# PHYS 122: Eleventh Homework Assignment

**April 12, 2009**

## This homework due in Box outside of Rock 207:
## 5:00 PM Sharp, Monday, April 20, 2009

## Announcements:

- This is the penultimate homework. The final homework (#12) (short!) will be due Monday, April 27th.
- **The Final Exam is Monday, May 4, 4 PM to 7 PM.** You cannot earn a passing grade in Physics 122 unless you sit for the final exam. Only the dean of students can excuse you or reschedule you for this exam for any reason whatsoever.
- Schedule for Remainder of Semester:
  - **Wed Apr 15:** Lecture: Mirrors, Refraction, Images, Ray Tracing
  - **Fri Apr 17:** Lecture: Huygens's Principle: diffraction
  - **Mon Apr 20:** Optional Lecture/Recitation: Optics Problem Solving
  - **Wed Apr 22:** TBD. Stay tuned.
  - **Fri Apr 24:** Lecture: Physical Interference patterns, gratings, etc.
  - **Mon Apr 27:** Final Lecture: Relativity and the nucleus: (includes live demonstration of a run-away chain reaction!)
  - **Tue Apr 28:** Absolute last date to complete and submit make-up labs.
  - **Sat May 02:** Physics Review-Palooza:, Thwing Ballroom (1-5 PM)
  - **Mon May 04:** **Final Exam** 4 to 7 PM, Strosacker
- **Office Hours:** Mr. Covault will be able to meet with students most days this week and also most days during the week before the final exam. Mr. Covault will be unavailable from April 20 through 24th.

**Homework Assignment continues next page....**

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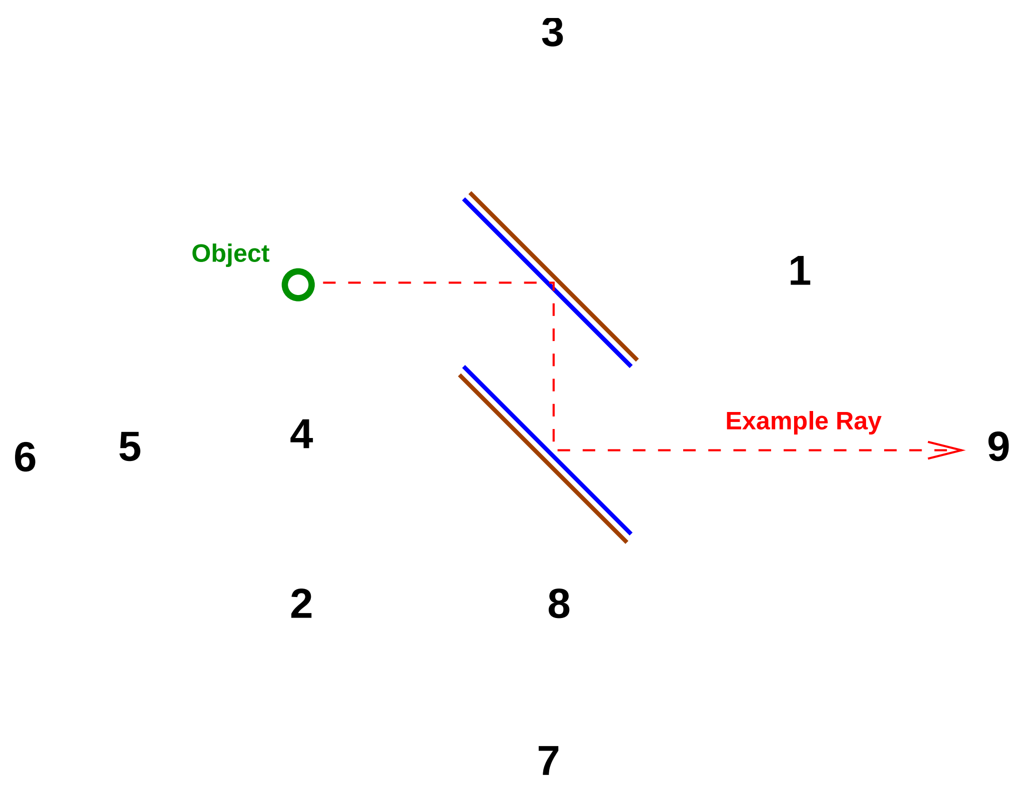
**Problem 1:**



