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PHYSICS ASSIGNMENT - I

1. Assume that you imbed some free charge in a piece of glass. About how long would it take for the charge to flow to the surface?

Soln: We know,

for glass, $\epsilon = 4.7\,\epsilon_0 = 4.7 \times 8.854 \times 10^{-12}$

$\sigma = 1 \times 10^{-13}$

$\tau = ?$ (Relaxation time)

We have,

$$\tau = \frac{\epsilon}{\sigma} = \frac{4.7 \times 8.854 \times 10^{-12}}{10^{-13}} = 415.95\ s$$

$$\therefore \tau \approx 416\ s$$

2. Silver is an excellent conductor, but is expensive. Suppose you designed a microwave experiment to operate at a frequency of 1010 Hz. How thick should the silver coating be?

Soln: for silver,

$\epsilon \approx \epsilon_0$

$\mu \approx \mu_0$

$\sigma = 6.29 \times 10^7$

We have,

$f = 1010\ Hz$

$\omega = 2\pi f = 2020\pi\ Hz$

So,

Now, the skin depth d is given by,

$$d = \frac{1}{k} = \sqrt{\frac{2}{\epsilon\mu}} \times \left[\sqrt{1+\left(\frac{\sigma}{\epsilon\omega}\right)^2} - 1\right]^{-\frac{1}{2}}$$

Placing values and calculating, we get,

$$d \approx 6.35 \times 10^{-7} \text{ m}$$
$$\therefore d \approx 0.64 \mu\text{m}$$

∴ The thickness of the silver should be approximately $0.64\mu m$

3. Find the wavelength and propagation speed in copper for radio waves at 1 MHz Compare the corresponding values in air (or vacuum).

Soln:

for copper,

$$\epsilon' \approx \epsilon_0$$
$$\mu \approx \mu_0$$
$$\sigma = 5.96 \times 10^7$$

Wave number, $k = \sqrt{\frac{2}{\epsilon\mu}} \left[\sqrt{1+\left(\frac{\sigma}{\epsilon\omega}\right)^2} + 1\right]^{\frac{1}{2}}$

Putting all the values, we get,

$$k \approx 15299.807 \text{ m}^{-1}$$

Now,

Wavelength, $\lambda = \frac{2\pi}{k} \approx 4.107 \times 10^{-4}$ m

And,

velocity, $v = \frac{\omega}{k} = f\lambda \approx 410.7$ m/s

In vacuum, velocity, $c = 3 \times 10^8$ m/s and wavelength, $\lambda = 300$ m