Problem 1:

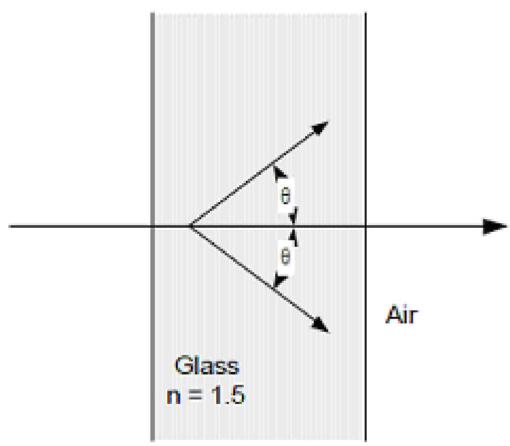
Let $\hat{x}$, $\hat{y}$, and $\hat{z}$ be three orthogonal unit vectors. The expression

$$u(r,t) = 2(\hat{x} - \hat{y})\exp\{i(6\hat{z}\cdot\vec{r} + 3t)\}$$

represents a traveling wave that is

(A) transversely polarized and propagating in the negative z direction
(B) transversely polarized and propagating in the positive z direction
(C) circularly polarized and propagating in the negative z direction
(D) circularly polarized and propagating in the positive z direction
(E) longitudinally polarized and propagating in the $\hat{x} - \hat{y}$ direction

Problem 2:




A Fast charged particle passes perpendicularly through a thin glass sheet of index of refraction 1.5. The cone of Cerenkov light, emitted in the glass at angle θ, is incident on the glass-air interface at the critical angle for total reflection. The speed of the particle is

(A) $\frac{2}{3}c$

(B) $\frac{4}{5}c$

(C) $\sqrt{\frac{5}{9}}c$

(D) $\sqrt{\frac{2}{3}}c$

(E) $\sqrt{\frac{4}{5}}c$

Problem 3:

During a hurricane, a 1,200 Hz warning siren on the town hall sounds. The wind is blowing at 55 m/s in a direction from the siren toward a person 1 km away. With what frequency does the sound wave reach the person? (The speed of sound in air is 330 m/s.)

(A) 1,000 Hz
(B) 1,030 Hz
(C) 1,200 Hz
(D) 1,400 Hz
(E) 1,440 Hz

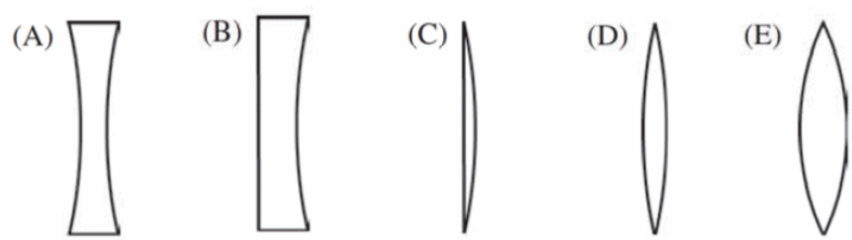
Problem 4:

A uniform thin film of soapy water with index of refraction $n = 1.33$ is viewed in air via reflected light. The film appears dark for long wavelengths and first appears bright for $\lambda = 540$ nm. What is the next shorter wavelength at which the film will appear bright on reflection?

(A) 135 nm
(B) 180 nm
(C) 270 nm
(D) 320 nm
(E) 405 nm

Problem 5:

If the five lenses shown below are made of the same material, which lens has the shortest positive focal length?




Problem 6:

Sound waves moving at 350 m/s diffract out of a speaker enclosure with an opening that is a long rectangular slit 0.14 m across. At about what frequency will the sound first disappear at an angle of 45° from the normal to the speaker face?

(A) 500 Hz
(B) 1,750 Hz
(C) 2,750 Hz
(D) 3,500 Hz
(E) 5,000 Hz

Problem 7:

In a hologram a photographic plate contains a wave pattern that produces a three-dimensional picture when illuminated with monochromatic coherent light from a laser. When only half of the photographic plate is illuminated, which of the following is true of the resulting picture?

(A) Only half of the picture is seen.

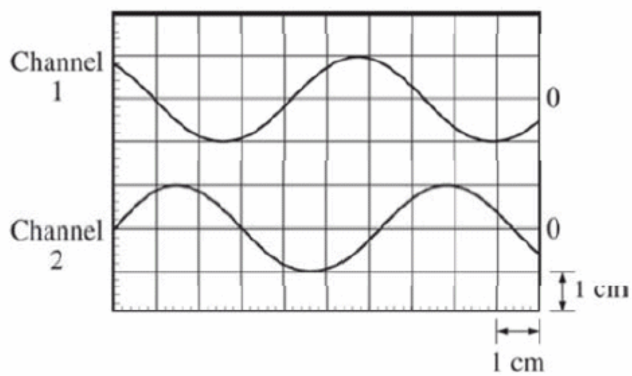
(B) The picture is still seen, but is less distinct than before.

(C) The picture is still seen, but is smaller than before.

(D) The color of the picture is changed.

