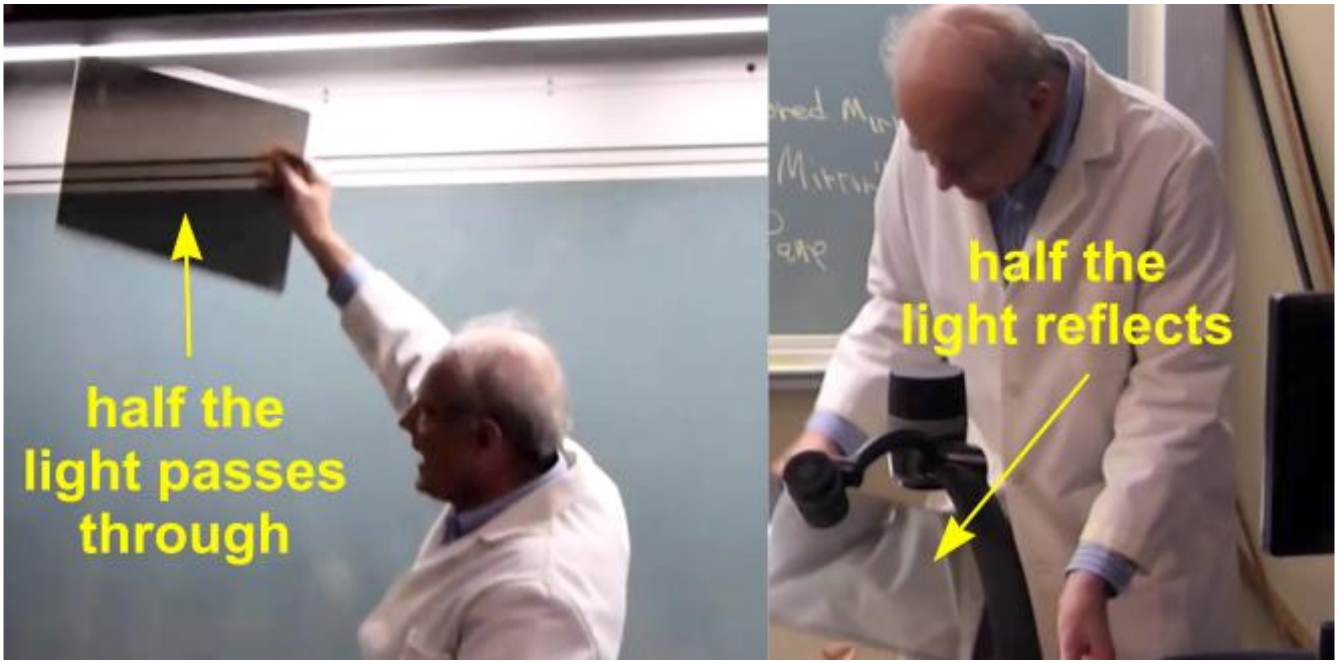
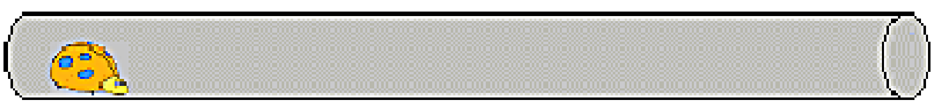
HW-D1. Half-Silvered Mirror. A half-silvered mirror (HSM) is a mirror not fully silvered so that when light hits the mirror, half of the light goes straight through the mirror, while half of the light reflects according to the usual law of reflection. Sometimes the mirror is called a "Translucent Mirror," "Mirror Pane," by the trademark name "Mirropane," a "Two-Way Mirror," and erroneously a "One-Way Mirror."



There is a bug at the end of a long dark cylindrical tube opened at the right end. Your task is to arrange a flashlight (source of light), a half-silvered mirror, and observer so that the observer can see the bug illuminated with light from the light source. The tube is opaque, which means that light cannot enter the tube from the cylindrical region. However, light can enter through the open end at the right.

