivity of insulator $(\rho_i) = 8 \times 10^{2}\ \Omega m$.

length of cable $(l) = 100\ m$.

To find :- Resistance of conductor (R_c)

Resistance of insulation (R_i)

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R_1 = conductor radius
R_2 = insulation radius
r = radius of cable
dr = small thickness
R_i = Insulation radius

$R = \frac{\rho l}{a}$ (l = length, a = area of cross section)

$dR_i = \frac{\rho\, dr}{2\pi r l}$ (a of cylinder $= 2\pi r l$)

$\int dR_i = \int \frac{\rho\, dr}{2\pi r l}$ (by intigrating both sides)

$R_i = \frac{\rho}{2\pi r l}$.

$$R_i = \int_{R_1}^{R_2} dR_i$$

$$R_i = \int_{R_1}^{R_2} \frac{\rho\, dr}{2\pi r l}$$

$$= \frac{\rho}{2\pi l} \int_{R_1}^{R_2} \frac{dr}{r}.$$

$$= \frac{\rho}{2\pi l} \left[\log r \right]_{R_1}^{R_2}$$

$$= \frac{\rho}{2\pi l} \left[\log R_2 - \log R_1 \right]$$

$$R_i = \frac{\rho}{2\pi r l} \log_e \frac{R_2}{R_1}$$

Thus,

$$R_{insulation} = \frac{\rho}{2\pi r l} \log_e \frac{R_2}{R_1}$$

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Formula :- $R_c = \frac{\rho_c l}{a}$

radius $= \frac{d}{2}$

$= \frac{5 \times 10^{-2}}{2} = 2.5 \times 10^{-2} m$

$R_c = \frac{1.73 \times 10^{-8} \times 100}{3.14 \times (0.025)^2} \approx 8.81 \times 10^{-4} \Omega$

$= \cancel{1.9635 \times 10^{-3} m^2}$

$=$

$R_i = \frac{\rho_i}{2\pi r l} \log_e \frac{R_2}{R_1}$

$= \frac{8 \times 10^{12}}{2 \times 3.14 \times 2.5 \times 10^{-2} \times 100} \ln$

R_2 not given in question

Q6.) A piece of silver wire has a resistance of 3 Ω What will be the resistance of a manganin wire one-third the length and amp; one third the diameter that of silver? The resisitivity of manganin is 30 times that of silver.

Ans Given :- Resistance of silver wire $(R_s) = 3\,\Omega$

Resisitivity of silver $= \rho_s$

Resisitivity of manganin $= \rho_m$

$\rho_m = 30\rho_s$

Length of manganin $= L_m$

$L_m = \frac{1}{3} L_{silver}$

Diameter of manganin $= D_m$

$D_m = \frac{1}{3} D_{silver}$

To find :- Resistance of manganin wire $= R_m$

Solution :- $R = \rho \frac{L}{A}$

Area of manganin $= \frac{\pi D_m^2}{4}$

$$= \frac{\pi\left(\frac{1}{3} D_{silver}\right)^2}{4} = \frac{1}{9} \times \frac{\pi D_{silver}^2}{4}$$

$$= \frac{1}{9} A_{silver}$$

$$R_m = \frac{30\rho_{silver} \times \frac{1}{3} L_{silver}}{\frac{1}{9} A_{silver}}$$

$$R_m = 90\rho_{silver} \times \frac{L_s}{A_s} \quad \left(\because R_s = \rho_s \frac{L_s}{A_s}\right)$$

$\therefore R_m = 90 \times R_s$

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$R_m = 90 \times 3 = 270\,\Omega$

∴ The resistance of the manganin wire is $270\,\Omega$

Q7) Find the current drawn by a crane motor when raising a mass of 1000kg through a height of 15 meters in 10 sec. The supply is 400 V D.C gear efficiency is 0.6 & amp; motor efficiency is 0.8

Given :- mass $(m) = 1000\,kg$
height $(h) = 15\,m$
Time $(t) = 10\,s$
Supply voltage $(V) = 400\,V$
Gear efficiency $\eta_{gear} = 0.6$
Motor efficiency $\eta_{motor} = 0.8$

To find :- Current drawn by crane motor (i)

Solution :- $W = mgh =$
$= 1000 \times 9.81 \times 15$
$= 147150\,J$

Power output $= \dfrac{Work}{t}$

$= \dfrac{147150}{10} = 14715$ Watt

Power gear input $= \dfrac{P_{output}}{\eta_{gear}}$

$= \dfrac{14715}{0.6} = 24525$ Watt

Power motor input = $\frac{P_{gear\ input}}{\eta_{motor}}$

$= \frac{24525}{0.8} = 30656.25$ Watt

current $(i) = \frac{P_{motor\ input}}{V}$

$= \frac{30656.25}{400} = 76.64A$

$\therefore$ The current drawn from motor is $76.64A$

Q8 Find the current flowing at the instant of switching 40 W lamp on 240 V supply. Given that working temperature of filament is 2000 °C and temp. co-efficient of resistance of filament at 15 °C is 0.005/°C

Given :- Power rating of lamp $(P) = 40W$
Supply Voltage $(V) = 240V$
Working temperature of filament $(T_{working}) = 2000°C$
Room temperature $(T_{room}) = 15°C$.
Temperature co-efficient of resistance $(\alpha) = 0.005/°C$

To find :- Current flowing at the instant of switching 40 W lamp.

