Physics 152 Roster No.:__________________________

Due: Wednesday, November 22, 2006

Score:______________________________

Take-Home Midterm Exam #3, Part A

NO exam time limit. Calculator required. All books and notes allowed, and you may obtain help from others. Complete all of Part A ***AND*** Part B.

For multiple-choice questions, circle the letter of the one best answer (unless more than one answer is asked for). For fill-in-the-blank and multiple-choice questions, do you NOT need to show your work, but include **units**!

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

Ignore friction/air resistance, gravity, and relativistic effects in all problems, unless told otherwise. Assume that all lenses and mirrors are ideally "thin" unless told otherwise.

Physical Constants & Conversions: It's an open-book test, so you can look them up!

1. (4 pts. total; –1 for each error) **TRUE or FALSE (T or F)**:

______ Red light travels slower than blue light in vacuum.

______ Red light travels slower than blue light in most types of glass.

______ Red light has a lower frequency than blue light does in vacuum.

______ X-rays have the shortest wavelengths of any waves in the EM spectrum.

______ Electromagnetic waves are longitudinal waves, like sound waves.

______ As light passes from air into water, its frequency does not change.

______ Electromagnetic waves are dispersive in water.

______ Light striking this sheet of paper undergoes specular reflection.

2. Let I_A be the intensity of plane-polarized light that emerges from polarizer *A*. The light then strikes polarizer *B*, and intensity I_B is successfully transmitted through polarizer *B*. The *same* beam of light then encounters polarizer *C*, and intensity I_C successfully emerges from polarizer *C*. Each polarizer can be rotated so that its axis can form an angle between 0˚ and 90˚ to the axis of the polarizer before it. (You do NOT need to show your work.)

a. (2 pts.) If polarizers *A* and *B* form an angle of 30.0˚ to each other, what is $\boldsymbol{I_B/I_A}$? __________

b. (2 pts.) Suppose polarizers *A* and *B* remain fixed at an angle of 30.0˚ to each other, as above. If I_C/I_A = 25.0%,

what must be the **angle** between **polarizers *B* and *C***? __________

3. a. (2 pts.) At what **distance *s*** from a converging mirror (focal length = 50.0 cm) should you place an object

so that its image has a *magnification* of +2.00? __________

b. (2 pts.) At what **distance *s*'** from the mirror will the **image** in part (a) be located? __________

c. (1 pt.) The **image** in part (a) will be located:

A. on the same side of the mirror as the object

B. on the opposite side of the mirror from the object

d. (1 pt.) The image in part (a) is...

A. upright and real C. inverted and real

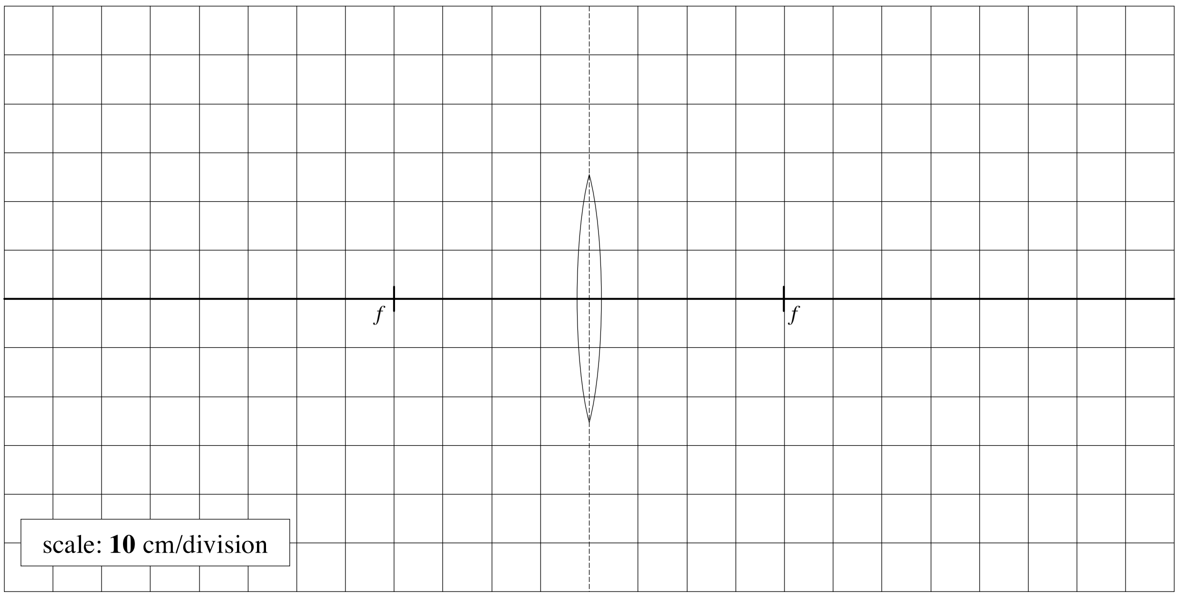
B. upright and virtual D. inverted and virtual

4. a. You place a 20.0-cm-tall object 70.0 cm away from a ***converging*** lens with a 40.0 cm focal length. Using our standard *plus/minus sign conventions*, find the following values. (You do NOT need to show your work.) Don't forget to include *units*!

