Physics 152
November 19, 2004

Roster No.:_____

Score:_____

Midterm Exam #3, Part A

Exam time limit: 50 minutes. You may use a calculator and both sides of TWO sheets of notes, *handwritten only*. Closed book; no collaboration. For multiple choice questions, circle the letter of the one best answer (unless more than one answer is asked for). Ignore gravity in all problems unless told otherwise, and ignore relativistic effects in non-relativistic problems.

$$c = 2.998 \times 10^8 \text{ m/s}$$

1. (3 pts.) **TRUE or FALSE (T or F)** for EM waves in **empty space** (vacuum):

_____ Orange light has lower frequency than blue light.

_____ Infrared light has longer wavelengths than ultraviolet light.

_____ Microwaves have shorter wavelengths than x-rays.

_____ Ultraviolet light travels faster than violet light.

_____ Electromagnetic waves are transverse waves.

_____ Radio waves, microwaves, and light are electromagnetic waves, but x-rays and gamma rays are not.

2. Crystal-ball gazing is one of the wizarding skills that Harry Potter is taught at Hogwarts School.
a. (1 pt.) Suppose that Harry accidentally looks all the way through the crystal ball at real-life objects on the other side of the ball. **Which kind of lens** will the crystal ball function as? (*Hint:* Think about the curvature of opposite sides of the ball. Which sort of lens does that remind you of?)

A. converging B. diverging

b. (2 pts.) Some lit candles are on the far side of the room, a very long distance from the crystal ball. When Harry looks at them through the center of the crystal ball, how will their **image** appear?

A. upright and real C. inverted and real
B. upright and virtual D. inverted and virtual

c. (2 pts.) A book of spells is just on the other side of the crystal ball from Harry, almost touching the crystal ball. When Harry reads the spells through the center of the crystal ball, he sees that the image is enlarged (magnified). The **image** is also:

A. upright and real C. inverted and real
B. upright and virtual D. inverted and virtual

3. You hold a circular soap film (from a bubble-blowing kit) vertically, causing the film to drain a bit downwards: the upper edge of the soap film becomes vanishingly thin, and the lower edge becomes thicker. When you illuminate it perpendicularly with monochromatic yellow light (λ = 589 nm *in air*) and you look at the light reflected directly back from the soap film (i.e., you are positioned on the *same side* of the film as the light source), you see a pattern of bright and dark fringes. You are told: $n_{film} = 1.33$ and $n_{air} = 1.00$.

a. (2 pts.) The **wavelength** of the yellow light *inside the soap film* is:

A. 295 nm
B. 443 nm
C. 471 nm
D. 503 nm
E. 556 nm
F. 589 nm (the same as in air)

b. (1 pt.) At the top of the film, where its thickness is very nearly *zero*, would you expect to see reflected a **bright or dark** fringe?

A. bright B. dark

c. (2 pts.) If you count a total of 12 bright fringes from the top to the bottom of the soap film, approximately **how thick** is the soap film near the bottom? (*Hint:* Without worrying about every detail, just estimate a rough answer, and choose the closest answer choice.)

A. 2.6 nm
B. 26 nm
C. 260 nm
D. 2.6 μm
E. 260 μm
F. 2.6 mm

4. When the Sun is moderately low in the sky, you see sunlight reflected from the surface of nearby water puddles. Light reflected an angle near Brewster's angle is almost entirely horizontally polarized.

a. (1 pt.) You hold up a **polarizer** so that the reflected light passes through it before reaching your eyes. If the reflected light is indeed horizontally polarized, then which of the following will be **TRUE**? *Choose one:*

A. When the polarizer's axis is *horizontal*, *none* of the reflected light is allowed through the polarizer.
B. When the polarizer's axis is *horizontal*, *all* of the reflected light is allowed through the polarizer.
C. When the polarizer's axis is *vertical*, *none* of the reflected light is allowed through the polarizer.
D. When the polarizer's axis is *vertical*, *all* of the reflected light is allowed through the polarizer.
E. both A and D
F. both B and C

b. (2 pts.) If you turn the polarizer so that its polarization axis is tilted at an angle of 30.° to the horizontal, what fraction of the above light's **intensity** will pass through the polarizer?

A. 50.%
B. 57%
C. 60.%
D. 67%
E. 72%
F. 75%

c. (1 pt.) Suppose that a different light ray traveling parallel to the ground also happens to be **horizontally polarized**. The light has which of the following properties? *Choose one:*

A. an *electric* field that is *horizontal*
B. an *electric* field that is *vertical*
C. a *magnetic* field that is *horizontal*
D. a *magnetic* field that is *vertical*
E. both A and D
F. both B and C

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Midterm Exam #3, Part B

Show your work on all free-response questions. Be sure to use **proper units** and **significant figures** in your final answers.