Solution:-

$$P = \frac{V^2}{R_{working}}$$

$$\therefore R_{working} = \frac{V^2}{P} = \frac{(240)^2}{40} = 1440\,\Omega$$

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$$R_{room} = \frac{R_{working}}{1 + \alpha(T_{working} - T_{room})}$$

$$R_{room} = \frac{1440}{1 + 0.005(2000 - 15)}$$

$$= \frac{1440}{10.925}$$

$$\approx 131.82\ \Omega$$

$$I_{initial} = \frac{V}{R_{room}}$$

$$= \frac{240}{131.82} \approx 1.82\,A$$

∴ The current flowing at the instant of switching the 40W lamp on is approximately 1.82 A.

Q9) A bucket contains 20 liters of water at 200 °C. A 2.5 kW immersion heater is used to raise the temperature of water to 95 °C. The overall efficiency of process is 90% and the specific heat capacity of water is 4200 J/kg°K. Find the time required for the process. Also find its cost of energy for 365 days if rate of energy is ₹3 per unit.

Given :- Volume of water = 20 liters = 20 kg
Initial temperature (T_i) = 20°C
Final temperature (T_f) = 95°C
Heat power (P) = 2.5 kW = 2500 W
Efficincy (η) = 90% = 0.9
Specific heat capacity of water (c) = 4200 J/kg°C/K

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Energy cost per unit, ₹ 3 per unit

To find :- Time required for the process and cost of energy for 365 days.

Solution :-

$$Q = m \cdot c \Delta T$$

$$Q = 20 \times 4200 \times 75$$
$$= 6,300,000 \, J$$

$$Q_{actual} = \frac{Q}{n} - \frac{6300000}{0.9} = 7000000 \, J$$

$$t = \frac{Q_{actual}}{P}$$
$$= \frac{7000000}{2500} = 2800 \text{ seconds.}$$

$$t = \frac{2800}{3600} \approx 0.778 \text{ hours} \quad (\because 1 \text{ hour} = 3600 \text{ secs})$$

$$\text{Energy per day} = P \times t$$
$$= 2.5 \, kW \times 0.778$$
$$\approx 1.945 \, kWh$$

$$\text{Total energy for 365 days} = 1.945 \times 365$$
$$\approx 710.925 \, kWh$$

$$\text{Total cost} = 710.925 \times 3$$
$$\approx \text{Rs. } 2132.78$$

∴ The time required for the process is 2800 seconds i.e 0.778 hours

∴ Cost of energy for 365 days is Rs 2132.78

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Q10) An electric furance is used to melt aluminium Initial temperature of solid aluminium is 32°C and its melting point is 680°C specific heat capacity of aluminium is 0.95 kJ/kg°C. Heat required to melt 1 kg of aluminium at its melting point is 450kJ. If the input power drawn by the furnace is 20 kW and its overall efficiency is 60%. Find the mass of alminium ~~melted~~ melted per hour.

Given :- Initial temperature $(T_i) = 32°C$

Melting point of aluminum $(T_m) = 680°C$

Specific heat capacity of aluminum $(c) = 0.95\,kJ/kg/°C$

$\approx 950\ J/kg/°C$.

Latent heat of fusion of alminium, $(L) = 450KJ$

$= 450000\ J/kg$.

Power drawn by furnace $(P) = 20\,kW = 20{,}000W$

Efficiency of furnace $(\eta) = 60\%. = 0.6$.

Q To find :- Mass of aluminum melted per hour.

Solution :-

$$Q_{heat} = m \cdot c \cdot \Delta T$$
$$= 1 \times 950\ (680 - 32)$$
$$= 1 \times 950 \times 648$$
$$= 615600\ J$$

$$Q_{melt} = L = 450{,}000\ J.$$

$$Q_{total} = Q_{heat} + Q_{melt} = 615600 + 450{,}000$$
$$= 1065600\ J$$

$P_{effective} = P \times \eta = 20\,000 \times 0.6 = 12000\,W$

$12{,}000\,J/s$

$\text{Energy per hour} = P_{effective} = P_{eff} \times 3600$

$= \cancel{20{,}000 \times 0.6}$

$= 12{,}000 \times 3600$

$= 43200000\,J$

$m = \dfrac{\text{Energy per hour}}{Q_{total}} = \dfrac{43200000}{1065600}$

$\approx 40.54\ kg$

$\therefore$ Mass of aluminum melted per hour is 40.5 kg approximately.