Electrical Assignment-1

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① Find the resistance at 20°C of the following annealed standard copper wire.

a) 1 mm^2 cross section and 10 m long

$$R = \frac{\rho l}{A}$$

for copper wire $\rho = 1.73 \times 10^{-8}\ \Omega m$

$$R = \frac{1.73 \times 10^{-8} \times 10}{\left(\frac{1}{1000}\right)^2} = 0.173\ \Omega\ \text{Ans}$$

b) 25 mm^2 cross section, 200 m long

$$R = \frac{\rho l}{A},$$

$$R = \frac{200 \times 10^{-3} \times 1.73 \times 10^{-8}}{\frac{25}{10^6}}$$

$$R = 1.384 \times 10^{-4}\ \Omega$$

② Determine the resistance of a metal tube in terms of the external diameter D, the internal diameter d, the length l & resistivity ρ. Calculate the resistance of a copper tube 0.5 cm thick and 2 m long. The external diameter is 10 m.

$$R = \frac{\rho l}{A}$$; A is area cross section

$$A = \pi\left[\frac{D^2 - d^2}{4}\right]$$

$$R = \frac{4 \rho l}{\pi (D^2 - d^2)}$$

Resistance of copper tube $= \dfrac{4 \times 1.73 \times 10^{-8} \times 2}{\pi\left[\left(\frac{10}{100}\right)^2 - \left(\frac{9.5}{100}\right)^2\right]}$

$$R = 23.2\ \mu\Omega\ \text{Ans}$$

③ Calculate the loss in watts per kg of a current carrying conductor in terms of the resistivity ρ μΩm, the current density σ A per mm² & specific gravity S.

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$$R = \frac{\rho l}{A}$$

$$\text{Loss} : \frac{\text{Power}}{\text{mass}} = \frac{i^2 R}{\delta \times A \times l}$$

$$R = \frac{\rho . l}{A}$$

$$\text{Loss} = \frac{i^2 \rho \cancel{l}}{A \times \delta \times A \times \cancel{l}} = \left(\frac{i^2}{A^2}\right)\frac{\rho}{\delta}$$

$$\sigma = \frac{i(A)}{A\ m^2} \Rightarrow \quad \frac{i\ (A)}{10^6 A\ mm^2}$$

$$\frac{i^2}{A^2} = \sigma \times 10^{12}$$

$$\delta =$$

$$R = \frac{\sigma^2 . 10^{12} \times \rho \times 10^{-8} \times 10^{-3}}{S}$$

$$\boxed{\text{Loss} = \frac{10 . \sigma^2 \rho}{S}}$$ Ans

④ Determine the length l and diameter d of a cylinder of copper in terms of the volume, x; resistivity ρ, and the resistance between ends r.

$$r \Rightarrow \frac{\rho\ l}{\pi r^2} \quad \left[\frac{\rho l}{A} = R\right]$$

$$l \Rightarrow \frac{V}{A} = \frac{x}{\pi r^2}$$

$$r = \frac{\rho x}{\pi^2 r^4}$$

$$r = \sqrt[4]{\frac{\rho x}{\pi^2}} \quad ; \quad d = \sqrt[4]{\frac{16 \rho x}{\pi^2}}$$ Ans

$$r = \frac{\rho l}{\pi r^2}$$

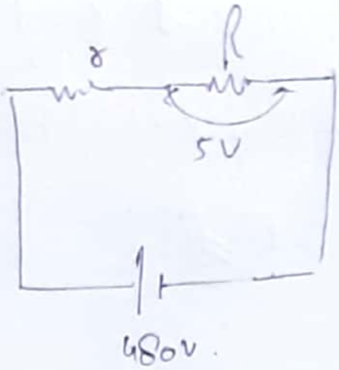
$$\pi r^2 = \frac{x}{l}$$

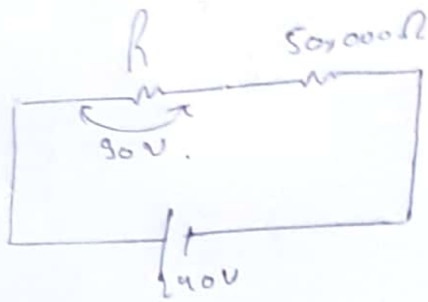
$$r = \frac{\rho l^2}{x}$$

$$l = \sqrt{\frac{r x}{\rho}}$$ Ans

(5) The insulation resistance of a single cable core is connected in series with a voltmeter across a 480 V supply. The voltmeter reads 5V. When connected in parallel with a 50,000 Ω resistor across 240 mains, the voltmeter reads in 90 V. Calculate the value of the insulation resistance.

