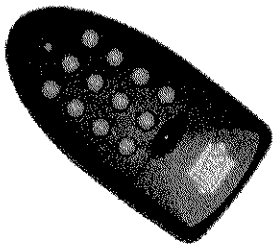
Lecture

4/12/05

Index of Refraction

- Light propagating into a material with a larger n bends towards the normal.
- Light propagating into a material with a smaller n bends away from the normal.
- The property n is called *the index of refraction* of a material.
- The n of empty space (vacuum) is taken to be 1.
- The index of refraction of a material can depend on the color (frequency) of the light.

Puzzle

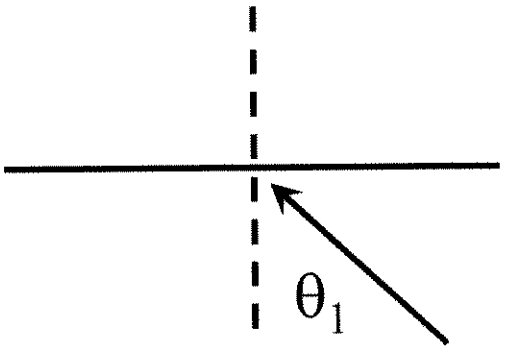


- What happens if the ray comes from inside the dense medium so that there is no external angle for which Snell's law holds?

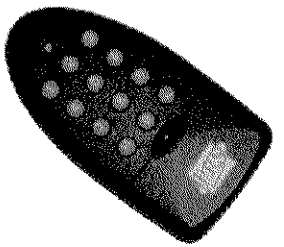
$$\sin\theta_2 = \frac{n_1}{n_2}\sin\theta_1$$

$$n_1 > n_2$$

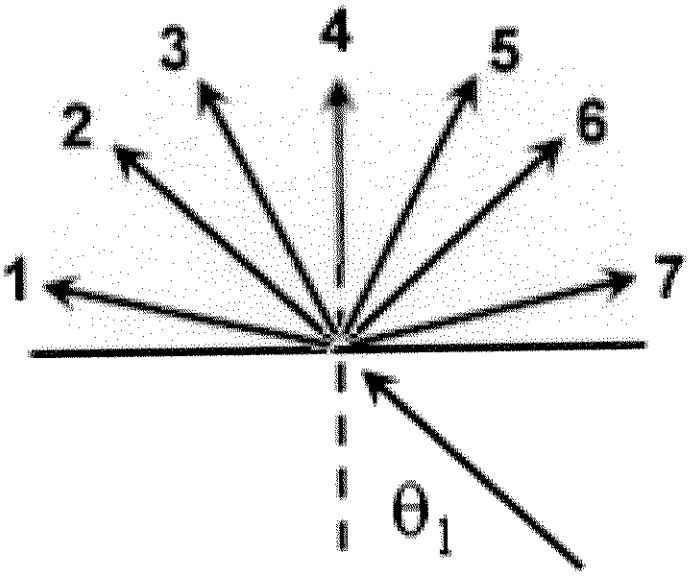
Choose an angle so $\sin\theta_1 > \frac{n_2}{n_1}$



