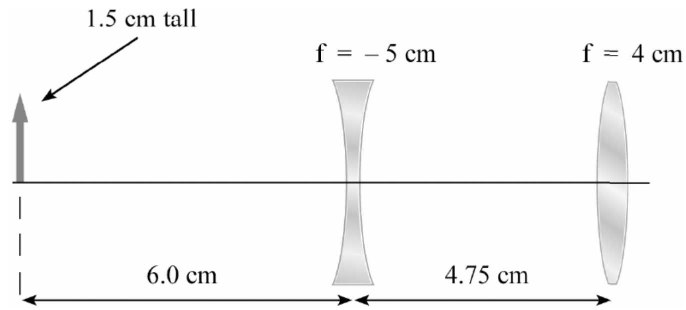
Sample Midterm Questions, Phyx 130-3, Summer 2009

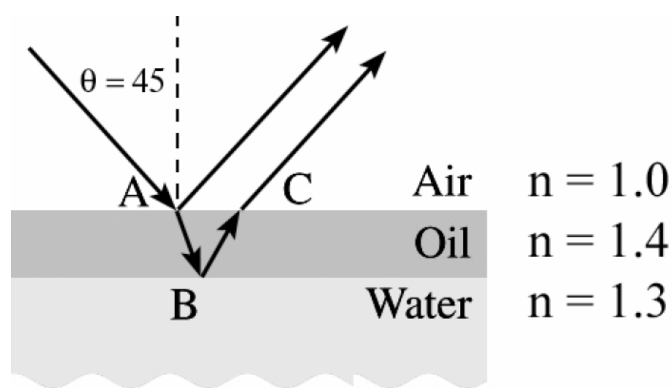
1) You are fiddling with some lenses in the physics laboratory. You place a concave lens 6.0 cm from a 1.5 cm tall object as shown below, and then you place a convex lens 4.75 cm behind the first lens. The two lenses have focal lengths of –5 cm and 4 cm, respectively.



a) Where is the image of the object (upright arrow) after the light has passed through both lenses? Give your answer in terms of cm from the upright arrow.
b) What is the size and orientation of the image, after the light has passed through both lenses?

2) You are repairing an old church organ. One of the organ pipes is closed at one end and open at the other, is 45 cm long, and when played produces a note that has a frequency of 571.7 Hz.
a) What is the wavelength of this note?
b) When this note is playing, how many nodes are there inside the pipe?
c) What is the lowest possible frequency note that this tube can produce?

3) After a rainfall, the grimy oil slicks floating on puddles of water often show irridescent colors. Suppose we have the situation at right, where an oil film is floating on water. (The index of refraction for each layer is shown beside it.)



Yes or No for parts a to d
Does the light undergo a phase inversion as it:
a) Travels from point A to point B?
b) Is reflected from the oil at point A?
c) Travels from point B to point C?
d) Is reflected from the water at point B?

e) If an incoming ray of light at point A makes a 45° angle with the normal to the oil surface, as shown in the figure, what angle does the light make with the normal to the water surface at point B?

f) My laser pointer has a wavelength of 532 nanometers. What is the thinnest possible oil slick which could completely cancel it out (total destructive interference)?

Multiple Choice
4) A sound with an intensity of 40 decibels is:
A) 20 times as intense as a sound of 20 decibels
B) four times as intense as a sound of 20 decibels
C) twice as intense as a sound of 20 decibels
D) 100 times as intense as a sound of 20 decibels
E) 10 times as intense as a sound of 20 decibels
F) 1000 times as intense as a sound of 20 decibels

5) In an electromagnetic wave, the **E** and **B** fields are oriented such that:
A) they are parallel to one another and perpendicular to the direction of wave propagation
B) they are parallel to one another and parallel to the direction of wave propagation
C) they are perpendicular to one another and perpendicular to the direction of wave propagation
D) they are perpendicular to one another and parallel to the direction of wave propagation
E) they are oriented at 45° to each other and perpendicular to the direction of wave propagation
F) none of the above

6) Which of the following gives the correct order of electromagnetic waves from longer to shorter l?
A) radio waves, infrared, UV, microwaves, visible, X-rays, gamma rays
B) radio waves, UV, X-rays, microwaves, infrared, visible, gamma rays
C) radio waves, microwaves, visible, X-rays, infrared, UV, gamma rays
D) radio waves, microwaves, infrared, visible, gamma rays, X-rays, UV
E) radio waves, infrared, X-rays, microwaves, UV, visible, gamma rays
F) none of the above

7) The transverse nature of electromagnetic waves is best proven by the fact that:
A) they are electric in nature
B) they are magnetic in nature
C) they can be polarized
D) they move faster than sound
E) they can move through a vacuum
F) they can be refracted

8) A vertically polarized beam of light of intensity 100 W/m^2 passes through a polarizer which has its transmission axis oriented 40° to the vertical. What is the transmitted intensity of the beam of light?
A) 100 W/m^2 B) 0 W/m^2 C) 25 W/m^2 D) 44.4 W/m^2 E) 58.7 W/m^2 F) 76.6 W/m^2

9) The image formed in a plane mirror is:
A) at the same distance behind the mirror as the object is in front of the mirror
B) at the same distance in front of the mirror as the object is in front of the mirror
C) at a shorter distance in front of the mirror than the the object is in front of the mirror
D) at a longer distance behind the mirror than the object is in front of the mirror
E) at a shorter distance behind the mirror than the object is in front of the mirror
F) at a longer distance in front of the mirror than the object is in front of the mirror