Let resistance of voltmeter be R and insulation be r.





$$\frac{R \times 240}{R + 50000} = 90$$

$24\cancel{0}R \Rightarrow 9\cancel{0}R + 45000\cancel{0}$

$15R = 450000$

$R = 30000$

$R_{eq} \Rightarrow R + r$

$$R \times \frac{480}{r + R} = 5V$$

substituting R in above eq.

$$\frac{30000 \times 480}{r + 30000} = 5$$

$r = 2.85 \times 10^6 \, \Omega$

$r = 2.85 \, M\Omega$ Ans

(6) The resistance temperature coefficient of phosphor bronze is 39.4×10^{-4} per 1°C at 0°C. Find the coefficient for a temperature of a) 20°C b) 100°C

$R = R_0(1 + \alpha \Delta T)$

$$\boxed{\alpha_n = \frac{1}{\frac{1}{\alpha_1} + (\theta_n - \theta_i)}}$$

a) 20°C $= \dfrac{1}{\frac{1}{39.4 \times 10^{-4}} + (20-0)} \Rightarrow \alpha_{20°C} = 36.5 \times 10^{-4}$ per °C

b) 100°C $= \dfrac{1}{\frac{1}{39.4 \times 10^{-4}} + (100-0)} = \alpha_{100°C} = 28.2 \times 10^{-4}$ per °C

(7) Calculate the capacitance of a air insulated capacitor with 13 plates each $10\,cm^2$ & distance b/w plates being 2 mm.

$$C = \frac{A\epsilon_0}{d}$$

$\epsilon = 8.854 \times 10^{-12}$

$A \Rightarrow 10\,cm^2 = \frac{10}{10000}\,m^2$

$d = \frac{2}{1000}\,m$

$$C \Rightarrow \frac{10 \times 8.854 \times 10^{-12} \times 10^{-4} \times 10^{3}}{2}$$

$$\Rightarrow 4.427 \times 10^{-12}\,F$$

C b/w 13 such plates = no. of gaps × C of 1 plate with air

$$\Rightarrow 12 \times 4.427 \times 10^{-12}\,F$$

$$= 53.1\,pF \text{ Ans}$$

(8) Find the equation to the voltage to be applied to a $50\,\mu F$ capacitor initially uncharged to produce a steady current of 10mA. If the charging ceased after 10 s, calculate

a) the capacitor voltage

b) the charge

c) stored energy

$$v(t) = \frac{1}{C}\int_0^t i\,dt + \cancel{v(0)}^{\,0}$$ (since capacitor is initially uncharged)

$$v(10\,sec) = \frac{1}{50 \times 10^{-6}}\int_0^{10} 10^{-3} \times 10\,dt \Rightarrow \frac{10^{-2}}{5\cancel{0} \times \cancel{10^{-6}}_{10^{-4}}} \times 1\cancel{0} \Rightarrow 2000\,V$$

a) voltage = 2000 V Ans

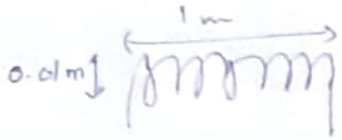
b) charge = $C \times V \Rightarrow 50 \times 10^{-6} \times 2000$

$Q \Rightarrow 0.1\,C$ Ans

c) stored energy = $\frac{1}{2} Q V = \frac{1}{2} \times 0.1 \times 2000 = 100\,J$ Ans

(9) Calculate for approximate resistance and inductance of a solenoid of mean diameter 1 cm, 1 m long, wound with thousand turns of a copper wire 0.5 mm in diameter. What potential difference exists at the terminal of the solenoid at the instant when the current is 1 A and increasing at the rate of 10,000 A/sec.

$$\text{Resistance} = \frac{\rho l}{A}$$



1000 turns ; $\frac{0.5}{2}$ mm $= r$

$$l = n\pi d = 1000 \times \frac{2 \times \pi \times 0.5}{100 \times 2} \Rightarrow \frac{50}{10}\pi \text{ m}$$

$$A \Rightarrow \pi r^2 \Rightarrow \frac{\pi \times 0.5 \times 0.5}{2 \times 2 \times 10 \times 100 \times 100} \Rightarrow \frac{\pi}{1600000} \text{ m}^2$$

$$\rho = 1.73 \times 10^{-8}$$

$$R \Rightarrow \frac{1.73 \times 10^{-8} \times 50 \pi \times 1600000 \times 2}{\pi \quad 100}$$

$$R \Rightarrow 2.752\ \Omega \text{ Ans}$$

$$L = \frac{N^2 \mu A}{l} = (1000)^2 \frac{\pi}{4} \times 10^{-4} \times 4\pi \times 10^{-7}$$

$$= 9.86 \times 10^{-5} \text{ H}$$

$$L = 0.09869 \text{ mH Ans}$$

$$V = L\frac{di}{dt} + IR$$

$$V \Rightarrow 0.0987 \times 10^{-3} \times 10000 + (1 \times 2.752)$$

$$V \Rightarrow 3.738 \text{ V Ans}$$

(10) A circuit has thousand turns enclosing a magnetic circuit 20 m^2 in section. With 4A the flux density is 1 Wb/m^2 & with 9 A is 1.4 Wb/m^2. Find the mean value of the inductance b/w these current limits and induced electromotive force if the current fell uniformly from 9 A to A in 0.05 sec.

$N = 1000$
$A = 20 m^2$
$i_2 \Rightarrow 4A ; \phi = 1 \, Wb/m^2$
$i_1 = 9A = \phi = 1.4 \, Wb/m^2$
$\Delta t = 0.05$

$$L = \frac{NA d\phi}{dt} \Rightarrow \frac{1000 \times 0.4 \times 20}{5} \Rightarrow 1.6 \, H \text{ Ans}$$

$$V = L\frac{di}{dt} = \frac{1.6 \times 5}{0.05} \times 100$$

$$V = 160 V \text{ Ans}$$