Puzzle



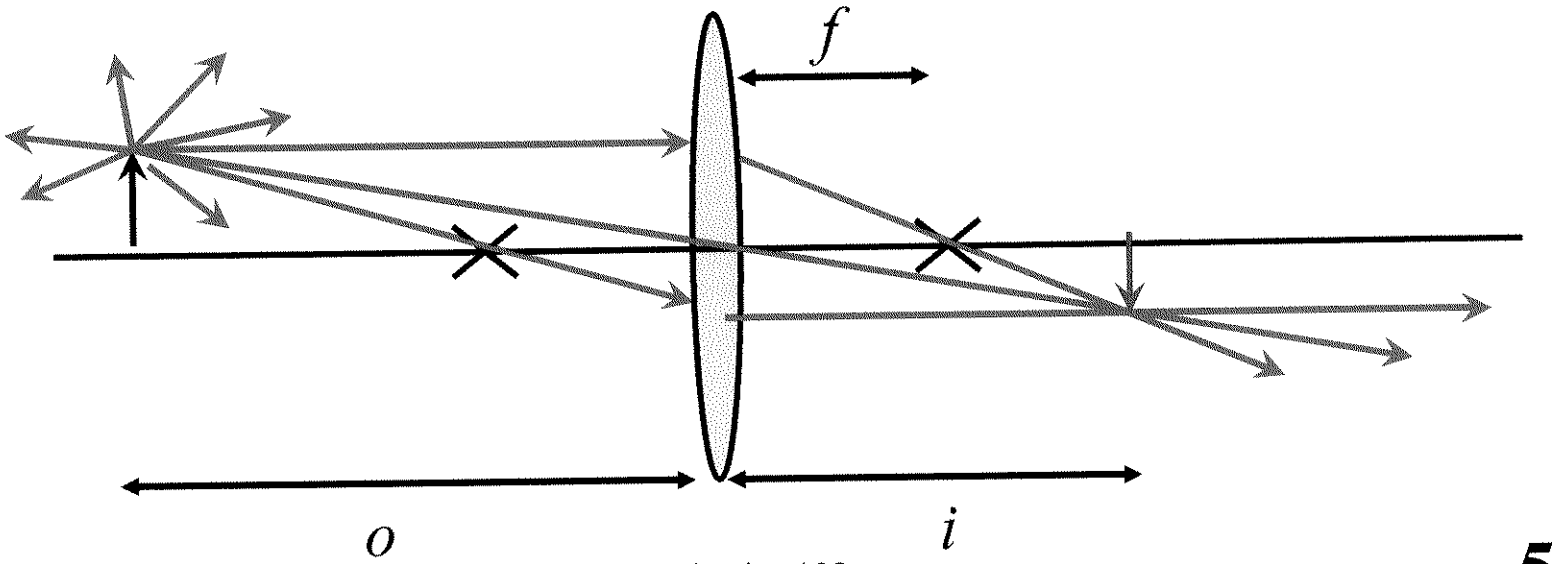
- A ray of light is moving from one medium (blue) into another (yellow).
- Which of the outgoing rays is the most plausible if
  - both media have the same n?
  - $n_{blue} > n_{yellow}$?
  - $n_{blue} < n_{yellow}$?



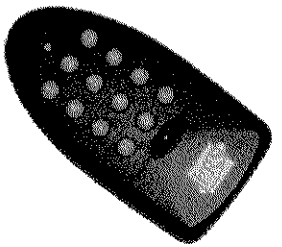
The Lens Equation: Real Image

- For a thin lens

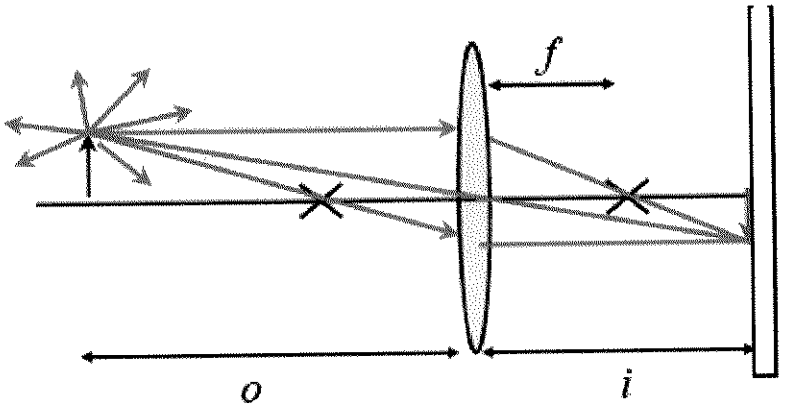
$$\frac{1}{o}+\frac{1}{i}=\frac{1}{f} \qquad \frac{h'}{h}=\frac{i}{o}$$



