Answer on Question #80087, Physics / Other

2. b) A surface wave with frequency w = 3 × 10^{-5} rad s^{-1} is propagating at a metal-free space boundary. The plasma frequency of metal is 9 × 10^{15} rad and $\varepsilon_r = 7$. Estimate k. If the amplitude of the wave is 10^5 Vm^{-1} at the surface, what will be its value at the depth of 0.2 μm in the metal? Ignore the collision effect.

Solution:

Dispersion relation:

$$\omega = \sqrt{\omega_P^2 + c^2 k^2}$$

So,

$$k = \sqrt{\frac{\omega^2 - \omega_p^2}{c^2}} = \sqrt{\frac{(3 \times 10^{-5})^2 - (9 \times 10^{15})^2}{(3 \times 10^8)^2}} = 3 \times 10^7 i \ \ m^{-1}$$

K is imaginary and the wave decays exponentially with distance inside the metal.

$$E(x) = E_0 e^{ikx}$$

So, for $x = 0.2 \ \mu m$

$$E(x) = 10^5 e^{-3 \times 10^7 \times 0.2 \times 10^{-6}} = 247.9 \ V/m$$

Answer: $247.9 \ V/m$