(4 pts.) What is the **position** of the **image**? ____________ What is the **height** of the **image**? ____________

What is the **magnification** of the **image**? ____________ Is the image **real** or **virtual**? __________

(3 pts.) **Draw a ray diagram *to scale*** on the graph below for this situation. Include an **object**, an **image**, and **all 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 above.) Use a straightedge!

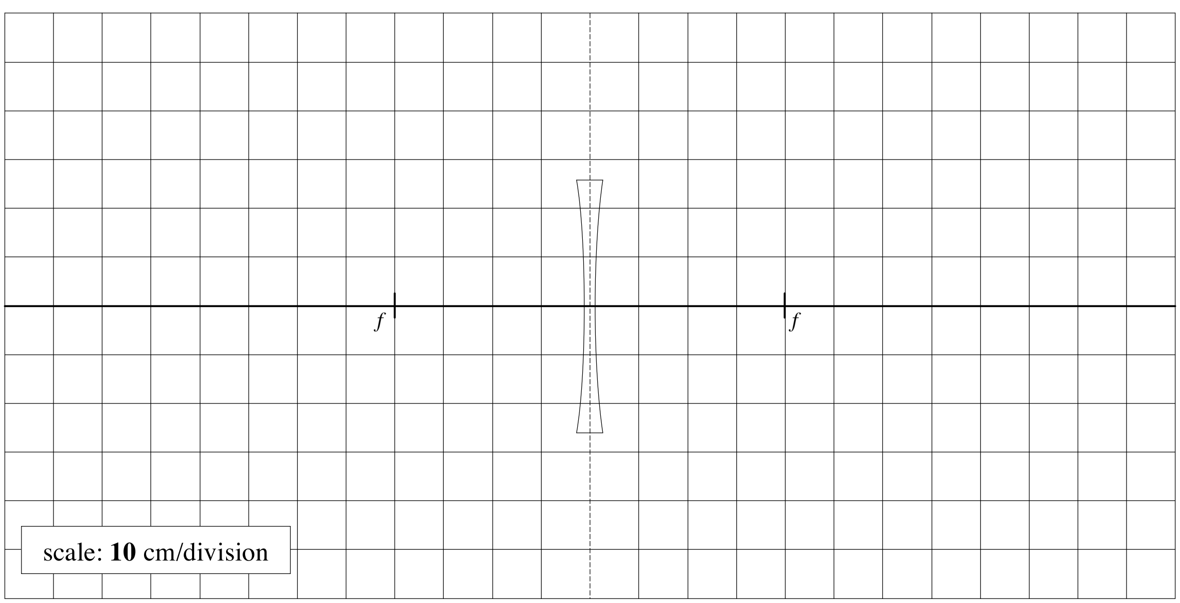


b. You place the same 20.0-cm-tall object 70.0 cm away from a ***diverging*** lens with a 40.0 cm focal length.

(4 pts.) What is the **position** of the **image**? ____________ What is the **height** of the **image**? ____________

What is the **magnification** of the **image**? ____________ Is the image **real** or **virtual**? __________

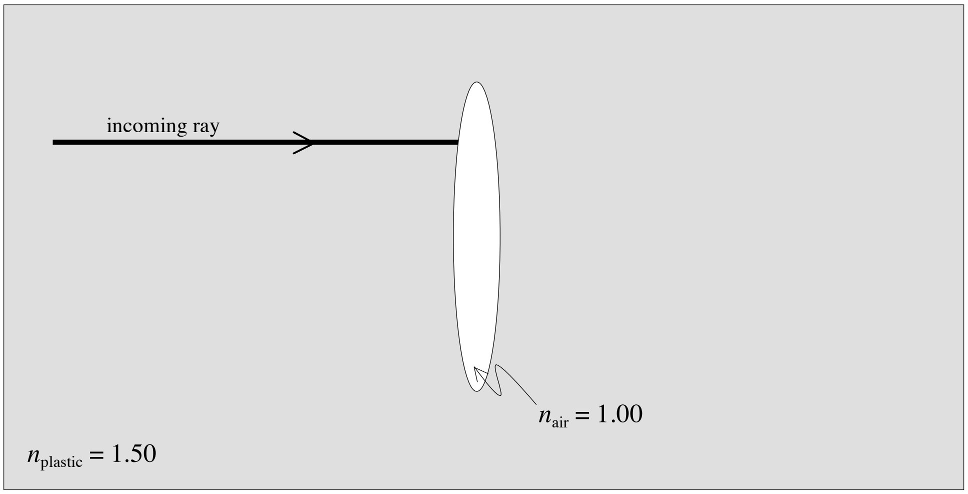
(3 pts.) **Draw a ray diagram *to scale*** on the graph below for this new situation. Same instructions as above.