Puzzle

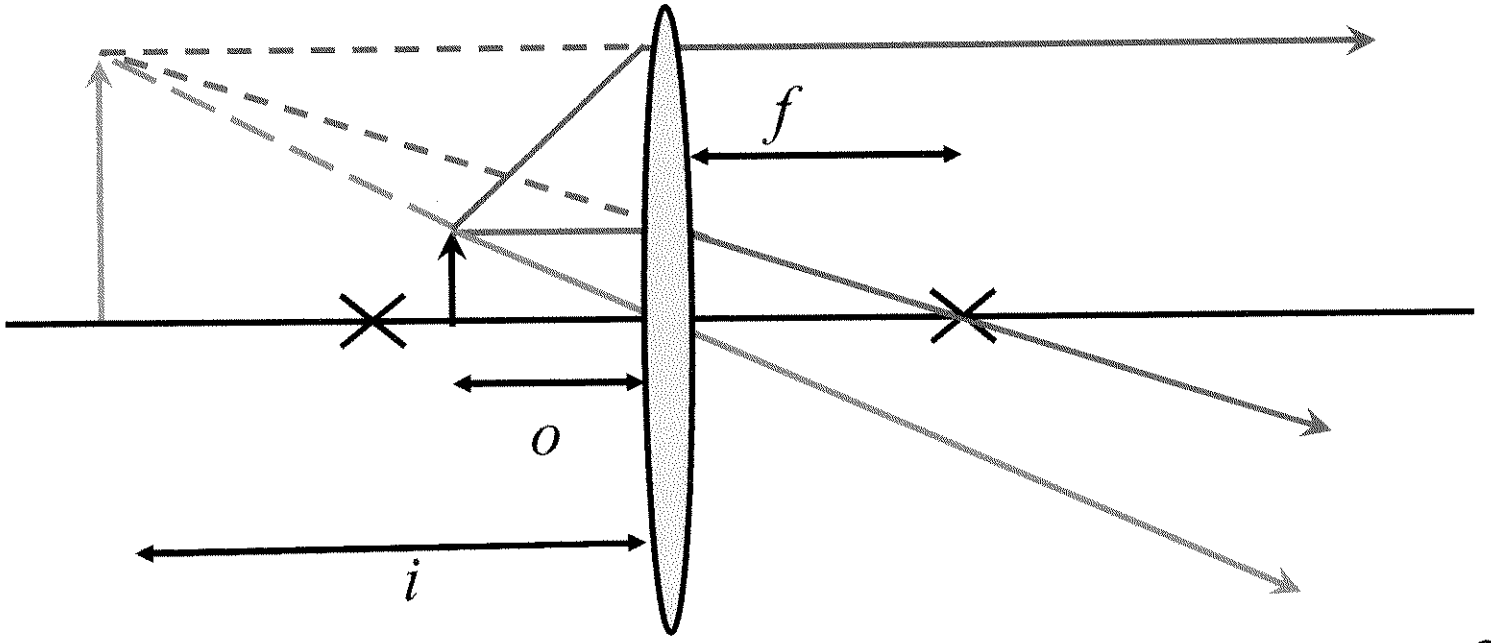


- What happens if you put a screen at the image distance for a real image?
  - 1. You won't be able to see the image from anywhere.
  - 2. You will be able to see the image from anywhere.
  - 3. You will be able to see the image on the screen if you are on the same side of the screen as the lens.
  - 4. You will be able to see the image only if you are lined up to see the object through the lens.