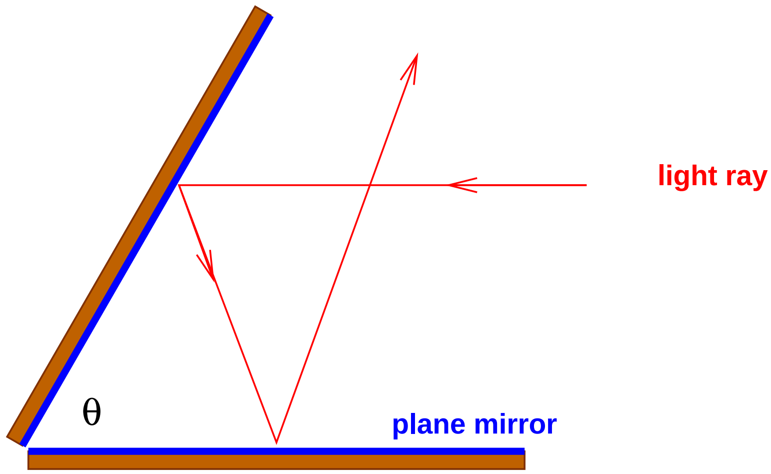

Suppose two plane mirrors are positioned exactly as shown above. A small round “object” is placed as shown. There are nine positions above labeled “1”, “2”, “3”....”9”. The path of one example ray from the object is shown.

**Part (a)** Of these nine positions, two of these (only) correspond to the positions of virtual images of the object. Which two positions are these? Explain your answer using a carefully annotated copy of this diagram.

**Part (b)** The numbered positions correspond to just two virtual images of the object. Are there other images that are located at other positions (un-numbered)? How many total virtual images exist in this system? Explain how you know this.

**Part (c)** At a fun-house you walk into a cubical room where two opposite walls are completely covered with flat mirror panels. What do you see when you look into either of the mirrored walls? How many “images” of yourself do you “see”? Explain.

**Problem 2:**

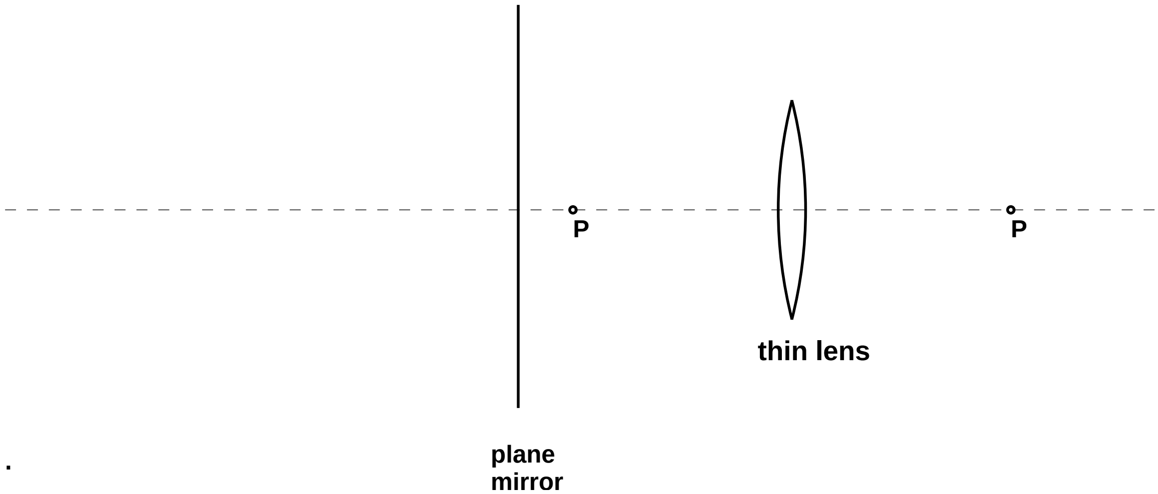



Assume that two plane mirrors have been placed together as shown so that they make an angle $\theta$ one mirror surface relative to the other. The result is that some rays of light that intersect the mirror may bounce more than once as shown in the example ray above.