5. The thin-lens **lensmaker's equation** can be written: $\frac{1}{f} = \left(\frac{n_{\text{lens}}}{n_{\text{surr}}} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$

where: f = focal length of lens (can be + or –)
n_{lens} = index of refraction of lens material
n_{surr} = index of refraction of medium surrounding the lens
R_1, R_2 = radius of curvature of either side of lens: *positive* if convex, *negative* if concave
(This equation still assumes that the lens is "thin," having negligible spatial thickness.)

a. Suppose that an infinite region of clear plastic (n = 1.50) contains an air gap (n = 1.00) shaped like a double-convex lens, as shown here:



(i). (1pt.) The air gap will behave like a ______________ lens. [*Note:* This should agree with (ii) and (iii)!]
A. **converging** B. **diverging**

(ii). (1 pt.) Suppose an incoming ray of light arrives parallel to the lens axis but offset vertically, as shown above. On the diagram above, **continue the path of the ray** as it passes through the air "lens" and continues into the plastic on the right side. (Your sketch need only be qualitatively correct.)

(iii). (3 pts.) If both sides of the air gap have a radius of curvature equal to 50.0 cm, calculate the **focal length** of the air gap "lens." Show your work.

b. (1 pt.) Suppose you have a pane of window glass with index n_{glass} = 1.65 surrounded by air (n_{air} = 1.00). Both sides of the glass are perfectly flat and are exactly parallel to each other. The **focal length** of the window pane is:
A. 0 B. 0.37 m C. 0.65 m D. ∞ E. not enough information is given

c. (1 pt.) Suppose you have a lens made of glass with index n_o that is immersed in oil with the *same* index n_o. The curvatures of the two sides of the lens are unknown. The **focal length** of this lens is:
A. 0 B. $(n_o - 1)$ C. $1/n_o^2$ D. ∞ E. not enough information is given

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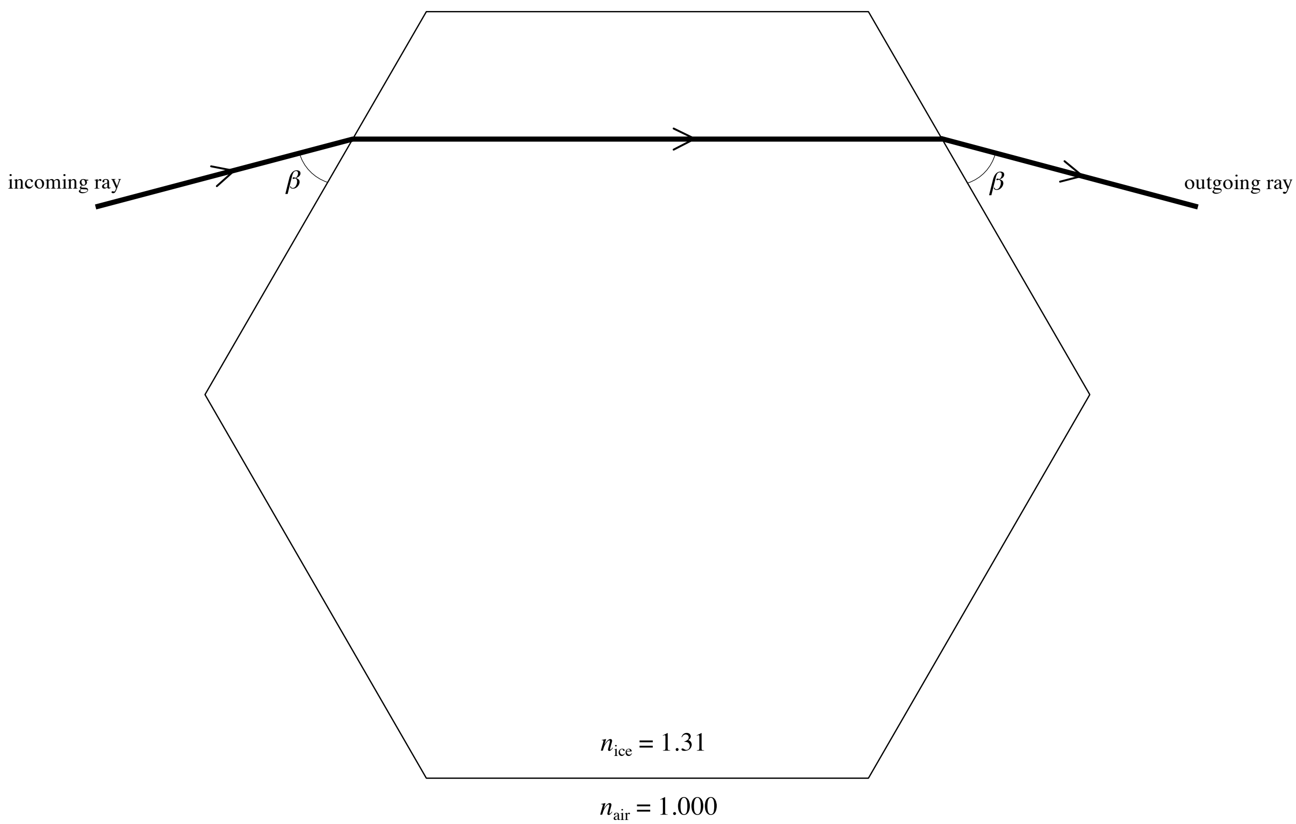
Take-Home Midterm Exam #3, Part B

