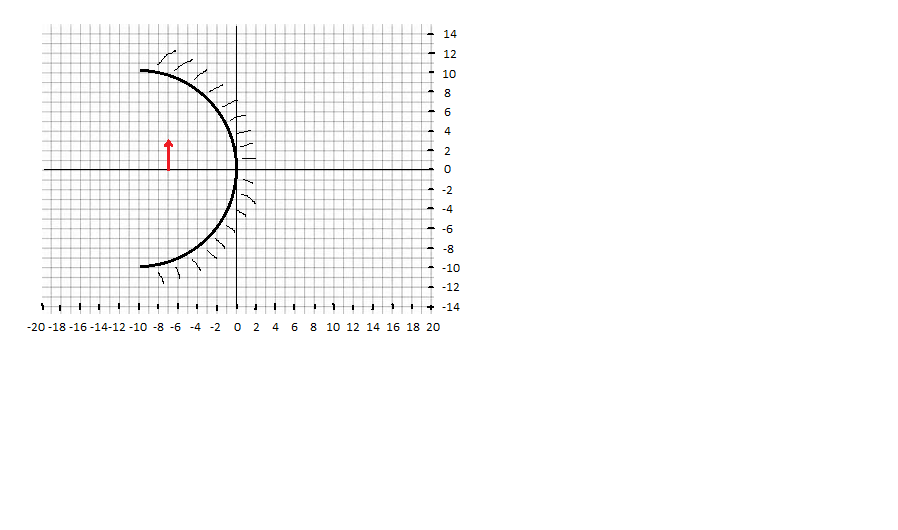
**Homework 6 Due 3/5**

\* For problems 1-8, I’d like/want/demand to see the rays used to locate the image.

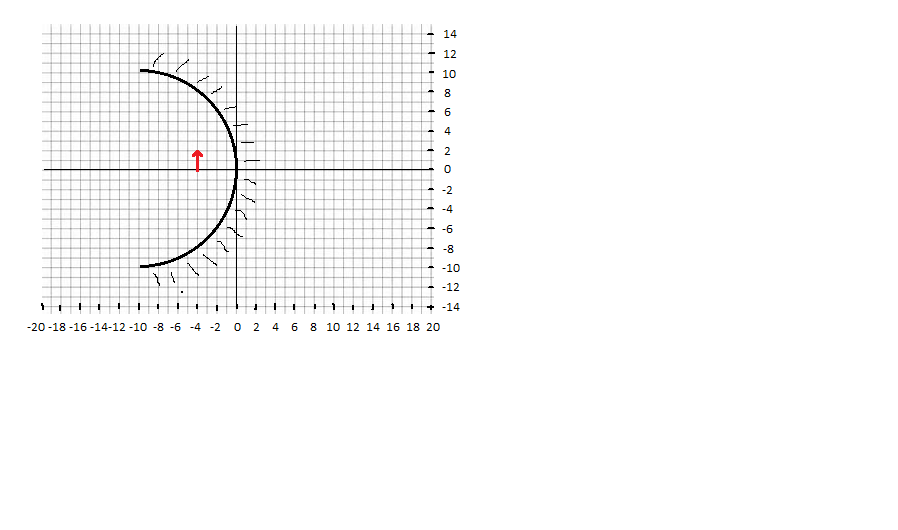
**Problem 1.** Consider the object below, in front of the concave mirror. (a) Using ray tracing alone, determine the location and size of the image. Let one ray proceed from the tip of the object to the center of the mirror on the principal axis, and the other proceed from the tip of the object directly away the center *of curvature* of the mirror. Fill your results into the table, with proper signs and all.

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| **xi** |  |
| **hi** |  |

(b) Now determine the position/height using the mirror equations. Are the results close? They *should* be, because the mirror equation is exactly true – just saying.

