Bizarre behavior with light

I have observed people with cameras undergoing some strange behavior.

a. When I was at a conference in North Carolina, one of the physics graduate students (who should have known better!) was trying to take a picture of the overhead projected on a white screen. Since the room was darkened, he used a flash. Explain why this is a bad idea and what his pictures are likely to show.

   The overhead puts light on the screen and no light in the areas we are supposed to see black. So the flash of the camera puts light on the whole screen so the black words will disappear.

b. I mentioned to him that he probably should not be using his flash so he turned it off. He then proceeded to try and take pictures of the participants in the darkened room! Explain why this is a bad idea and what his pictures are likely to show.

   In a dark room, light will not be bouncing off the participants. This guy really needs to recruit some graduate students with some common sense!

c. I once observed a woman on an airplane at night with a camera. As we flew low over Washington DC she was impressed with the view of the city lights in the dark. She stood back in the aisle and tried to take a picture through the window using her flash. Explain why this is a bad idea and what her pictures are likely to show.

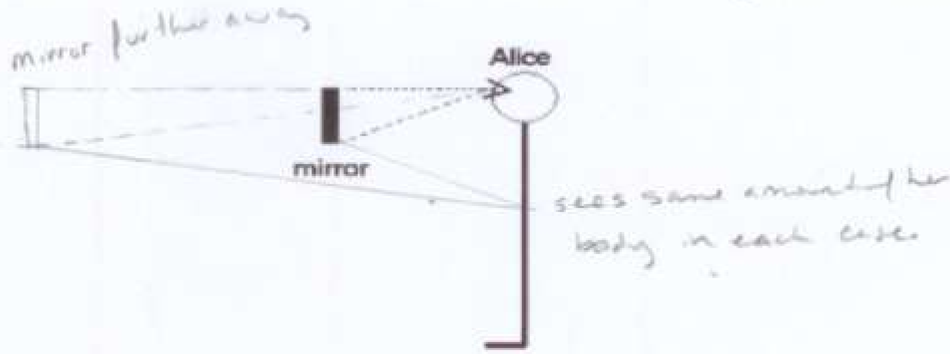
   The flash will reflect off the window so she'll just have a bright light on a window for her picture.

Alice and the looking-glass

Alice faces a looking glass (mirror) and is standing at a level so that her eyes appear to her to be right at the top of the mirror as shown in the figure. At the position she is standing, she can just see her belt buckle at the bottom of the mirror. If she steps back far enough

a. she will be eventually able to see all of herself in the mirror at the same time.
b. she will see no change in how much of herself she can see.
c. she will see less of herself as she steps back.
d. some other result (explain)

Put the letter of the choice that completes the sentence correctly in the box at the right below and explain why you think so with a few sentences and some rays on the diagram.



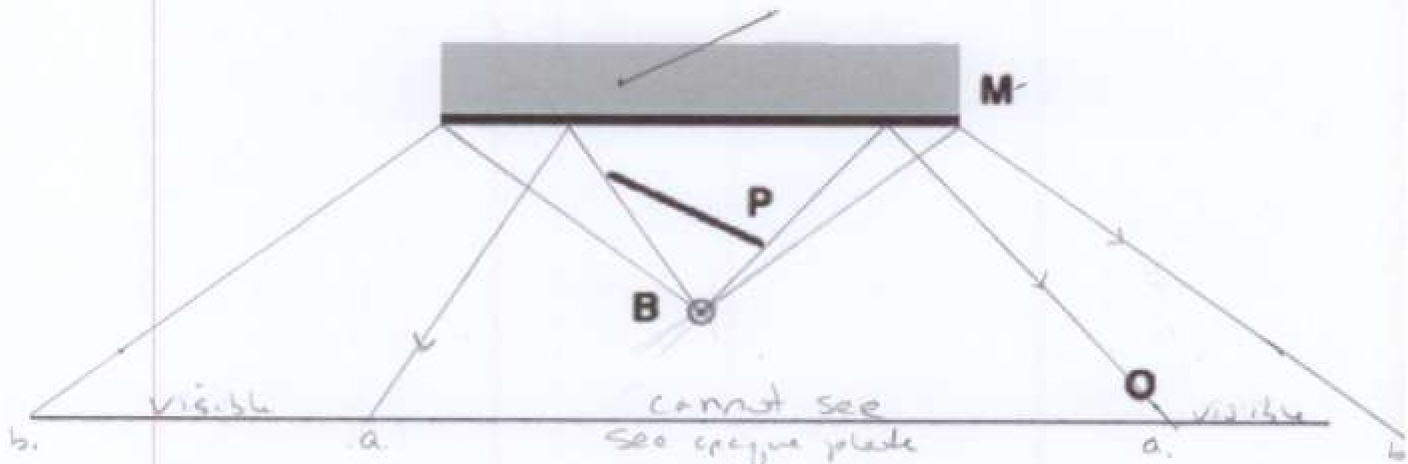
On the mirror

While doing a tutorial lesson on "How to find out where something is by looking," two students, Ethelred and Guinivere, answered the question, "Where does the image [in the mirror] appear to be located?" by saying "On the mirror." Do you agree with them or not? If you disagree, where would you say the image is and how would you justify your answer to them? If you agree, propose a different plausible position for the image in the mirror and explain why you prefer Ethelred and Guinivere's answer.