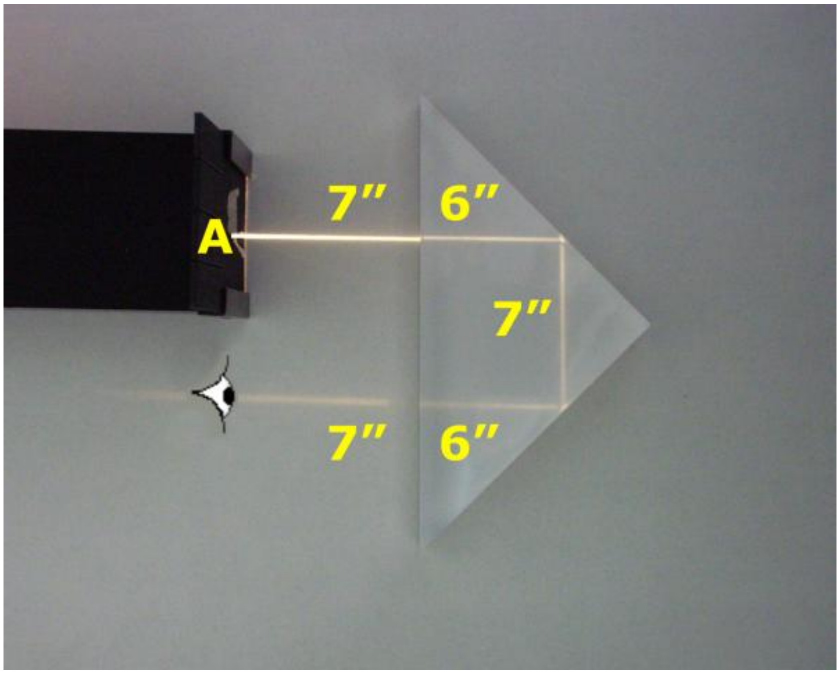


Carefully give a ray diagram with the bug in the tube as is, the other items in their proper places, and the mirror oriented correctly (i.e., vertical, horizontal, or slanted in some way).

Finally, sketch a ray of light from the light source and show all the necessary light rays to demonstrate that light indeed reaches the bug and eventually returns from the bug to the observer. Place a cute little arrow on each light ray near the middle of each ray so that the reader can easily know the path the light is taking during all legs of the journey.

You may consider this problem as a proof by a ray diagram. To receive full credit, the laws of physics must be satisfied for all of your light rays and all light directions must be indicated by appropriate arrows as described above.

HW-D2. Porro Prism.



Original Photo Courtesy Wikimedia: Zátonyi Sándor, (ifj) Fizped

A light source sends light East toward a porro prism. The light reflects from the upper slanted surface by total internal reflection. The reflected light proceeds South and again undergoes total internal reflection at the lower slanted surface. The reflected light from this lower surface heads West to the observer.

You can consider the rays in the figure as perfectly horizontal or vertical. Distances are given in inches.

Sketch the entire configuration shown here and add the location of the virtual image for Point A. Label the location of the virtual image for A as A'. Include any relevant additional lines that assist in locating A'. Remember to use dotted lines whenever you trace rays backwards to locate virtual images and never place an arrow on a dotted extended line since light is not there.

HW-D3. Concave Mirror. (a) Math. Use mathematics to determine the distance s_o that an object needs to be placed in front of a concave mirror with focal length f so that the magnification is -3, i.e., 3 times as large but inverted. Also find the distance s_i that the image is located from the mirror. (b) Ray Diagram Design Drawing. Use a ruler to give a nice engineering ray diagram that illustrates such an arrangement. Your diagram should be sharp and clean, best accomplished with graph paper. From the graph-paper boxes you can should clearly indicate distances and height comparisons for magnification. As an example, if the height of your object is 4 boxes or blocks tall, then your image height should be 12 boxes or blocks in length at the appropriate image location. Be sure to always label each ray with a cute arrow somewhere near the middle of the ray, indicating the direction of light travel. And whenever you need to extend a ray behind a mirror for analysis, always use a dotted line and never place an arrow on such a line since light is not there. Similarly, the convention for virtual images is to use a dashed vertical line whenever you sketch a virtual image: a dashed line with a hat "^" on top to represent the top of the image like we do for the object.