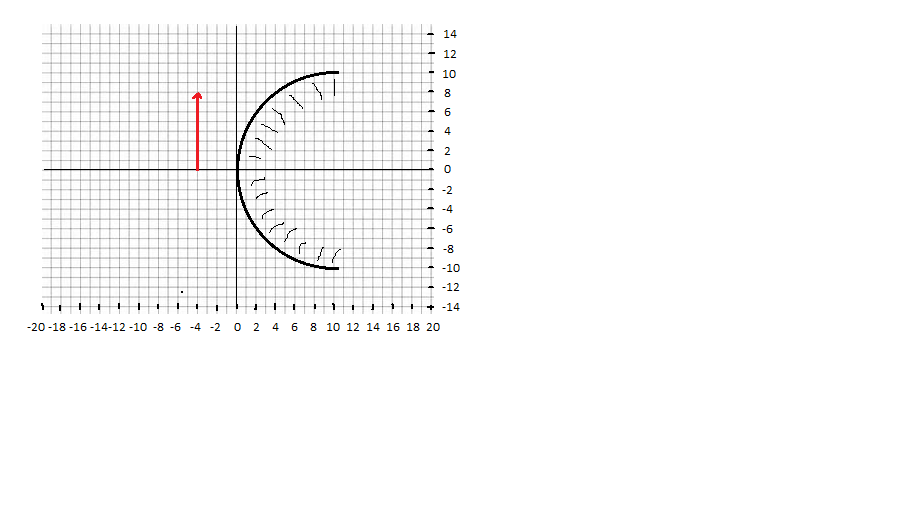
**Problem 2.** Consider the object below, in front of the concave mirror. (a) Using ray tracing alone, determine the location and size of the image. Let one ray proceed from the tip of the object to the center of the mirror on the principal axis, and the other proceed from the tip of the object directly away the center *of curvature* of the mirror. Fill your results into the table, with proper signs and all.

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| **xi** |  |
| **hi** |  |

(b) Now determine the position, height using the mirror equations. Are the results close?

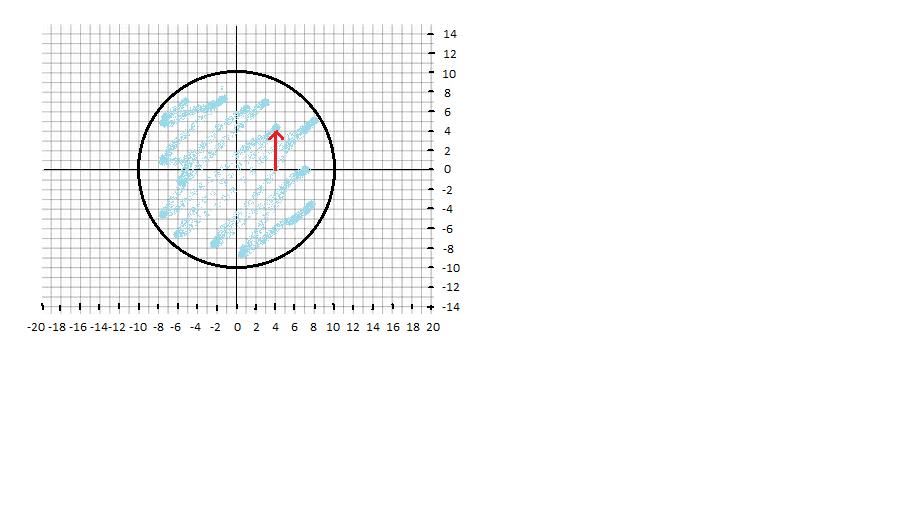
**Problem 3.** Consider the object below, in front of the convex mirror. (a) Using ray tracing alone, determine the location and size of the image. Let one ray proceed from the tip of the object to the center of the mirror on the principal axis, and the other proceed from the tip of the object directly towards the center *of curvature* of the mirror. Fill your results into the table, with proper signs and all.

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| **hi** |  |

(b) Now determine the position, height using the mirror equations. Are the results close?

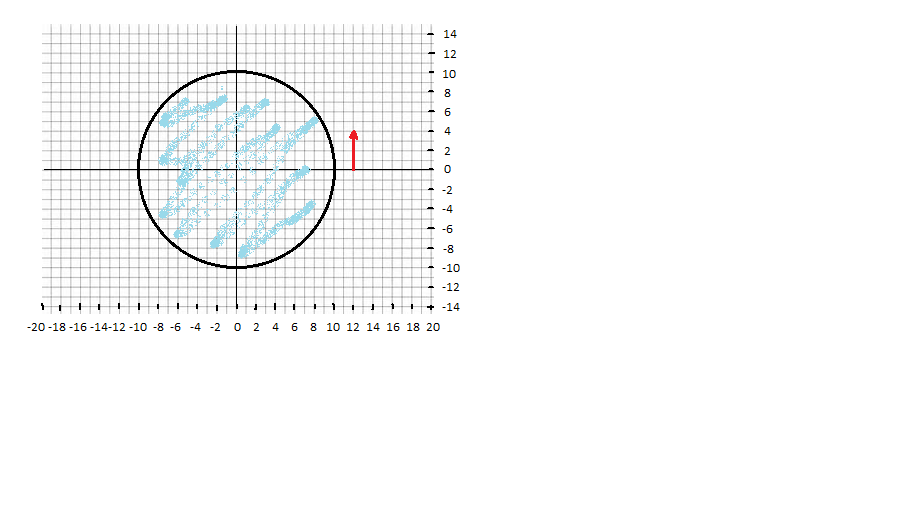
**Problem 4.** Now consider the object below in a refractive medium, like a fish bowl of water, but with an index of refraction n = 1.5 rather than 1.33. (a) Using ray tracing alone, determine the location and size of the image (as viewed from outside the medium, on the right looking left). Let one ray proceed from the tip of the object to the center of the interface on the principal axis, and the other proceed from the tip of the object directly away the center of curvature of the interface. Note you’ll have to use Snell’s law to do this correctlly. Fill your results into the table, with proper signs and all.