10) Which of the following statements is true?
A) spherical lenses and spherical mirrors both suffer from both spherical and chromatic aberration
B) spherical lenses suffer from spherical aberration, but spherical mirrors do not
C) spherical mirrors suffer from spherical aberration, but spherical lenses do not
D) spherical lenses suffer from chromatic aberration, but spherical mirrors do not
E) spherical mirrors suffer from chromatic aberration but not spherical aberration
F) neither spherical lenses or spherical mirrors suffer from chromatic aberration

11) If the distance between the slits in a double-slit diffraction experiment is decreased, which of the following statements about the interference pattern is true?
A) the angular distance between the maxima stays the same
B) the answer depends on how far away the screen is
C) the brightness of the maxima increases
D) the question cannot be answered without knowing the wavelength of the light
E) the angular distance between the maxima decreases
F) the angular distance between the maxima increases

12) An astronomer is using a telescope whose primary lens has a diameter of 5.60 m. What is the minimum angle of resolution for this telescope at a wavelength of 620 nm?
A) 1.11×10^{-7} rad
B) 3.11×10^{-7} rad
C) 1.35×10^{-7} rad
D) 2.70×10^{-7} rad
E) 4.05×10^{-7} rad
F) 2.53×10^{-7} rad

13) Polarized light is:
A) brand name for the light used to develop Polaroid film
B) light emitted by a household light bulb
C) light where the electric fields of the waves are aligned
D) light that has passed through glass
E) light that is aligned with the Earth's magnetic field
F) none of the above

Solutions

1a) First we need to find where the image due to the first lens is. We have: $1/d_O + 1/d_I = 1/f$, where $d_O = 6$ cm and $f = -5$ cm. Inserting the numbers: $1/d_I = -{}^1/_5 - {}^1/_6 = -{}^{11}/_{30}$, or $dI = -2.73$ cm. The image is 2.73 cm to the *left* of the concave lens. Next, we use this image as the object of the convex lens. We again use the lens equation, this time with $d_O = 2.73 + 4.75 = 7.48$ cm, and $f = 4$ cm. Inserting the numbers: $1/d_I = {}^1/_4 - {}^1/_{7.48}$, or $dI = 8.6$ cm. The image is 8.6 cm to the *right* of the convex lens. Thus, the distance from the object to the final image is: $d = 6 + 4.75 + 8.6 = 19.35$ cm. (The lenses are acting like a projector.)

1b) $m = -d_I / d_O$. Looking at the numbers from part (a), the magnification of the first lens is: $m = -(-2.73) / 6 = 0.455$, and that of the second lens is: $m = -(8.6) / (7.48) = -1.15$ The magnification of both lenses is the product of their individual magnifications, so overall we have: $m = (0.455)(-1.15) = -0.523$ The image is thus $(0.523)(1.5) = 0.78$ cm tall, and is inverted (because m is negative).

2a) We have: $v = f\lambda$, where $v = 343$ m/s for sound and $f = 571.7$ Hz. This yields: $\lambda = 343 / 571.7 = 60$ cm

2b) The organ pipe is 45 cm long, so 45/60 = 3/4 of one λ of the sound is contained inside the pipe. Thus, the node at the start of the wave and the node in the middle of the wave are inside the pipe: we have 2 nodes.

2c) The lowest possible frequency for the pipe corresponds to the longest wavelength it can produce. For a closed end / open end pipe, this happens when the length of the pipe equals $\lambda / 4$. So, $L = \lambda / 4$ means $\lambda = (4)(45) = 180$ cm, which gives us: $f = v / \lambda = 343 / 1.8 = 190.6$ Hz. (Also, since we already know that $3\lambda/4$ corresponds to 571.7 Hz for this pipe, we could just note that $\lambda / 4$ must be $571.7 / 3 = 190.6$ Hz.)

3) Light is only phase-inverted if it is reflected at a boundary where it is moving from a lower to a higher index of refraction. Only reflection at point A satisfies this rule, so the answers are:

a) NO
b) YES
c) NO
d) NO

e) Snell's Law gives us: $n_1\sin\theta_1 = n_2\sin\theta_2$, where we have $n_1 = 1.0$, $n_2 = 1.4$, and $\theta_1 = 45°$. Inserting the numbers: $\sin\theta_2 = \sin(45°) / 1.4 = 0.505$, which gives us $\theta_2 = 30.3°$

f) We can use the formula for destructive interference in a soap film. This is $2nt / \lambda = m$. We have $n = 1.4$, $\lambda = 5.32 \times 10^{-7}$ m, and we set $m = 1$ for the minimum film thickness. $t = \lambda / 2n = 5.32 \times 10^{-7} / 2.8 = 1.9 \times 10^{-7}$ m.

4) D. Each increase of 10 decibels corresponds to multiplying the sound intensity by 10.

5) C

6) F. The correct order is: radio, infrared, microwaves, visible, UV, X-rays, gamma rays

7) C. Longitudinal waves cannot be polarized.

8) E. We have $I = I_0\cos^2\theta = 100\cos^2(40°) = 58.7$ W/m^2

9) A

10) D

11) F

12) C. We use the Rayleigh formula: $\theta_{MIN} = 1.22\,\lambda / D = (1.22)(6.2 \times 10^{-7}) / 5.6 = 1.35 \times 10^{-7}$ rad

13) C