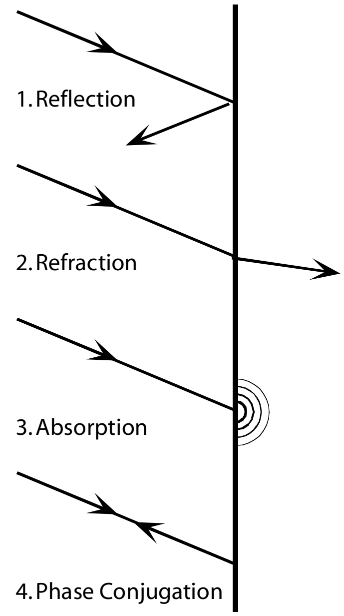
PhyzGuide: Plane Old Reflection

WHEN A WAVE HITS

When a wave encounters a boundary, a number of things can happen.
1. **Reflection**. Most or some portion of the wave may undergo a complete or partial reversal in direction.
2. **Refraction**. Some portion of the wave may continue through a second medium.
3. **Absorption**. Some portion of the wave may pass into a second medium in which it dissipates as random motion or thermal energy among the particles of that medium.
4. **Optical phase conjugation**. (Electromagnetic waves.) Light rays come back along the exact path of incidence regardless of the angle of incidence.

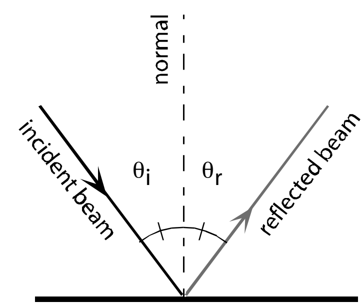
Refraction is a topic that will be covered soon; absorption and optical phase conjugation (also known as "time reversal") are topics for another course. Our attention here will be devoted to reflection.



THE LAW OF REFLECTION

Consider a ray of light approaching a boundary at an angle. This ray is called the **incident ray**. The angle it makes with the boundary is not given a name. Where the ray meets the boundary, a normal is drawn. The angle between the incident ray and the normal is called the **angle of incidence**. Upon striking the boundary, incident light is reflected. The ray that emerges is called the **reflected ray**. The angle between the normal and the reflected ray is called the **angle of reflection**.

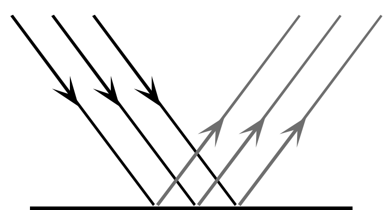
It has been found that the angle of reflection is always equal to the angle of incidence. This finding is called the law of reflection: $\theta_r = \theta_i$.



The law of reflection: $\theta_i = \theta_r$

SPECULAR REFLECTION

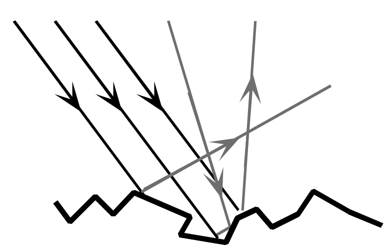
When light reflects from a smooth surface, it maintains its geometry. Incident parallel rays reflect as parallel rays. This is called **specular reflection**. For a surface to produce a specular reflection, its irregularities must be small compared to the wavelength of the waves. A surface "smooth" to radio waves can appear very irregular to visible light.



Specular reflection from a smooth surface

DIFFUSE REFLECTION

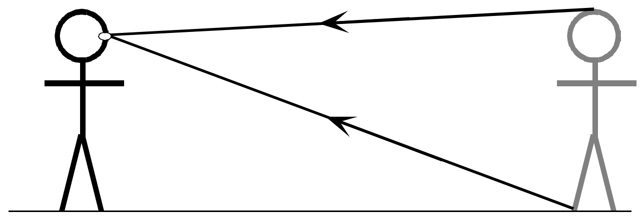
When a surface has irregularities that are significant compared to the wavelength of a wave, **diffuse reflection** occurs. The law of reflection still holds, but incident parallel rays do not reflect as parallel rays. The reflected rays come out in all directions. Light reflects diffusely from relatively rough surfaces. Paper, whiteboards, your nose, etc.



Diffuse reflection from a rough surface

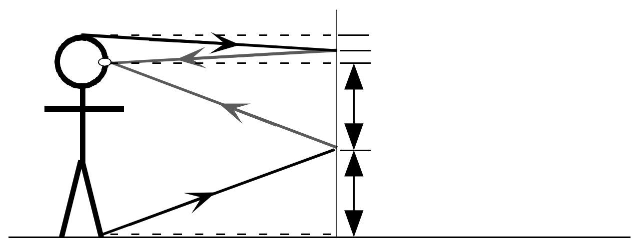
WHAT YOU SEE WHEN YOU LOOK IN A MIRROR

Beauty by the boatload? Mucho machismo? Oops, sorry; that's what *I* see when *I* look in a mirror. But let's talk about you for a moment. Before you start ogling yourself in the mirror, consider what you see when you look at a friend. You see your friend of course. But how? Remember that light reflects from your friend diffusely in all directions. Light reflected from your friend enters your eyes. Light from the top of your friend's head enters your eyes. Light from your friend's feet enters your eyes. If your friend is 10 m away, your eyes focus at 10 m. Pretty simple, eh?

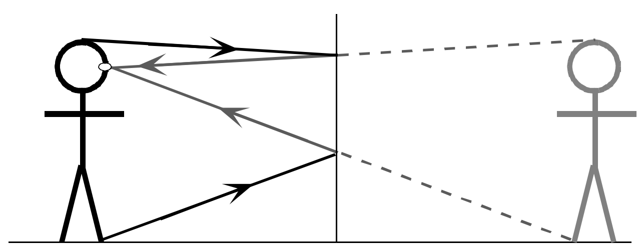


Now we're ready for the mirror. Your friend is gone but there is now a mirror 5 m in front of you. The mirror extends from the floor to the ceiling. Light is reflecting diffusely from you. One ray coming from your foot will hit the mirror and reflect into your eye. So will one from the top of your head. So you will be able to see your whole body in the mirror.

The light that travels from your foot to your eye strikes the mirror half way up from your foot level to your eye level. The light that travels from the top of your head to your eye strikes the mirror half way down from your head-top level to your eye level.



But the image you see does not exist on the surface of the mirror. The light traveled 5 m to the mirror and 5 m to get from the mirror back to your eye. So your eyes focus 10 m away. Your brain believes that light that comes to your eyes has followed a straight path from the source, and therefore believes the source lies at the end of that straight line. And so your *image* is as far behind the mirror as you are in front of it.



So how much of the wall actually needs to be mirrorized? Suppose the wall is not mirrorized below point A or above point B. Could you still see yourself in the mirror? How far is A from B?

Could you use a smaller mirror if you backed away from it? What happens to the amount of mirror you need as you get farther from it? Consider the diagram below and determine an answer.