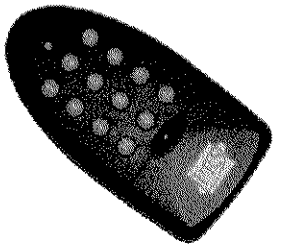


The Lens Equation: Virtual Image

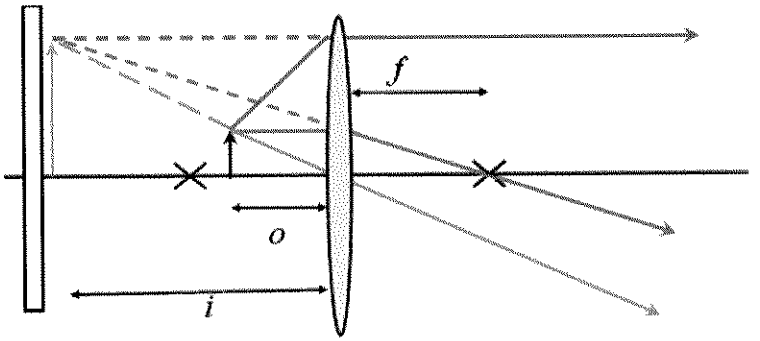
$$\frac{1}{o} - \frac{1}{|i|} = \frac{1}{f} \qquad \frac{h'}{h} = -\frac{|i|}{o}$$



Puzzle



- What happens if you put a screen at the image distance for a virtual image?
  - 1. You won't be able to see the image from anywhere.
  - 2. You will be able to see the image from anywhere.
  - 3. You will be able to see the image on the screen if you are on the same side of the screen as the lens.
  - 4. You will be able to see the image only if you are lined up to see the object through the lens.



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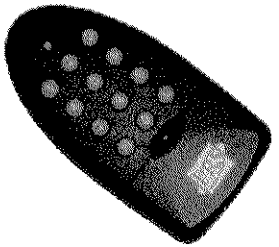
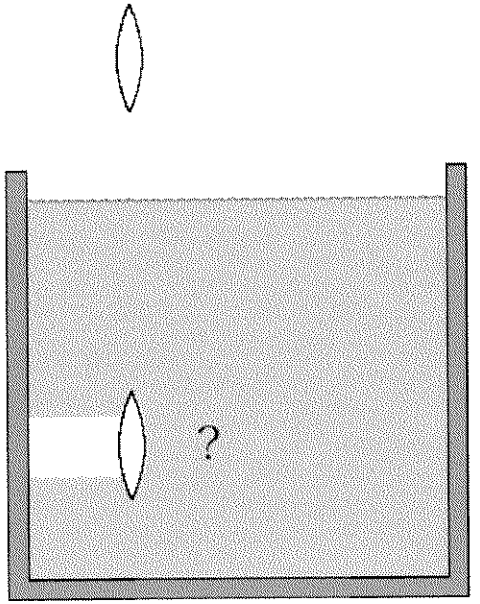


- A parallel beam of light is sent through an aquarium. If a convex glass lens is held in the water, it focuses the beam
  - 1. closer to the lens than
  - 2. at the same position as
  - 3. farther from the lens than

  when the lens is outside the water.

