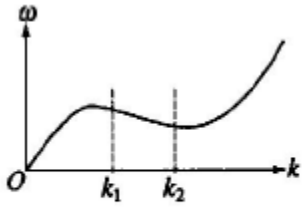
Problem 1:



The dispersion curve shown above relates the angular frequency ω to the wave number k. For waves with wave numbers lying in the range $k_1 < k < k_2$, which of the following is true of the phase velocity and the group velocity?

(A) They are in opposite directions.
(B) They are in the same direction and the phase velocity is larger.
(C) They are in the same direction and the group velocity is larger.
(D) The phase velocity is infinite and the group velocity is finite.
(E) They are the same in direction and magnitude.

Problem 2:

The dispersion law for a certain type of wave motion is $\omega = (c^2k^2 + m^2)^{\frac{1}{2}}$, where ω is the angular frequency, k is the magnitude of the propagation vector, and c and m are constants. The group velocity of these waves approaches

(A) infinity as $k \to 0$ and zero as $k \to \infty$
(B) infinity as $k \to 0$ and c as $k \to \infty$
(C) c as $k \to 0$ and zero as $k \to \infty$
(D) zero as $k \to 0$ and infinity as $k \to \infty$
(E) zero as $k \to 0$ and c as $k \to \infty$

Problem 3:

The Lyman alpha spectral line of hydrogen (λ = 122 nanometers) differs by 1.8×10^{-12} meter in spectra taken at opposite ends of the Sun's equator. What is the speed of a particle on the equator due to the Sun's rotation, in kilometers per second?

(A) 0.22
(B) 2.2
(C) 22
(D) 220
(E) 2200

Problem 4:

A plane electromagnetic wave is a superposition of two independent, orthogonal plane waves and can be written as the real part of
$\mathbf{E} = \hat{\mathbf{x}}E_1 \exp(\mathrm{i}[kz - \omega t]) + \hat{\mathbf{y}}E_2 \exp(\mathrm{i}[kz - \omega t + \pi])$,
where k, ω, E_1, and E_2 are real.

If $E_2 = E_1$, the tip of the electric field vector will describe a trajectory that, as viewed along the z-axis from positive z and looking toward the origin, is a

(A) line at 45° to the + x-axis
(B) line at 135° to the + x-axis
(C) clockwise circle
(D) counterclockwise circle
(E) random path

Problem 5:

A plane electromagnetic wave is a superposition of two independent, orthogonal plane waves and can be written as the real part of
$\mathbf{E} = \hat{\mathbf{x}}E_1 \exp(\mathrm{i}[kz - \omega t]) + \hat{\mathbf{y}}E_2 \exp(\mathrm{i}[kz - \omega t + \pi])$,
where k, ω, E_1, and E_2 are real.

If the plane wave is split and recombined on a screen after the two portions, which are polarized in the x- and y-directions, have traveled an optical path difference of $2\pi/k$, the observed average intensity will be proportional to

(A) $E_1^2 + E_2^2$
(B) $E_1^2 - E_2^2$
(C) $(E_1 + E_2)^2$
(D) $(E_1 - E_2)^2$
(E) 0

Problem 6:

Waves on a string propagate with a speed v and are represented by giving the displacement y as a function of x and t. Which of the following is NOT a possible wave or pulse? (c, b, and k are constants.)

(A) $y = ac^{-b(x-vt)^2}$
(B) $y = ac^{-b(x-vt)^2} \sin k(x+vt)$
(C) $y = a\cos k(x-vt)$
(D) $y = ae^{-bx^2}e^{-b(vt)^2}$
(E) $y = a/\cosh b(x-vt)$

Problem 7:

A converging lens of focal length 4 centimeters is used as a magnifier. If an object is place 3 centimeters from the lens,what is the magnification?

(A) 3 (B) 4 (C) 6 (D) 12 (E) 24