Grading and Philosophy. As with all engineering design diagrams, architectural layouts, and surveyor plots of land, you know you have an excellent diagram if you want to look at it longer and admire it as a work of art. Evaluate your finished product in this fashion. Grading of your assignment will include points for an elegant drawing that is pleasing to the eye. From hanging out with engineers, I learned that some engineering courses are classified as design courses and these carry much prestige. By being able to produce such design work, in addition to mathematical analysis, a physics major becomes more powerful and marketable for jobs.

HW-D4. Concave Mirror Engineering Design. Design a magnifying make-up mirror for a wall in a theatre dressing room with any diameter of your choice so that when an actor is 20 cm from the mirror, the magnification is 3x and upright.

a) Math. Use mathematics to determine the radius of curvature for the mirror.

b) Ray Diagram Design Drawing. Give a nice engineering diagram to proper scale illustrating the arrangement where an object is 20 cm from the mirror. A diagram on graph paper is highly recommended.

Be sure to indicate the diameter width dimension of your choice and the radius dimension in the diagram since the manufacturer will use these specs to shape and cut the mirror.

Caution. Note that your radius relevant for the focal length is in the third dimension with respect to the mirror surface. So that your choice for the diameter of the mirror width has nothing to do with your calculated radius of curvature in the direction perpendicular to the mirror.

Your completed diagram should show all the relevant ray-tracing parameters such as the center of curvature, the focal point, the focal length, also the radius in this case, the height of the object, the height of the image, the object distance, the image distance, and two key rays from the object to the image. All relevant dimensions should be labeled. All light rays should have a cute arrow somewhere near the middle of the ray to indicate light direction. Any needed extended lines behind the mirror must be dashed lines since light does not really go there. These dashed line must not have arrows on them since they are not light rays. And a virtual image must always be made with dashed lines since light is not there: a dashed line with a hat "^" on top to represent the top of the virtual image.

HW-D5. Convex Mirror Engineering Design – Reverse Engineering. You are going to reverse engineer in this problem. Reverse engineering is figuring out the design specs from studying an actual product already designed and built. NO DIAGRAM IS REQUIRED. You have done enough diagrams for this homework set.

You will reverse engineer the wide-angle safety mirror for the Edgewood-Wildwood intersection. Such a mirror allows drivers and pedestrians to see other cars and pedestrians over a large range of angles very easily.

In the photo you are looking down Edgewood Road toward Merrimon Avenue. The wide-angle mirror you are reverse engineering is at the left in the photo and Wildwood Avenue is the road entering from the right.

From the left photo we can estimate that the diameter of the mirror is 2 ft. The tree is about 1.5 ft.

I am $h_o = 6\text{ ft}$ tall and I am standing across the street a little way into Wildwood Avenue. My distance from the mirror is about $s_o = 25\text{ ft}$, somewhat more than the width of Edgemont Road.

In the photo below you are seeing me standing on Wildwood Avenue. The house behind me is on Wildwood.

My small virtual image appears in the photo. I determined the size by carefully placing a ruler up to the computer screen and measuring first the diameter of the mirror and then my image height. Your monitor will be of a different size than mine but we would both get the same ratio. I found the ratio of my image height to the mirror diameter being very close to $\frac{1}{7}$, which makes my image height about $h_o = \frac{1}{7} \cdot 24\text{ inches} = 3.4\text{ inches}$.

So let's approximate the my magnification as $M = \dfrac{3.4\text{ inches}}{6 \cdot 12\text{ inches}} = \dfrac{1}{20}$. You are now all set.

Use math to calculate the focal length f of the mirror and its radius of curvature R, each to two significant figures. Note that by convention a minus sign is included for the focal length of a convex mirror.