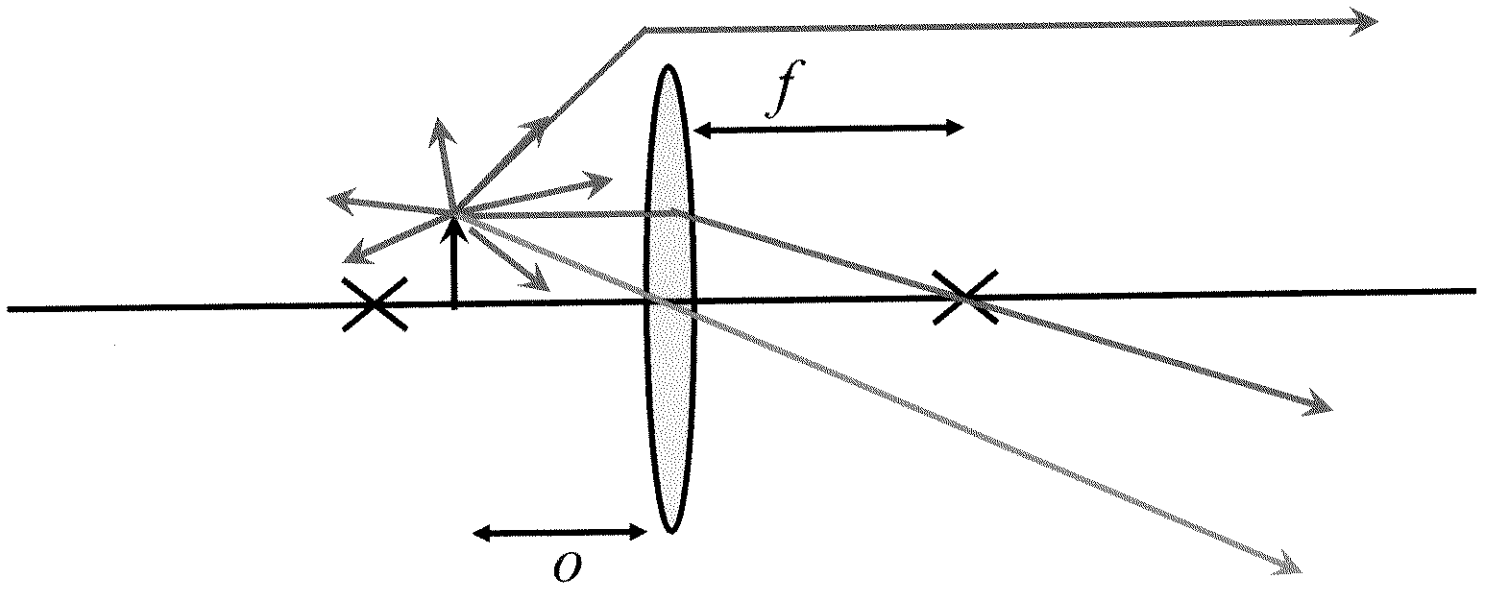


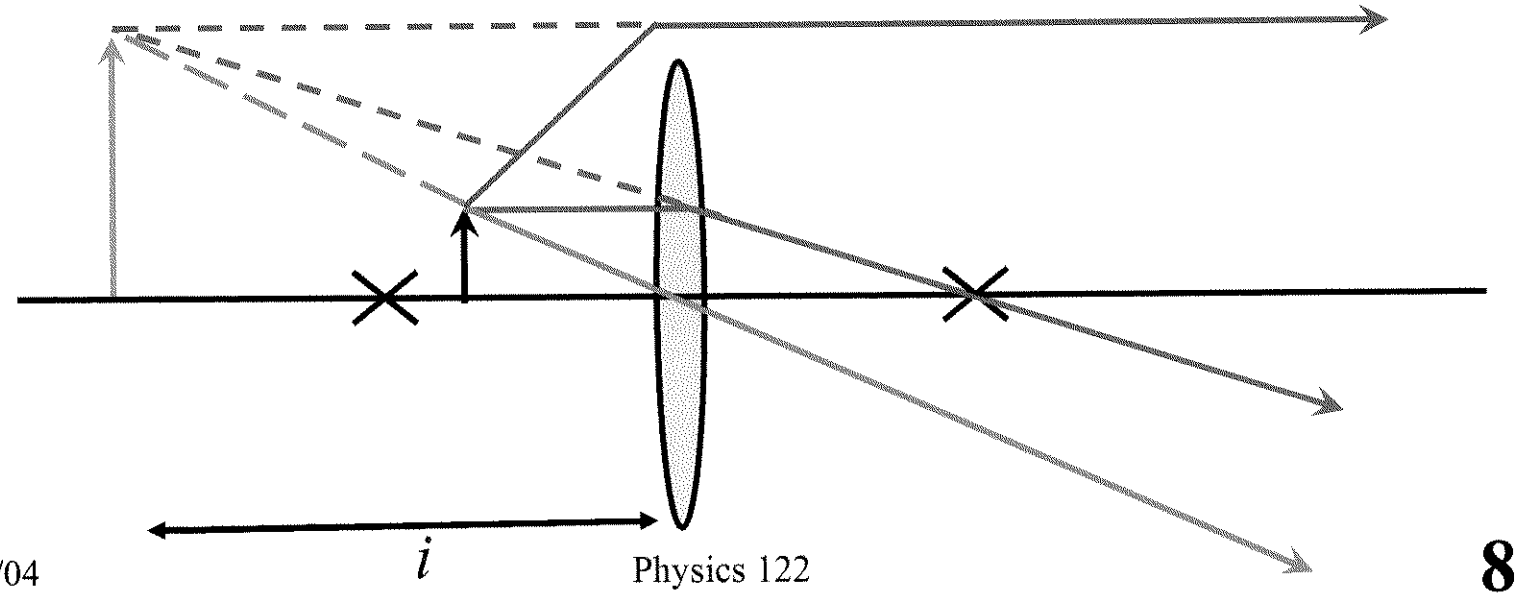
The Magnifying Glass

- What happens if the object is inside the focal point (closer to the lens)?

$$\frac{1}{o}+\frac{1}{i}=\frac{1}{f} \qquad \frac{h'}{h}=\frac{i}{o}$$

- If $o < f$ then $1/o > 1/f$.
  So $1/i = 1/f - 1/o < 0$.
- If $i < 0$, then $h' < 0$.
- The image is virtual and oriented upward.


f
o


i

