Physics 256 Assignment 4 Fall 2012

Due: Wednesday, October 10th, 2012 4:00 pm in the drop box on Physics 2nd floor or electronically 47 marks

1) a) A point source is located 3 m from me. If the light travels 1 m beyond me where it hits a lens, what is the radius of curvature of the wavefront at the lens? **2 marks**

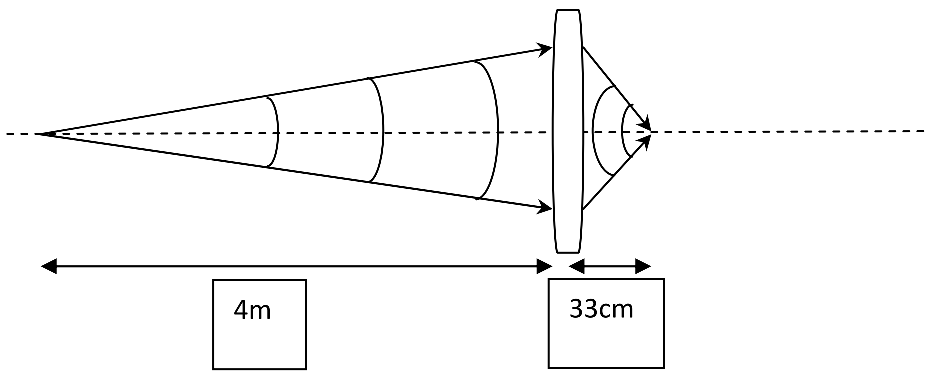
distance from lens to source= radius of curvature=3+1 =4 m. **2 marks**

b) If the light is focused by the lens to a point 33 cm beyond the lens, what is the radius of curvature of the wavefront leaving the lens? **1 mark**

image to lens =33 cm= radius of curvature. **1 mark**

c) Sketch these wavefronts and the paths of 2 light rays through the lens. **3 marks**

3 marks rays are perpendicular to wavefronts



2) An infrared beam with wavelengths 700 nm to 1000nm is used in OCT imaging to measure the positions of two plates in Argon gas. Proportionally, how much of the light will be scattered at 1000 nm compared with 700 nm? **3 marks**

$$\text{scatter}\,\alpha\,\frac{1}{\lambda^4}\;;\;\frac{scatter(1000)}{scatter(700)}=\frac{700^4}{1000^4}=0.7^4=0.24$$

Scatter at 1000 nm is 24% of scatter at 700 nm. **3 marks**

3) Hecht 4.6 Assume the beam strikes the wall 5.0 m along the reflected ray. Reflection See posted websites for review of geometry. **3 marks**

4.6 $\sin 58° = x/(5.0 \text{ m})$, $x = 4.2$ m.

4) Hecht problem 5.76. Two mirror reflection. **4 marks Use the law of reflection.**

5.76 Recall that the angles of a triangle sum to 180°. Recall that at both mirrors $\theta_r = \theta_i$. For the triangle made by the three rays, $(2\theta_{i1}) + (2\theta_{i2}) + (180° - \alpha) = 180°$ so $\alpha = 2(\theta_{i1} + \theta_{i2})$. For the triangle containing "β," $\beta + (90° - \theta_{i1}) + (90° - \theta_{i2}) = 180°$. $\beta = (\theta_{i1} + \theta_{i2})$, so, $\alpha = 2\beta$.

5) a) Hecht 4.12. The angle given is the angle to the normal. **2 marks They want the angle of refraction.**

4.12 $\theta_t = \sin^{-1}[(\sin 45°)/2.42] = 17°$,

b) Hecht problem 4.16. **2 marks** The angle given is the angle to the normal.

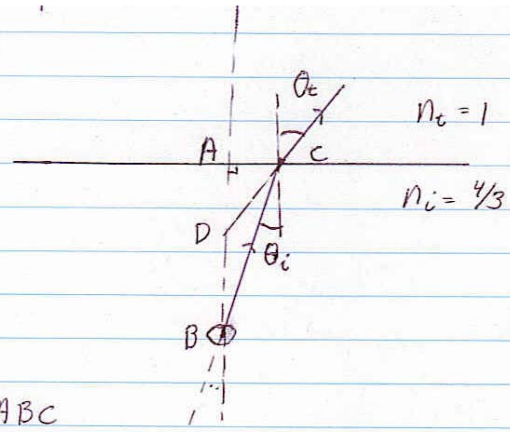
4.16 $1.00 \sin 55° = n \sin 40°$; $n = 1.27$ or 1.3.