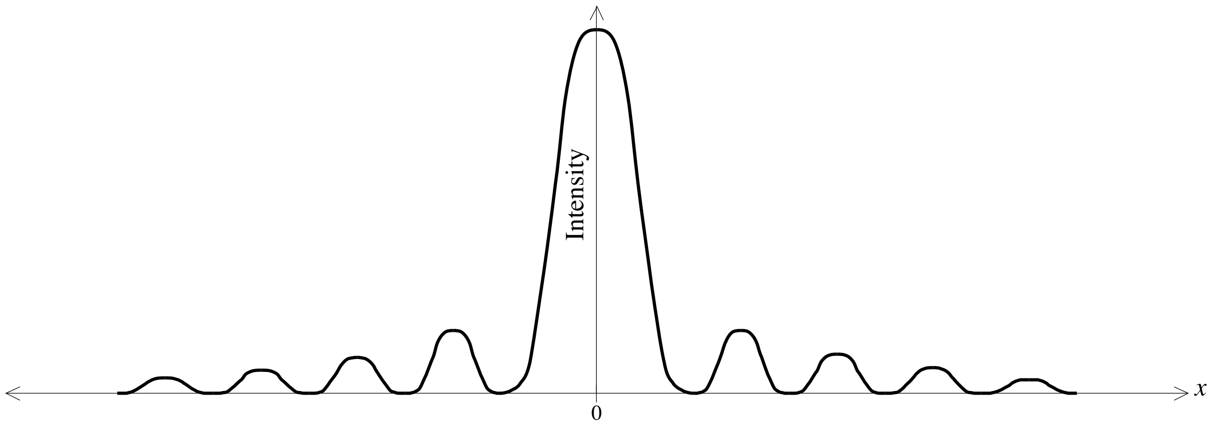
1. High in our atmosphere, H_2O can form ice crystals ($n = 1.31$) in the shape of perfect hexagonal solids, like the one shown here. (Assume that the hexagon is a perfect regular hexagon with six equal sides and six equal internal angles.) A particular ray of sunlight enters from the air ($n = 1.000$) on the left side of the hexagon, passes through the hexagon along a path *parallel to the top edge*, and then leaves the right side of the hexagon, all as shown in the diagram here.

a. (5 pts.) Based on this geometry, find the **angle β** that the incoming (or outgoing) ray makes with the surface of the hexagon. Express your final answer to at least the nearest tenth of a degree. Show your work clearly.

b. (1 pt.) Calculate the **total deflection angle** of the ray, i.e., the angle that the outgoing ray (after leaving the ice) makes with the direction of the incoming ray (before entering the ice). [*Note:* This angle is well known: it is the radius of the "halo" that encircles the sun when high cirrus-cloud ice crystals are present.]



2. Suppose that monochromatic light from a green diode laser (λ_{air} = 532.0 nm) is incident on a single narrow slit of width 1.2 mm, and an interference pattern is observed on a white wall 2.0 m away from the slit. Using a photometer, you find that the interference pattern has the following intensity as a function of distance x along the wall, as measured from the center of the pattern:



a. (1 pt.) **Label** the m = 1, 2, and 3 **minima** on the above graph. (You do not need to label both sides; just the right or left side is fine.)
b. (5 pts.) Calculate the ***x*-positions** of these three minima (m = 1, 2, and 3), in **millimeters**. Show your work clearly.

c. (3 pts.) Suppose that the room is filled with water (n = 1.33). (The slit width and the slit-wall distance remain unchanged.) Find the new **wavelength of the laser light in water**, and calculate the ***new x*-positions** of all three of the above minima (m = 1, 2, and 3). In what overall way does the interference pattern **change**?