When an EM wave travels from a media with a very high index of refraction to a very low index of refraction, where is most of the energy (intensity)?

A. In the wave in the high index material
B. In the wave in the low index material
C. It depends

When an EM wave travels from a media with a very high index of refraction to a very low index of refraction, where is the wave the highest amplitude?

A. In the high index material
B. In the low index material
C. It depends

An EM wave passes from air to metal, what does **your intution** say happens to the wave in the metal?

A. It will be amplified because of free electrons
B. It will die out over some distance
C. It will be blocked right at the interface because there's no E field in a metal
D. Not sure

An EM wave passes from air to metal, which do you think is **most likely** the physics will give us?

A. It will be amplified because of free electrons
B. It will die out over some distance
C. It will be blocked right at the interface because there's no E field in a metal
D. Not sure

Suppose I stick some charge ρ_f down somewhere in a metal (with conductivity σ). What does $\rho(t)$ look like if we can invoke Ohm's law ($\mathbf{J} = \sigma\mathbf{E}$)? *Hint: Think about charge conservation.*

A. $\rho(t) = \rho_f \sin(\sigma t/\varepsilon_0)$
B. $\rho(t) = \rho_f \cos(\sigma t/\varepsilon_0)$
C. $\rho(t) = \rho_f e^{-\sigma t/\varepsilon_0}$
D. $\rho(t) = \rho_f e^{-\varepsilon_0 t/\sigma}$
E. Something else

Consider a good conductor ($\sigma \sim 10^8$ S/m), how long roughly does it take for free charge to dissipate ($t \sim \varepsilon_0/\sigma$)?

A. 10^{-19} s
B. 10^{-12} s
C. 10^{-8} s
D. 10^{12} s
E. Something else

Given our estimates of collision times (10^{-14} s), for what kinds of light is our analysis not so great for?

A. X-Rays ($\sim 10^{18}$ Hz)
B. Visible light ($\sim 10^{15}$ Hz)
C. IR ($\sim 10^{13}$ Hz)
D. Radio ($\sim 10^{8}$ Hz)
E. More than one of these

What does this ansatz attempt (i.e., using $\sim e^{(kz - i\omega t)}$) remind you for this?

A. Solving the simple harmonic oscillator

B. Solving the damped harmonic oscillator

C. Solving the driven harmonic oscillator

D. Some other set up

With the proposed solution, $\widetilde{\mathbf{E}} = \widetilde{\mathbf{E}}_0 e^{i(kz-\omega t)}$, what equation does k satisfy?

Think about the wave equation: $\nabla^2 \mathbf{E} = \mu\sigma \frac{\partial \mathbf{E}}{\partial t} + \mu\varepsilon \frac{\partial^2 \mathbf{E}}{\partial t^2}$

A. $k^2 = i\omega\mu\sigma + \omega^2\sigma\varepsilon$
B. $k^2 = \omega\mu\sigma + i\omega^2\sigma\varepsilon$
C. $k = \omega\mu\sigma + i\omega^2\sigma\varepsilon$
D. $k = i\omega\mu\sigma + \omega^2\sigma\varepsilon$
E. Something else

What is the $\sqrt{i}$?

A. -i

B. $\frac{1+i}{\sqrt{2}}$

C. -1

D. $e^{i\pi/4}$

E. None or more than one of these

An EM wave passes from air to metal, what happens to the wave in the metal?

A. It will be amplified because of free electrons
B. It will die out over some distance
C. It will be blocked right at the interface because there's no E field in a metal
D. Not sure

We found a traveling wave solution for the conductor situation,

$$\widetilde{\mathbf{E}}(\mathbf{r}, t) = \widetilde{\mathbf{E}}_0 e^{i(\widetilde{k}z - \omega t)}$$

where $\widetilde{k} = \omega^2 \mu \varepsilon + i(\omega \mu \sigma)$

True (A) or False (B): This traveling wave is transverse.

(C) I'm not sure.

The magnetic field amplitude in a metal associated with a linearly polarized electric EM wave is:

$$\widetilde{B}_0 = \left(\frac{k_R + i k_I}{\omega} \right) \widetilde{E}_0$$

True (A) or False (B): The B field is in phase with the E field.

(C) It depends!

The magnetic field amplitude in a highly conductive metal ($\sigma \gg \varepsilon\omega$) associated with a linearly polarized electric EM wave is

$$\widetilde{B}_0 = \sqrt{\frac{\mu\sigma}{\omega}} \frac{1+i}{\sqrt{2}} \widetilde{E}_0$$

$$\widetilde{B}_0 = \sqrt{\frac{\sigma}{\varepsilon_0\omega}} \frac{1+i}{\sqrt{2}} \frac{\widetilde{E}_0}{c}$$

True (A) or False (B): The B field is in phase with the E field.

(C) It depends!

Fourier tells us that we can write a "pulse" by summing up sinusoidal functions:

$$f(x) = \int_{-\infty}^{\infty} a(k)e^{ikx}dk$$

If we were to compute $f(x) = \int_{-\infty}^{\infty} a(k)e^{ik(x-vt)}dk$ where v is a known constant, what would we get?

A. $f(x)$
B. $f(vt)$
C. $f(x - vt)$
D. Something complicated!
E. ???

ANNOUNCEMENTS

- HW 11 is posted
  - Looks long, but 2 questions are roughly the same...
- Graded HW 9, Quiz 5, and HW 10 will be returned Wednesday; sorry!

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Fourier tells us that we can write a "pulse" by summing up sinusoidal functions:

$$f(x) = \int_{-\infty}^{\infty} a(k) e^{ikx} dk$$

If we were to compute $f(x) = \int_{-\infty}^{\infty} a(k) e^{ik(x - v(k)t)} dk$ where $v(k)$ is function, what would we get?

A. $f(x)$
B. $f(vt)$
C. $f(x - vt)$
D. Something more complicated!
E. ???