If the transmitted beam is reversed so that it impinges on the interface, show that θ_t =55°. **2 marks**

If the light is reversed, θ_i= 40deg, $n_t \sin\theta_t = n_i \sin\theta_{I;}$ $\theta_t = \sin^{-1}(1.3 * \sin 40°)$; θ_t=55°

6) a) Apparent depth problem. Hecht 4.21: Take an object emitting light at the bottom of a pool with water of refractive index 4/3. Draw the rays seen by the eye at a small angle to the normal. Use Snell's Law and assume the small angle approximation sin θ=θ=tan θ. Draw a diagram. **6 marks**

7)a)



Consider ΔABC

By geometry $\angle ABC = \theta_i$ and $\angle ADC = \theta_t$

Snell's Law
$n_t \sin\theta_t = n_i \sin\theta_i$

$\tan\theta_i = \dfrac{AC}{AB}$ $\qquad$ $\tan\theta_t = \dfrac{AC}{AD}$

$$\frac{AD}{AB} = \frac{\left(\frac{AC}{\tan\theta_t}\right)}{\left(\frac{AC}{\tan\theta_i}\right)} = \frac{\tan\theta_i}{\tan\theta_t} \approx \frac{\sin\theta_i}{\sin\theta_t} = \frac{n_t}{n_i} = \frac{1}{4/3} = 3/4$$

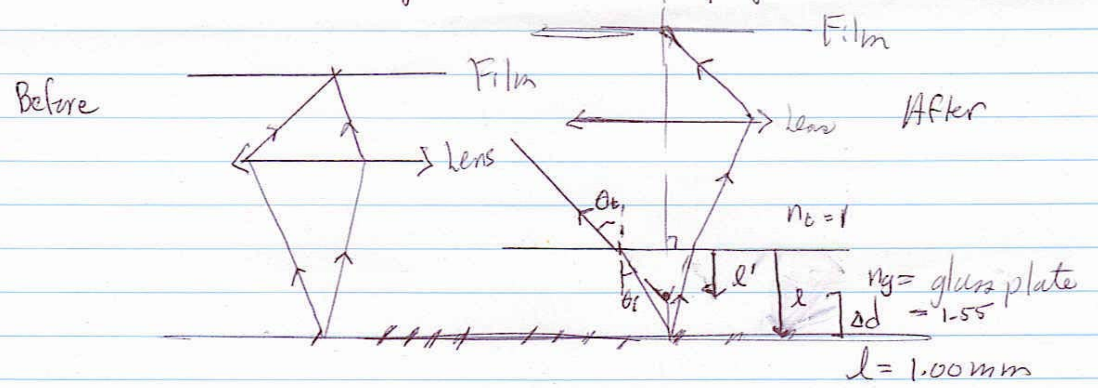
OR draw the diagram and use the apparent depth equation for small angles directly:

$$\frac{\boldsymbol{AD}}{\boldsymbol{AB}} = \frac{\boldsymbol{n_t}}{\boldsymbol{n_i}} = \frac{1}{4/3} = \frac{3}{4}$$

b) Do 4.24. **3 marks Move the camera the same distance that the object appears to move. You will get the same effect independent of the glass thickness. I recommend drawing a diagram.**

4.24 The glass will change the depth of the object from d_R to d_A, where $d_A/d_R = 1.00/1.55$; but $d_R = 1.00$ mm; hence, $d_A = 0.645$ mm and the camera must be raised 1.00 mm − 0.645 mm = 0.355 mm.

7b) If I place a glass slide onto the page:



It is as if the object for the camera has moved upwards.
The camera must be moved upwards by the apparent movement.

$$l' = \frac{n_t}{n_g} l = \frac{1}{1.55} \times 1.0\text{ mm} = 0.645\text{ mm.}$$

$$\Delta d = l' - l = 1.00 - 0.645 = 0.355\text{ mm.}$$

The camera needs to be moved upwards by 0.355 mm.

7) a) 4.52:Critical angle. **2 marks** Do not do the comparison as the question # is incorrect.

$$\theta_c = \sin^{-1}\left(\frac{1}{1.5}\right) = 42^\circ$$

b) What is the angle of refraction for this angle of incidence? **2 marks**

The angle of refraction is 90 degrees. **2 marks**

c) 4.55 **2 marks**

4.55 $\sin 48.0^\circ = (1.00/n)$; $n = 1.35$.

8) Hecht problem 4.57. **4 marks** Draw a sketch. **6 marks** Fish is looking upwards- reverse the ray paths in Week 5 slide.

4.57 Light entering at glancing incidence is transmitted at the critical angle and those rays limit the cone of light reaching the fish; $\sin\theta_c = 1/1.333$; $\theta_c = 49°$ and the cone-angle is twice this or 98°.

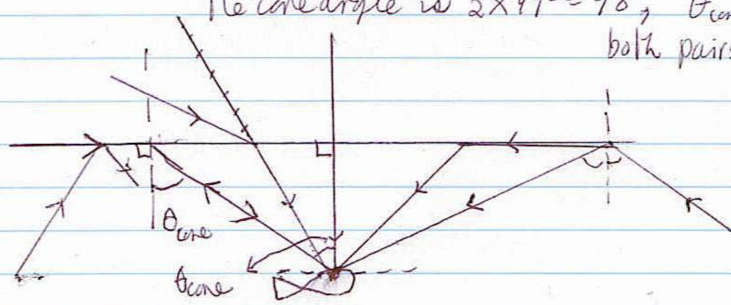
11) Hecht 4.57

The cone angle is determined by the refraction of light into the water. If I reverse the critical angle geometry, then the sky ($\pm 90°$) fills a cone whose edges are defined by the critical angle.

$\sin\theta_c = \frac{1}{1.333}$ or $1\sin(90°) = 1.333\sin(\text{cone}°)$

$\theta_c = 49°$

The cone angle is $2\times 49° = 98°$, $\theta_{cone} = \theta_{critical}$ because both pairs of angles add to 90°



Assumption - the bottom of the pond is poorly lit.