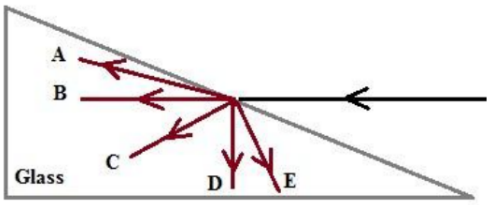
An Introduction to Optics - Solutions

Hitesh Yalamanchili

May 22, 2015

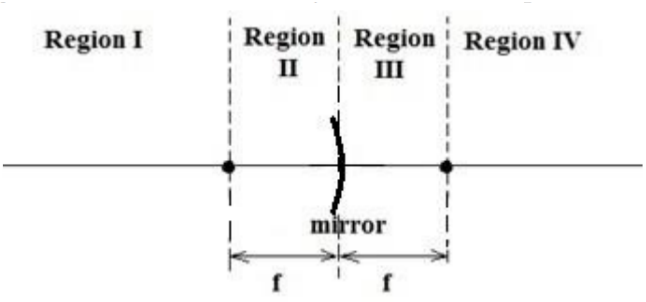
1. Where is the image of an object placed 7 centimeters away from a 5 centimeter focal length convex lens? Concave mirror? Are the images real or virtual in each case? [Easy]
Solution: A convex lens has a positive focal length. We can apply the lens equation: $\frac{1}{f} = \frac{1}{s_o} + \frac{1}{s_i}$. This gives: $\frac{1}{5} = \frac{1}{7} + \frac{1}{s_i}$. Solving for s_i, we find $s_i = 17.5$ centimeters. The image is real since s_i is positive. A concave mirror also has a positive focal length so we get the same result (the image is real and 17.5 centimeters in front of the mirror).

2. Light of wavelength 600 nm is transmitted from air (n = 1) into a piece of glass (n = 1.5). Which one of the labeled arrows best indicates the path of the light ray after it enters the glass? [Easy]



Solution: As the light enters a medium with a higher index of refraction, it bends toward the normal. We need to look at the figure to determine which way that is directed. Since the angles are measured from normal to the surface, that angle must decrease in the glass, meaning that the ray travels along C.

3. A concave mirror with focal length f is shown in the figure. A real object is now placed to the left of the mirror. In theory, in which regions is it impossible for an image to form from the mirror, regardless of where the object is placed to the left of the mirror? [Medium]



Solution: By placing the object in Region I, the image formed will be real and located in Region I. Once inside the focal length of the mirror, the image formed will become virtual and appear on the right-hand side of the mirror. Using the mirror equation, we can compute the image location using the object location as nf where n is a number. We have then $\frac{1}{f} = \frac{1}{nf} + \frac{1}{s_i}$, leading to $s_i = \frac{n}{n-1}f$. For example, letting $n = \frac{3}{4}$, then $s_i = -3f$, which is in Region IV, while if $n = \frac{1}{4}$, then $s_i = -\frac{1}{3}f$ which is in Region III. It is impossible to form an image anywhere in Region II.

4. Why does a plane mirror only reflect from left to right? [Tricky]
   Solution: The two easiest directions to define for any human are the up-down and the front-back directions. Since left and right are simply defined as the cross product of these two strong directions, we perceive mirrors to reflect from left to right. This is because the person standing behind the mirror has a front direction defined differently from the person standing before the mirror, leading to a cross product for both left and right that are inverted. Thus, the left for the person or object standing in front of the mirror is the right for the image of the person or object behind the mirror and vice versa.