**Part (a):** Consider the case that $\theta = 90°$. Suppose an object is placed somewhere in the region between the two mirror surfaces. Show that there are three virtual images of this object.

**Part (b):** Now suppose that $\theta = 10°$. Can you find a way to determine the number of virtual images? What would you "see" if you were the standing in the narrow space between these two mirrors? What is the "rule" for the number of virtual images that appear as a function of the angle $\theta$? Hint: the problem you considered for Problem 1, Part (c) is exactly the same as this problem in the limit where $\theta$ goes to zero.

**Problem 3: From a previous final exam:**




A thin lens with a diameter of 4.00 cm is placed in front of a plane mirror as shown. The focal length of the lens is 4.00 cm. We define the position of the lens as $x = 0$. The mirror is at position $x = 5.00$ cm and the two focal points of the lens are at $x = +4.00$ cm and $x = -4.00$ cm indicated by the letters "P" as shown above.

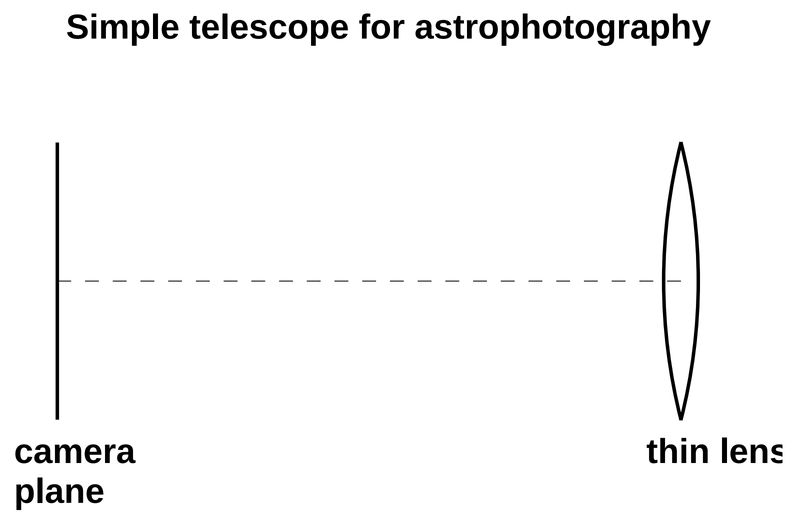
**Part a)** The mirror will make an *image* of the lens. What is the location of the image of the lens? Is this a real or virtual image? Draw the image on the figure above.

**Part b)** Now since the mirror creates an image of the lens, the lens can also create an image of the image of the lens. Use the Lens Equation to determine the position of this image. Also, on the diagram above draw three principle rays to indicate the rays from the image of the lens to the image of the image of the lens. Is the image of the image of the lens upright or inverted? Is it real or virtual? Explain your work.

**Problem 4:**

A lit candelabra is located 5.0 meters from a screen. Determine the focal length and location of a lens needed to form an real inverted image that is three times the size of the candelabra. Please also draw a careful “ray trace diagram” that shows how this optical system actually works.

**Problem 5:**




A simple telescope is used for astrophotography (taking pictures of the stars). The stars are (of course) at a great distance. The diameter of the entrance lens of the camera is $d$.

**Part (a):** A student says, "We should put the camera plane at a distance from the lens that equals the focal length, $f$." Is the student right or wrong? Explain. Hint: perhaps the "lens equation" is helpful here.

**Part (b):** The ratio of angular size in the sky over the physical distance in the camera plane is called the "plate scale". What is the plate scale for this system in terms of $f$ and/or $d$? Hint: if angle is measured in (unitless) radians of angle, then the units of the plate scale should be inverse length.

**Part (c):** Suppose after taking photographs of the stars you decide to use the same telescope camera system to take a photo of a deer which is located at a finite distance $D$ from your camera. The effect of focusing changes the distance between the lens and the camera plane. By how much and in what direction must you change the lens-to-camera plane distance so that the image of the deer is sharply focused on the film?