The Microscope

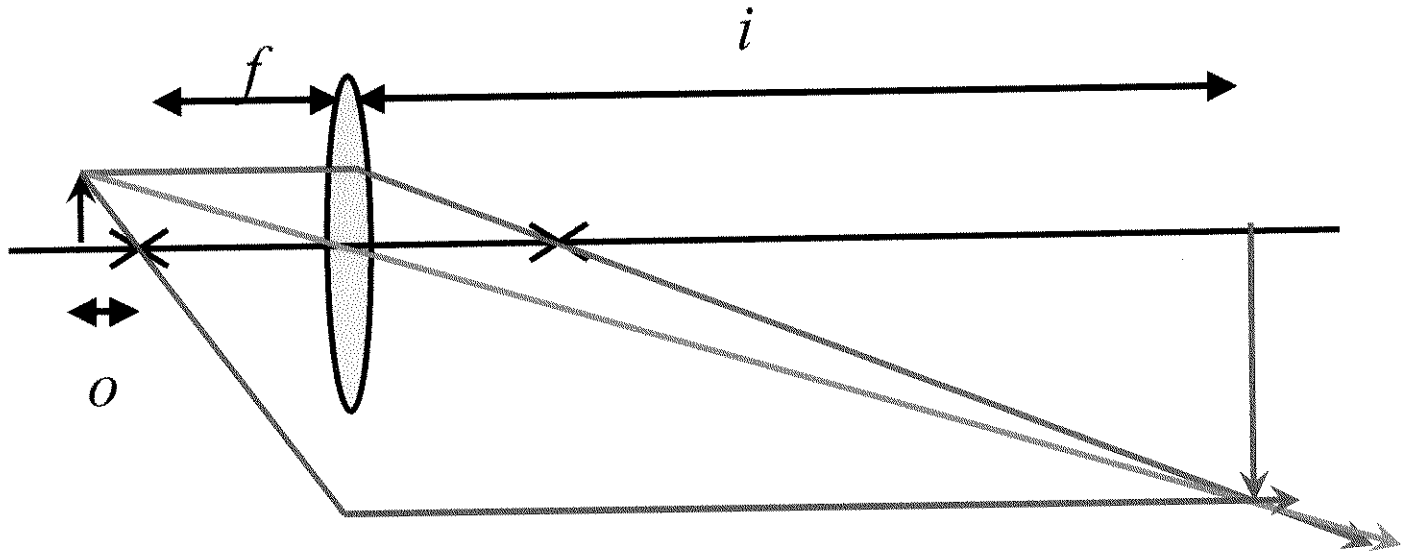
- The real image from a convex lens can also make the image bigger.
- For this to happen we need

$$\frac{h'}{h} = \frac{i}{o} > 1$$

- So let's make o just a tiny bit bigger than f.

$$\frac{1}{i} = \frac{1}{f} - \frac{1}{o}$$

- Then we'll look at the enlarged real image with a magnifying glass.


f
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