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(b) Now determine the position, height using the refractive surface equations. Are the results close? Note that the refractive surface equations explicitly invoke a small angle approximation in their derivation, which our object violates. So don’t expect *too* much accuracy.

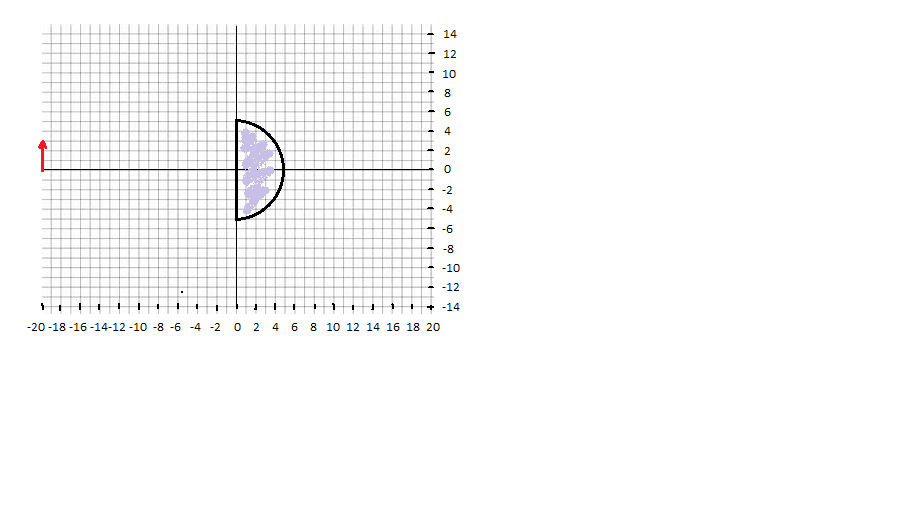
**Problem 5.** Now consider an object outside the n = 1.5 water filled fish bowl, but in the n = 1 air. From the fish’s perspective, looking right, what would be position and location of the person (object) shown below. Again, use a ray that heads towards the center of curvature of the interface, and one that hits the center of the interface on the principal axis. And again, you’ll have to use Snell’s law. Fill your results into the table, with proper signs and all.

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(b) Now determine the position, height using the refractive surface equations. How do these results compare. And once again, don’t expect great agreement since the small angle approximation is being violated.

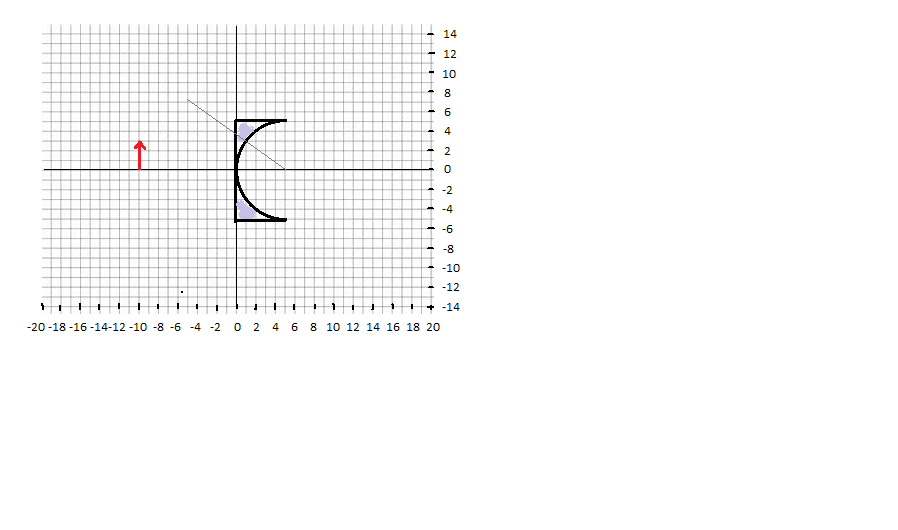
**Problem 6.** Think we’re done? Foolish person. We have not yet begun to physics! Let’s consider a semi-circular shaped lens – the circular part has radius of curvature |R| = 5. Let it have an index of refraction n = 1.5 too. (a) Use Snell’s law to determine the location of the image. The two rays you’ll want to use are these: one which proceeds from the tip of the object parallel to the principal axis so as to hit the flat surface perpendicularly, and another which emerges from the tip and impinges upon the flat surface at its center, where it intersects the principal axis. Fill your results into the table, with proper signs and all. You can measure distance from the flat surface.