The image is where the light appears to come from. That means it's behind the mirror. The light did reflect off of the front of the mirror but that's not the "image". The "image" is defined as where it looks like the object is.

One more mirror

In the diagram below, M is a plane mirror, B is a very small bulb that can be treated as a point source, and P is an opaque plate that does not transmit light. O is a line anywhere along which an observer can stand to try to see the image of the light bulb in the mirror. By using relevant rays of light, determine the locations along line O from which the image of B is visible in the mirror and the locations from which it is not visible. Mark these regions accordingly along line O and explain your reasoning.



My two rays marked a. are the narrowest rays from the bulb that make it to the mirror.

My two rays marked b. show the limits of how far from the mirror along line O you can be & get light from the bulb into your eyes.

Bending Light – *PhET Simulation*

In the PhET sim *Bending Light*, there are two mystery materials, Mystery A and Mystery B. These materials appear in both the "Intro" and the "Prism Break" tabs. Determine what the index of refraction is for each of these materials and propose substances that fit these values. Describe clearly how you determined the two values of *n* including all calculations.

I found the critical angle for each mystery substance when light went from the substance to air.

Mystery A $\theta_c = 25°$

Mystery B $\theta_c = 46°$

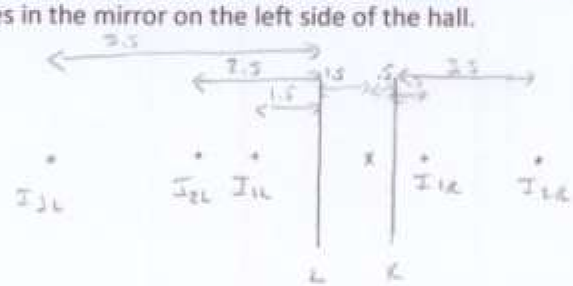
$\sin\theta_c = \frac{n_2}{n_1}$ so $n_1 = \frac{n_2}{\sin\theta_c}$

$n_A = \frac{1}{\sin 25°} = 2.37$ close to diamond

$n_B = \frac{1}{\sin 46°} = 1.39$ close to alcohol

Mirror Mirror in the Halls

Sheila is standing in wide mirrored hallway. The hall is 2 meters wide and has mirrors covering both walls. If Sheila stands 0.5 a meter from the right hand side of the hall, find the distance from Sheila to the first three images in the mirror on the left side of the hall.



The first image in each mirror is just as far behind the mirror as Sheila is from the front so 0.5m on the right & 1.5m on left. Now each of these images acts as an object to form the second images in each mirror. I2L is an image of I1R.

Distances are measured from Sheila so I1L = 3.0m I2L = 4.0m & I3L = 7.0m

Snell's law for ultrasound

a. Snell's law correctly predicts the refraction (bending) of light as it moves from one homogeneous medium into another where the speed of light differs from the speed in the first medium. Discuss what has been assumed about the speed of light in a more dense medium in order to describe experimental observations.

The speed of light in a more dense medium is slower which is what causes it to bend towards the normal.

b. We typically deal with sound that has wavelengths comparable to the objects it interacts with (on the order of a few centimeters to a few meters) so we don't usually talk about "sound rays" or Snell's law for sound. But if we are working with high frequency ultrasound, as is used currently in many medical probes, it would be appropriate to consider it. We are pretty certain of a couple of relevant facts about sound:

- Sound propagates as a wave.
- The speed of sound is greater in a dense medium.

Discuss what this would mean for Snell's law for sound. Do you expect a ray of sound coming onto a denser medium to bend towards the normal (like light) or away from the normal? Explain your reasoning.

I would expect it to bend in the opposite direction as light. The reason being that sound travels faster in a more dense medium (light traveled slower in more dense).

c. Can we have the analog of total internal reflection for sound? If so, this could have severe implications for imaging using ultrasound. The speed of sound for some relevant media are given below. Determine which boundaries between two media could lead to total reflection of sound rays. Describe the configuration (entering from which medium) and find the angle above which total reflection occurs.*

Since light bends away from the normal when speeding up, we'll get total internal reflection for air to muscle, air to bone and muscle to bone.