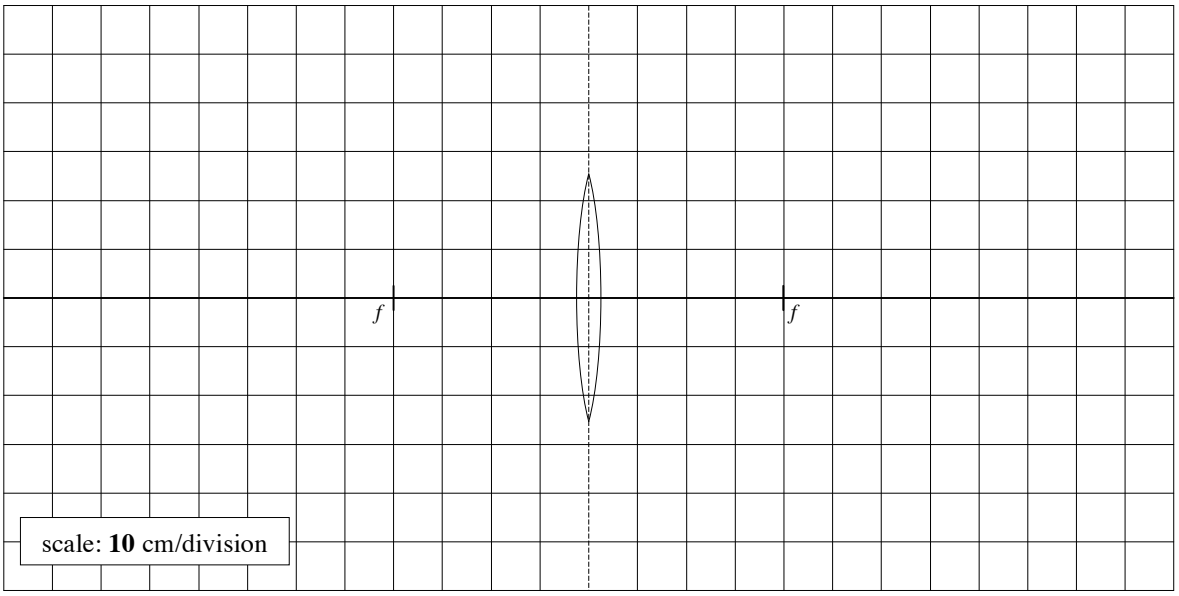
1. You have two lenses at your disposal: a converging lens and a diverging lens, both with 40.0-cm focal lengths.

a. (1 pt.) If you want to create a *real* image of an object, **which lens** must you use?

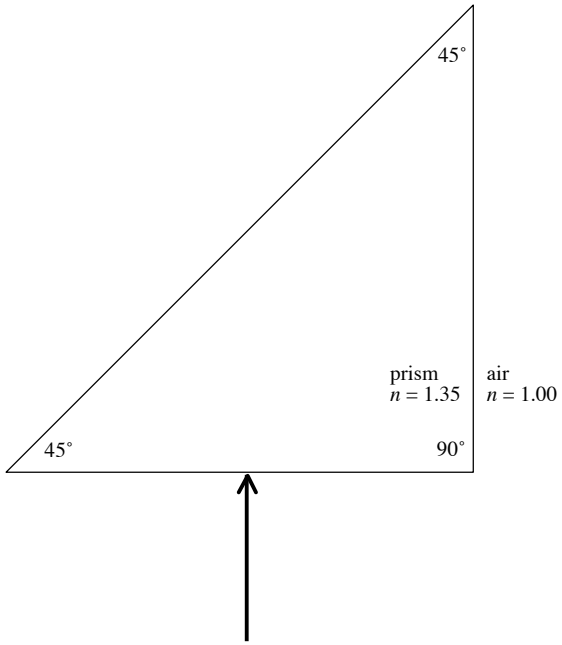
A. converging B. diverging C. either lens can create a real image

b. (6 pts.) Suppose you place a 15.0-cm-tall object 60.0 cm away from the *converging* lens (focal length = 40.0 cm). What is the **magnification** of the image? Show your work, and be sure to use the proper sign in your answer.

c. (4 pts.) **Draw a ray diagram *to scale*** on the graph below for the situation in part (b). Include an **object**, an **image**, and **at least 2 of the 3 principal rays**. Clearly **label** the object and image. *Show rays as solid lines with directional arrowheads on them. If needed, show "tracebacks" as dashed lines.* (Your diagram should agree completely with your values calculated in part (b).) Use a straightedge!



2. The cross-section of a 45°-45°-90° prism is shown at right. A ray of light enters exactly perpendicularly (normally) at the bottom face of the prism, as shown. (Assume 3 significant figures on all values.)



a. (2 pts.) Suppose that the index of refraction of the prism is **1.35**. Carefully **draw the path of the ray** through the prism and back into the air. Use a straightedge! While you do *not* need to measure the angles precisely with a protractor, your angles must be roughly correct. Be sure to continue the final ray some distance back into the air.

b. (4 pts.) Calculate the final **angle of refraction** of the light ray as it emerges from the prism back into the air. Show your work.

