Do all 7 problems. The point value for each problem is indicated next to the problem number. Show all of your work in the space provided to receive partial credit. You may use additional sheets of paper if necessary. Be sure to turn in the additional sheets with your name written on each sheet. Put your final answer to each question on the line provided unless instructed otherwise.
_____

<u>1.</u> [20 pts]
A green beam is traveling in air. The beam hits a glass plate at an angle of incidence of $42°$. Some of the light is reflected. The rest enters the glass with a refracted angle of $23°$ with respect to the surface normal. It travels in the glass with a wavelength of 300 nm.

(a) Find the angle of <u>reflection</u> for the reflected beam.

                                                                                                                              42°

(b) Find the index of refraction of the glass for this light.

                                                                                                                             1.71

(c) Find the following quantities of the green light:

wavelength in air = _514 nm_ frequency in air = _5.84x10^{14} Hz_

speed in glass = _1.75x10^8 m/s_ frequency in glass = _5.84x10^{14} Hz_

(d) Suppose a beam of red light hits the same glass plate with the same angle of incidence of $42°$. If the glass has normal dispersion, then will the following quantities for the red beam be <u>larger</u>, <u>smaller</u>, or the <u>same</u> compared to those for the green beam. (Write <u>larger</u>, <u>smaller</u>, or the <u>same</u> on the line following each quantity.)

speed in glass of red light:_larger_ angle of reflected beam of red light:_same_

<u>2.</u>[6 pts]
(a) Both sketches below show an optic axis and collimated light rays traveling to the right. In the dashed box marked "positive" sketch a shape of a positive lens and show what happens to the light rays after they pass through the lens. Indicate the focal <u>length</u> of the lens. In the dashed box marked "negative" sketch a shape of a negative lens and show what happens to the light rays after they pass through the lens. Indicate the focal <u>length</u> of the lens.
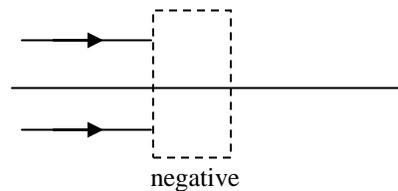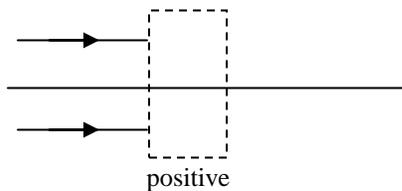
positive   negative

(b) Which lens can form a virtual image?   (Circle <u>one</u> choice.)   *positive*   *negative*   (*both*)
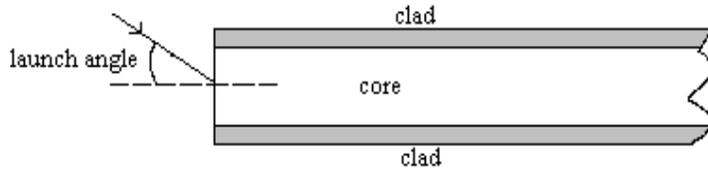
(c) Which lens can form a real image?   (Circle <u>one</u> choice.)   (*positive*)   *negative*   *both*

3. [10 pts]
An optical fiber has a
core index of 1.60 and a
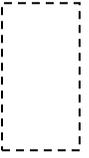clad index of 1.56.

Find the <u>largest</u> launch angle that can be used so that the light in the fiber will experience TIR at the core/clad interfaces.

_20.8°_

4.[24 pts]
You need to make a positive lens with a focal length of +15 cm out of glass with an index of 1.50. The lens is used in air and one side must be flat.

(a) Sketch the shape of the lens in the dashed box.

(b) Find the radii of curvature of the two surfaces.

front surface: $R_1 = $ _+7.5 cm or ∞_

back surface: $R_2 = $_$\infty$ or -7.5 cm_

(c) An object is placed 100 cm <u>in front</u> of your lens. Complete the following sentences by filling in the blanks with the correct values and circling the correct word choices in the parentheses.

"The image of the object is formed _____17.65____ cm (*in front of* /(behind)the lens. The image is (*bigger* /(smaller)) than the object.

The image is ((*inverted*) / *not inverted*) and is (*real*)/ *virtual*)."

(d) Show a ray trace for this set up. The trace does not have to be to scale but should show clearly the approximate relative sizes of the object, image, object distance, and image distance. Label the trace with p, q, h, h'.

5.[16 pts]
Suppose the lens designed in Problem 4 with the focal length of +15 cm is used as a simple projector where a slide (object) is placed 17 cm from the lens.
Complete the following sentences by filling in the blanks with the correct values and circling the correct word choices in the parentheses.

"The screen should be placed _____127.5_____ cm from the lens."

"The image on the screen will be (*real* / *virtual*) and (*inverted* / *not inverted*). "

"The image will be _____7.5_____ times (*smaller* / *bigger*) than the object."

6. [16 pts]
(a) Does a single lens used as a simple magnifier provide a <u>real</u> or <u>virtual</u> image?   <u>virtual</u>

(b) The following focal lengths are for four lenses when used in air. Which lens is capable of producing the largest image when used as a magnifying glass? (Circle one choice.)

1. f = -45 mm   2. f = -35 mm   3. f = +45 mm   4. f = +35 mm

(c) What is the largest possible magnification if the proper lens is used?

<u>8.14</u>

(d) How close is the <u>object</u> to the lens if this magnification is obtained?

<u>30.7 mm</u>

(e) Show a ray trace for this set up. The trace does not have to be to scale but should show clearly the approximate relative sizes of the object, image, object distance, and image distance. Label the trace with p, q, h, h'.

7. [8 pts]
Consider the interesting situation where the near point and far point of a person's eye are both equal to 40 cm. Complete the following sentences by filling in the blanks with the correct values and circling the correct word choices in the parentheses.

"For reading, this eye needs a (*positive* / *negative*) lens with a focal length of _____66.7____ cm or a lens power of

_____+1.5_____ diopters.

To see distant objects, this eye needs a (*positive* / *negative*) lens with a focal length of _____-40_____ cm or a lens power of

_____-2.5_____ diopters."