$\sin\theta_c = \frac{n_2}{n_1} = \frac{v_1}{v_2}$

air to muscle $\theta_c = \sin^{-1}\frac{330\,m/s}{1600\,m/s} = 11.9°$

air to bone $\theta_c = \sin^{-1}\frac{330\,m/s}{4000\,m/s} = 4.7°$

muscle to bone $\theta_c = \sin^{-1} 1600\,m/s / 4000\,m/s = 23.6°$

Material	*Speed of Sound*
Air	330 m/s
Muscle	1600 m/s
Bone	4000 m/s

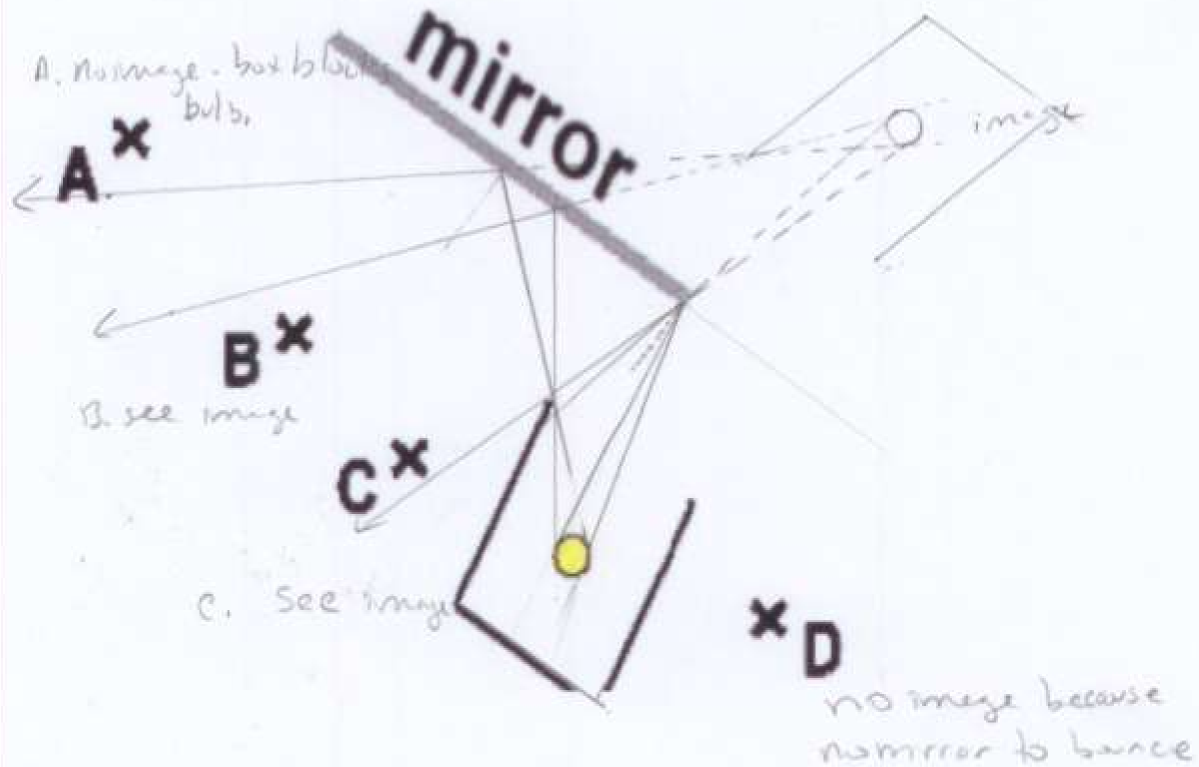
* Data taken from J. R. Cameron and J. G. Skofronick, *Medical Physics* (John Wiley & Sons, Inc., 1978) p. 255.

Tutorial Homework:
Mirrors **Name** Solution

In tutorial, we developed a method, called "the Mel and Taylor method," to determine where an object appears to be. We individually use this method, each of our eyes serving as "Mel" or "Taylor". Our brains combine the information coming from our two eyes (in particular, the difference between the angles the two eyes have to turn in order to look directly at the object) to decide where that object is.

In the figure at the right is shown a top view of a mirror and a bulb in an opaque housing. Use the M&T method to decide whether you could see the image of the bulb in the mirror and where your brain would place the image if you stood at the points A, B, C, and D.

Draw your lines carefully using a ruler and a protractor.



Did you find that you could see the bulb from all of the four points? If not, which ones could you not see them from? Explain why not.

No. Cannot see from A because the box blocks A.
Cannot see from D because the mirror is missing in the area in front of D.

For those points from which you could see the bulb, does your diagram say that ~~would~~ your brain would interpret the light it received in these different cases as coming from an object sitting at a single place in space? Or as you moved from one point to the other does the position of the bulb appear to change?

Single place in space as drawn.

Is this what you expect happens in the real world? If not, reconcile the discrepancy.

yes