You have this solution to Maxwell's equations in vacuum:

$$\widetilde{\mathbf{E}}(x, y, z, t) = \widetilde{\mathbf{E}}_0 \exp[i(\mathbf{k} \cdot \mathbf{r} - \omega t)]$$

If this wave travels in the y direction, is polarized in the x direction, and has a complex phase of 0, what is the x component of the physical wave?

A. $E_x = E_0 \, cos\,(kx - \omega t)$
B. $E_x = E_0 \, cos\,(ky - \omega t)$
C. $E_x = E_0 \, cos\,(kz - \omega t)$
D. $E_x = E_0 \, cos\left(k_x x + k_y y - \omega t\right)$
E. Something else

An electromagnetic plane wave propagates to the right. Four vertical antennas are labeled 1-4. 1, 2, and 3 lie in the $x - y$ plane. 1, 2, and 4 have the same x-coordinate, but antenna 4 is located further out in the z-direction. Rank the time-averaged signals received by each antenna.

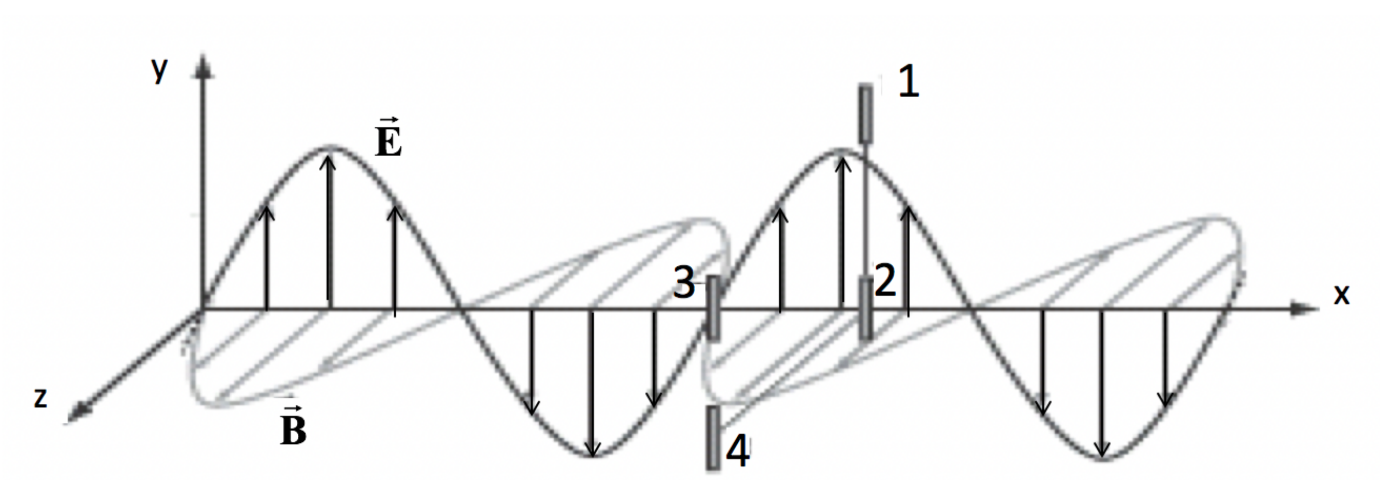
A. 1=2=3>4

B. 3>2>1=4

C. 1=2=4>3

D. 1=2=3=4

E. 3>1=2=4



A point source of radiation emits power P_0 isotropically (uniformly in all directions). A detector of area a_d is located a distance R away from the source. What is the power P_d received by the detector?

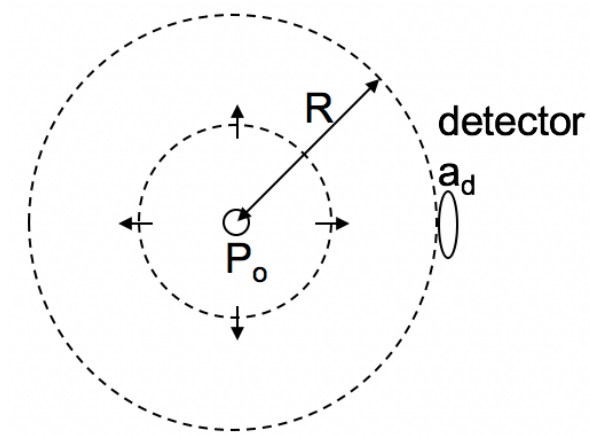
A. $\frac{P_0}{4\pi R^2} a_d$

B. $P_0 \frac{a_d^2}{R^2}$

C. $P_0 \frac{a_d}{R}$

D. $\frac{P_0}{\pi R^2} a_d$

E. None of these



The electric fields of two EM waves in vacuum are both described by:

$$\mathbf{E} = E_0 \sin(kx - \omega t)\hat{y}$$

The "wave number" k of wave 1 is larger than that of wave 2, $k_1 > k_2$. Which wave has the larger frequency f?

A. Wave 1
B. Wave 2
C. impossible to tell

For a wave on a 1d string that hits a boundary between 2 strings of different material we get,

$$\widetilde{f}(z<0) = \widetilde{A}_I e^{i(k_1)z-\omega t} + \widetilde{A}_R e^{i(-k_1 z-\omega t)}$$
$$\widetilde{f}(z>0) = \widetilde{A}_T e^{i(k_2)z-\omega t}$$

where continuity (BCs) give,

$$\widetilde{A}_R = \left(\frac{k_1 - k_2}{k_1 + k_2}\right)\widetilde{A}_I$$
$$\widetilde{A}_T = \left(\frac{2k_1}{k_1 + k_2}\right)\widetilde{A}_I$$

Is the transmitted wave in phase with the incident wave?

A) Yes, always B) No, never C) Depends

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Is the reflected wave in phase with the incident wave?

A) Yes, always B) No, never C) Depends

In matter we have,

$$\nabla \cdot \mathbf{D} = \rho_f \qquad \nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \qquad \nabla \times \mathbf{H} = \mathbf{J}_f + \frac{\partial \mathbf{D}}{\partial t}$$

with

$$\mathbf{D} = \varepsilon_0 \mathbf{E} + \mathbf{P} \qquad \mathbf{H} = \mathbf{B}/\mu_0 - \mathbf{M}$$

If there are no free charges or current, is $\nabla \cdot \mathbf{E} = 0$?

A. Yes, always

B. Yes, under certain conditions (what are they?)

C. No, in general this will not be true

D. ??

In linear dielectrics, $\mathbf{D} = \varepsilon_0 \mathbf{E} + \mathbf{P} = \varepsilon \mathbf{E}$. In a linear dielectric is $\varepsilon > \varepsilon_0$?

A. Yes, always

B. No, never

C. Sometimes, it depends on the details of the dielectric.

In a non-magnetic, linear dielectric,

$$v = \frac{1}{\sqrt{\mu\varepsilon}} = \frac{1}{\sqrt{\mu\varepsilon_r\varepsilon_0}} = \frac{c}{\sqrt{\varepsilon_r}}$$

How does v compare to c?

A. $v > c$ always

B. $v < c$ always

C. It depends