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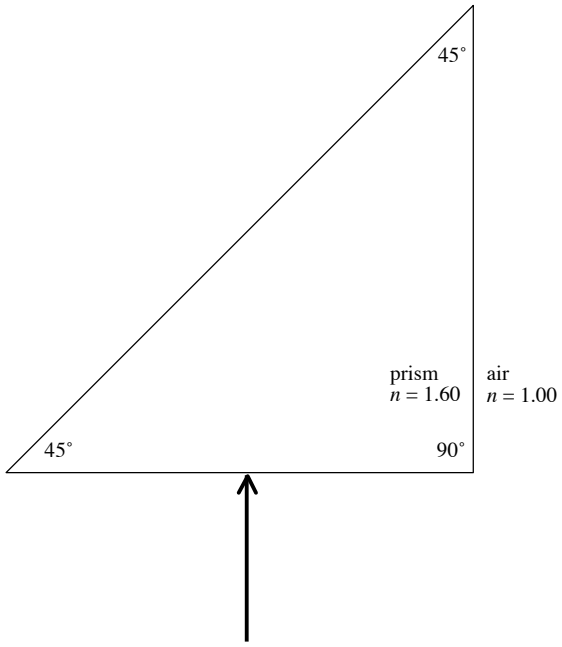
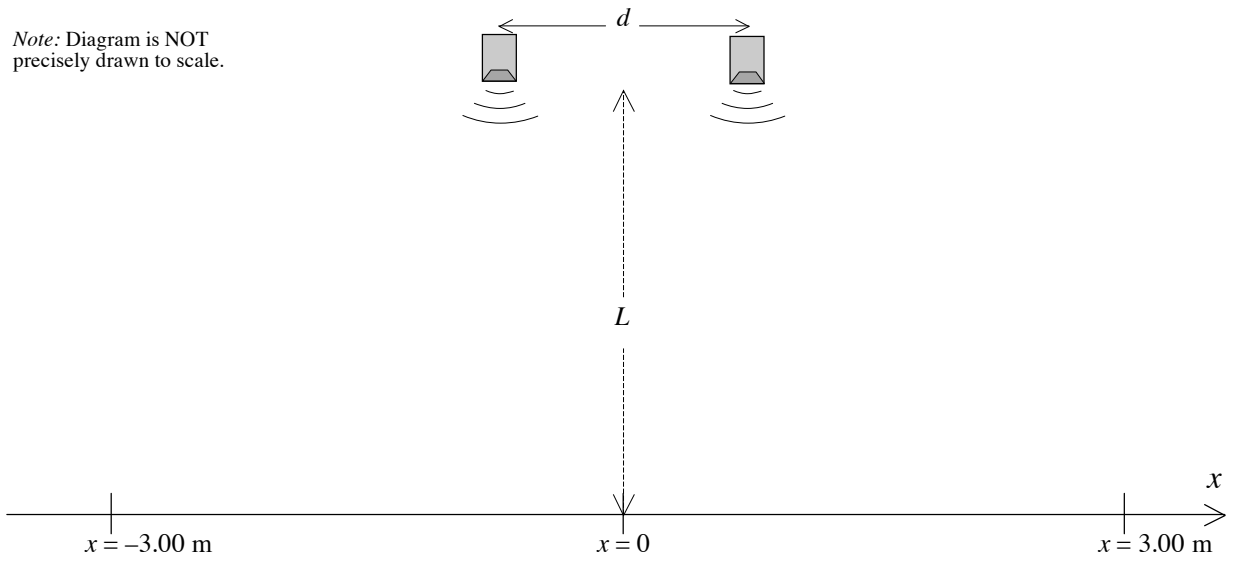
c. (3 pts.) Suppose that the index of refraction of a second identical prism is **1.60**. Calculate the **critical angle** for the prism-air interface in this case. Show your work.



d. (2 pts.) Carefully **draw the path of the ray** through the prism and back into the air. Use a straightedge! While you do *not* need to measure the angles precisely with a protractor, your angles must be roughly correct. Be sure to continue the final ray some distance back into the air.



3. Two loudspeakers simultaneously produce a single tone at 495 Hz, in phase with each other, as shown above.
a. (3 pts.) If the speed of sound is 343 m/s, calculate the **wavelength** of the sound waves. Show your work.

b. (6 pts.) The speakers are separated by d = 1.50 m, and are located L = 3.00 m away from the x-axis. As you move your ear along the x-axis from x = –3.00 m to +3.00 m, at which **three *x*-positions** will you hear *maxima* in the volume of the tone? Show your work, use the above diagram if needed, and explain your reasoning as necessary. (You may use the symmetry of the situation to save work.) *Warning:* Formulas using "small-angle approximations" are NOT valid in this case!

c. (2 pts.) As you move along the x-axis from x = –3.00 to +3.00 m, at **how many positions** will you hear *silence*?

A. none
B. one
C. two
D. three
E. four
F. five