(E) The picture is inverted.

Problem 8:




Two sinusoidal waveforms of the same frequency are displayed on an oscilloscope screen, as indicated above. The horizontal sweep of the oscilloscope is set to 100 ns/cm and the vertical gains of channels 1 and 2 are each set to 2 V/cm. The zero-voltage level of each channel is given at the right in the figure. The phase difference between the two waveforms is most nearly

(A) 30°

(B) 45°

(C) 60°

(D) 90°

(E) 120°

Problem 9:

Consider two slits of width w separated by a distance d.

If the width of one slit is reduced to $\frac{w}{2}$, what happens to the interference pattern of the light from the two slits?

(A) It remains the same except that it has lower intensity.

(B) It remains the same except that it is displaced.

(C) It still has intensity $I_0$ at $\theta = 0$.

(D) It no longer has minima with zero intensity.

(E) It has zero intensity at $\theta = 0$.

Problem 10:

The angular separation of the two components of a double star is 8 microradians, and the light from the double star has a wavelength of 5500 angstroms. The smallest diameter of a telescope mirror that will resolve the double star is most nearly

(A) 1 mm

(B) 1 cm

(C) 10 cm

(D) 1 m

(E) 100 m

Problem 11:

Unpolarized light is incident on a pair of ideal linear polarizers whose transmission axes make an angle of 45° with each other. The transmitted light intensity through both polarizers is what percentage of the incident intensity?

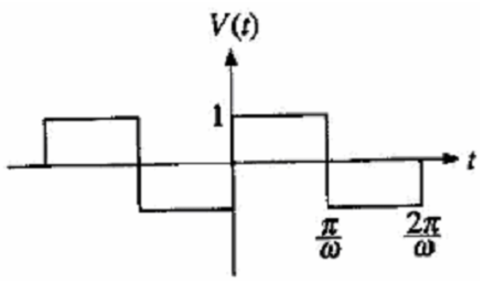
(A) 100%
(B) 75%
(C) 50%
(D) 25%
(E) 0%

Problem 12:

A rocket ship is moving away from Earth at a high speed. A spectral line from a source on the rocket ship is shifted from a wavelength λ to a wavelength 4λ for an observer on Earth. If c is the speed of light and the shift is assumed to be due to the relativistic Doppler effect, the velocity of the rocket ship relative to Earth is most nearly

(A) $\frac{1}{4}c$ (B) $\frac{2}{5}c$ (C) $\frac{1}{2}c$ (D) $\frac{3}{5}c$ (E) $\frac{15}{17}c$

Problem 13:




If $n$ is an integer ranging from 1 to infinity, $\omega$ is an angular frequency, and $t$ is time, then the Fourier series for a square wave, as shown above, is given by which of the following?

(A) $V(t) = \frac{4}{\pi}\sum_{1}^{\infty}\frac{1}{n}\sin(n\omega t)$

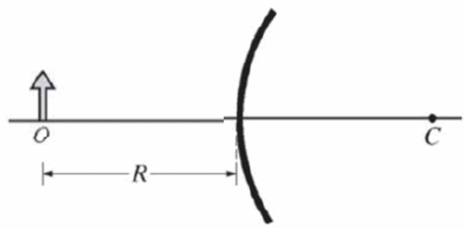
(B) $V(t) = \frac{4}{\pi}\sum_{0}^{\infty}\frac{1}{(2n+1)}\sin((2n+1)\omega t)$

(C) $V(t) = \frac{4}{\pi}\sum_{1}^{\infty}\frac{1}{n}\cos(n\omega t)$

(D) $V(t) = \frac{4}{\pi}\sum_{0}^{\infty}\frac{1}{(2n+1)}\cos((2n+1)\omega t)$

(E) $V(t) = -\frac{4}{\pi} + \frac{4}{\pi}\sum_{1}^{\infty}\frac{1}{n^2}\cos(n\omega t)$

Problem 14:




The figure above shows an object $O$ placed at a distance $R$ to the left of a convex spherical mirror that has a radius of curvature $R$. Point $C$ is the center of curvature of the mirror. The image formed by the mirror is at

(A) infinity

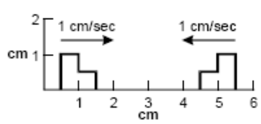
(B) a distance $R$ to the left of the mirror and inverted

(C) a distance $R$ to the right of the mirror and upright

(D) a distance $\frac{R}{3}$ to the left of the mirror and inverted

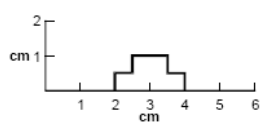
(E) a distance $\frac{R}{3}$ to the right of the mirror and upright

Problem 15:

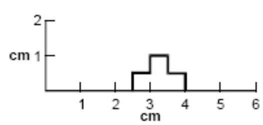



The diagram shows two wave pulses on a string. The wave pulses are traveling toward each other at 1 cm/sec. What does the wave pulse look like 2 seconds later?

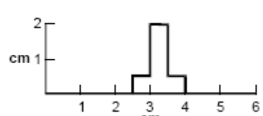
A.



B.



C.



D.