

## Chapter 25: Electromagnetic Waves

6. The figure shows the direction of propagation, direction of the electric field, and/or the direction of the magnetic field for four electromagnetic waves.

TABLE 25-2 Problem 6

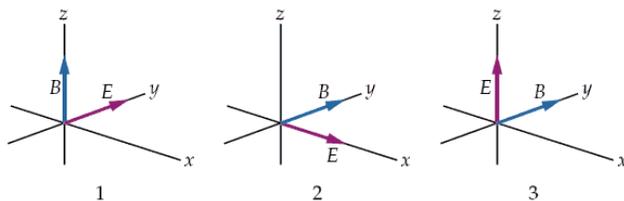
Direction of propagation	Direction of electric field	Direction of magnetic field
+x	+y	(a)
+x	(b)	+y
-y	+z	(c)
(d)	+z	+y

For each of the waves use the Right-Hand Rule to determine the missing information. Point the fingers of your right hand in the direction of the electric field, bend them in the direction of the magnetic field, and then your thumb will point in the direction of the wave propagation. If the electric field or magnetic field is unknown, guess the direction to see if your thumb points in the correct direction of propagation.

1. (a) The magnetic field points in the  $\boxed{+z}$  direction.
2. (b) The electric field points in the  $\boxed{-z}$  direction.
3. (c) The magnetic field points in the  $\boxed{-x}$  direction.
4. (d) The wave propagates in the  $\boxed{-x}$  direction.

9. The figure at the right shows three electromagnetic waves with various orientations.

The propagation direction is the same as the direction of  $\vec{E} \times \vec{B}$ . Use the Right-Hand Rule to determine the directions of propagation.



To find the direction of propagation of an E&M wave, point the fingers of the right hand in the direction of the electric field, curl them toward the direction of the magnetic field, and your thumb will point in the direction of propagation. Applying this rule, we find the following directions of propagation:  $\boxed{\text{case 1, positive } x \text{ direction; case 2, positive } z \text{ direction; case 3, negative } x \text{ direction.}}$

27. Dental X-rays have a wavelength of 0.30 nm.

Solve equation 25-4 for the frequency.

Calculate the frequency:

$$f = \frac{c}{\lambda} = \frac{3.00 \times 10^8 \text{ m/s}}{0.30 \times 10^{-9} \text{ m}} = \boxed{1.0 \times 10^{18} \text{ Hz}}$$

- $\boxed{35.}$  As a wave enters a medium in which the speed of light decreases, the frequency remains constant, but the wavelength changes.

Use equation 25-4 to write a ratio of the new wavelength in terms of the initial wavelength.

1. (a) The wavelength of an electromagnetic wave is directly proportional to its speed. Therefore, if the wave speed decreases, the wavelength will  $\boxed{\text{decrease.}}$

2. (b) Write a ratio using equation 25-4:

$$\frac{\lambda'}{\lambda} = \frac{\frac{3}{4}c/f}{c/f} = \boxed{\frac{3}{4}}$$

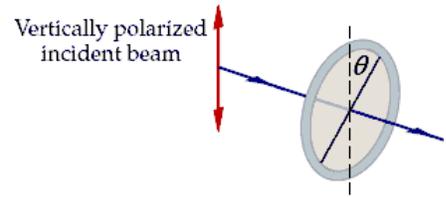
72. Vertically polarized light with intensity  $0.55 \text{ W/m}^2$  passes through a polarizer oriented  $\theta = 65.0^\circ$  from the vertical.

Calculate the intensity using Malus' Law (equation 25-13).

Determine the intensity:

$$I = I_0 \cos^2 \theta$$

$$= (0.55 \text{ W/m}^2) \cos^2 65.0^\circ = \boxed{0.098 \text{ W/m}^2}$$



74. The image shows unpolarized light incident upon two polarizers, the transmission axes of which are oriented at some angle with respect to each other.

Set the intensity after the first polarizer equal to half the intensity before (equation 25-14). Use Malus' Law (equation 25-13) to calculate the intensity after the second polarizer. Divide the result by the initial intensity to determine the relative intensity.

1. Calculate the intensity after the first polarizer:

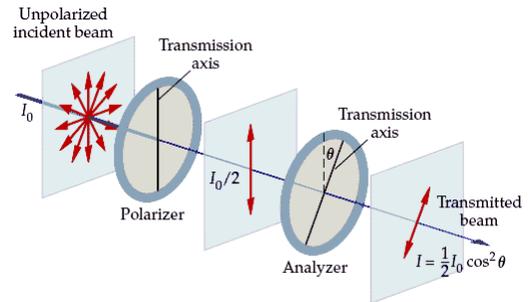
$$I_1 = \frac{1}{2} I_0$$

2. Calculate the intensity after the second polarizer:

$$I_2 = I_1 \cos^2 \theta = \frac{1}{2} I_0 \cos^2 \theta$$

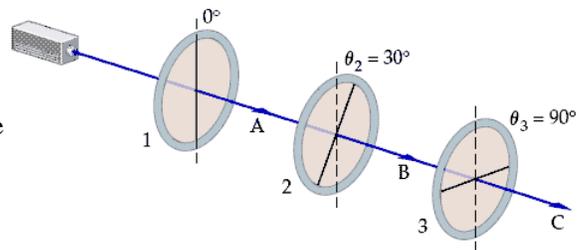
3. Divide the final intensity by the initial:

$$\frac{I_2}{I_0} = \frac{1}{2} \cos^2 30.0^\circ = \boxed{0.375}$$



80. The image shows unpolarized laser light passing through three polarizers.

Use equation 25-14 to calculate the intensity after the first polarizer. Then use Malus' Law (equation 25-13) to calculate the intensity as the light passes through each of the other polarizers.



1. (a) Use equation 25-14 to calculate  $I$  at point A:

$$I = \boxed{\frac{1}{2} I_0}$$

2. (b) Use Malus' Law to calculate the intensity at point B:

$$I = \left(\frac{1}{2} I_0\right) \cos^2 30.0^\circ = \boxed{0.375 I_0}$$

3. (c) Use Malus' Law to calculate the intensity at point C:

$$I = (0.375 I_0) \cos^2 (90.0^\circ - 30.0^\circ) = \boxed{0.0938 I_0}$$

4. (d) Use Malus' Law to calculate the intensity at point C, with the second polarizer removed:

$$I = \left(\frac{1}{2} I_0\right) \cos^2 90.0^\circ = \boxed{0}$$