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(b) Compare this to your results using the lens equation. The comparison won’t be too favorable because the lens equation requires the lens to be thin, which ours is *not*.

**Problem 7.** Last one (kind of)! Let’s consider diverging lens, with the circular part radius of curvature |R| = 5. Let it have an index of refraction n = 1.5 like before. (a) Use Snell’s law to determine the location of the image. Once again, the two rays you’ll want to use are these: one which proceeds from tip of the object parallel to the principal axis so as to hit the flat surface perpendicularly, and another which proceeds to the center of the flat surface, where it intersects the principal axis (this ray will not refract since the width of the lens at this point is zero). Also, I’ve drawn that line emanating from the center of curvature to help a bit with applying Snell’s law. Fill your results into the table, with proper signs and all. You can measure distance from the flat surface.

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(b) And compare to the lens equations. Results will be a little better since the lens is thinn*er*.

**Problem 8.**  Consider the side-mirrors on a car. These are convex mirrors.

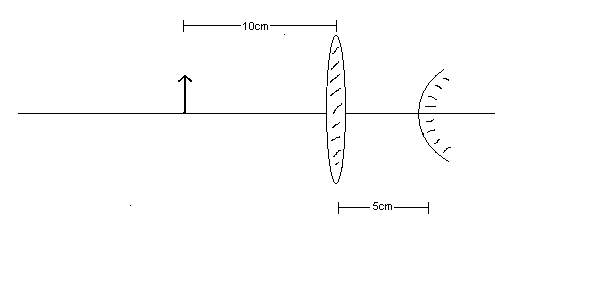
(a) List some reasons why that should be so.

(b) These mirrors always say, ‘object is closer than it appears’. Could this be a reference to the image position being further from the mirror than the object position? Maybe/Maybe not. Which is larger for a convex mirror: xo or xi? Prove it.

(c) What about image size? Which is larger for a convex mirror: ho or hi? Prove it.

(d) Do you have a conjecture for why the ‘object is closer than it appears’? Don’t need all the space below for your answer – just a line or two.

**Problem 9.** Suppose you have a 15cm tall object 10cm away from a convex lens (focal length 7cm), which itself is 5cm away from a convex mirror (radius of curvature 5cm). (a) Locate the image you would see if you were standing between the lens and the mirror, looking towards the mirror – specify its position with respect to the mirror (left/right).



(b) What is the height of this image?

(c) Is the image real or virtual?

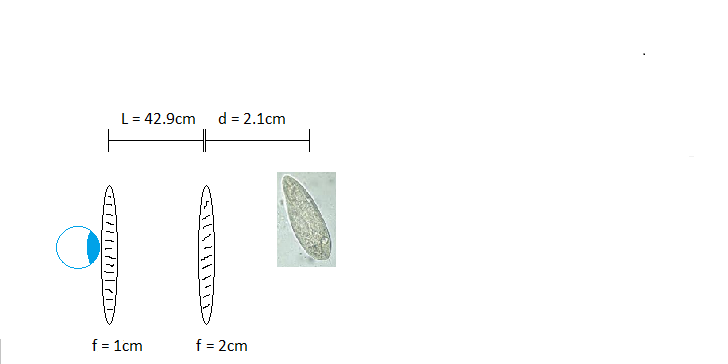
**Problem 10.** A nearsighted person can focus on objects as close as 10cm, but can’t see objects clearly when they are beyond 1.5m.

(a) What focal length should the prescribed contact lens have to correct this problem? What kind of lens is it?

(b) What is the new near point?

**Problem 11**. Gandalf is farsighted, both metaphorically and actually. His near point is 40cm. What lens power does Gandalf prescribe himself so that he can see clearly at x = 25cm? Also, draw a ray diagram illustrating the object and its image, as focused by the lens.

**Problem 12.** Say hi to Pete the paramecium, sitting under a microscope. What angular magnification does the microscope impart to his image? Assume a standard nearpoint of x = 25cm. Also compare to the standard magnification formula.



**Problem 13.** You are walking down the street when you think you see a 1.5m tall puma. Just to be sure, you pop the lenses out of your glasses and construct a telescope. What is the angular magnification of the puma? Compare to the standard approximate formula.

