Light and Flat Mirrors

by

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P4.8 Wave Behavior — Reflection and Refraction

The laws of reflection and refraction describe the relationships between incident and reflected/refracted waves.

P4.8A Draw ray diagrams to indicate how light reflects off objects or refracts into transparent media.

P4.8B Predict the path of reflected light from flat, curved, or rough surfaces (e.g., flat and curved mirrors, painted walls, paper).

P4.9B Explain how various materials reflect, absorb, or transmit light in different ways.

Items;

1- Light and Mirrors

2- Reflection

3- Image Formation by Plane Mirror

LIGHT AND MIRRORS

The speed of light in a vacuum is constant, and has a value of 3.00×10^8 m/s.

Since, in most applications, light travels in straight lines, rays are used to represent the transmission of light from a source.

Light travels in a straight line until it strikes an object. If the object is opaque, like a piece of wood, the transmission of light is interrupted. If the object is transparent, like a piece of glass, light passes through.

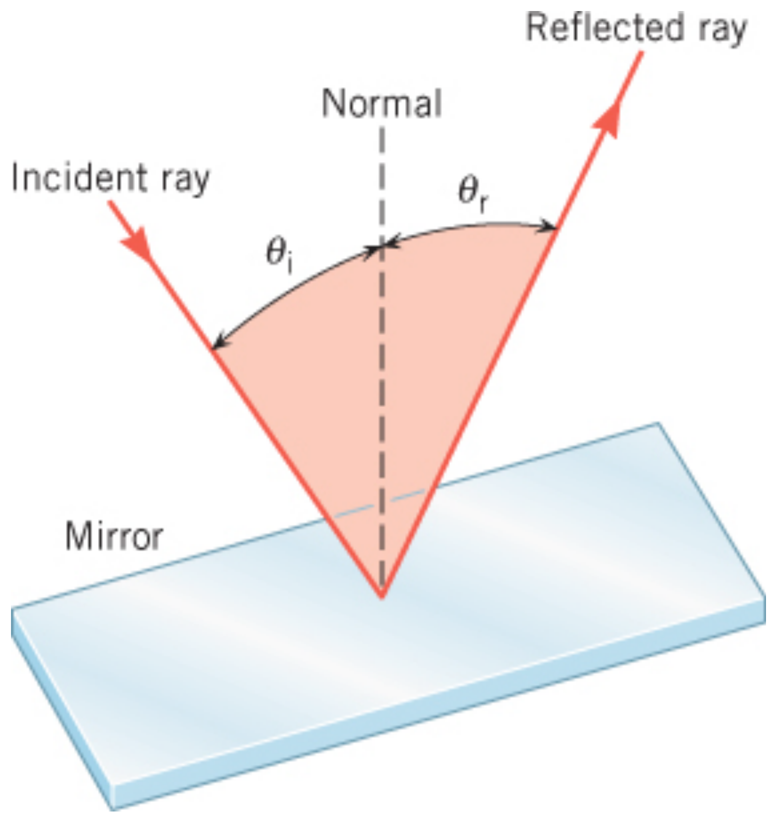
Mirrors and highly polished opaque surfaces reflect light in predictable ways.

An image that can be formed on a screen is called a real image. An image that cannot be formed on a screen is called a virtual image.

TERMS OF LIGHT REFLECTION

Physicists use the following terms to describe the reflection of light:

- The ray approaching the mirror is called the **incident ray.**
- The ray reflected by the mirror is called the **reflected ray.**
- The point where the incident ray strikes the mirror is called the **point of incidence**.
- The construction line drawn at right angles to the mirror at the point of incidence is called the **normal**.
- The angle between the incident ray and the normal is called the **angle of incidence (θ_i)**.
- The angle between the reflected ray and the normal is called the **angle of reflection (θ_r)**.

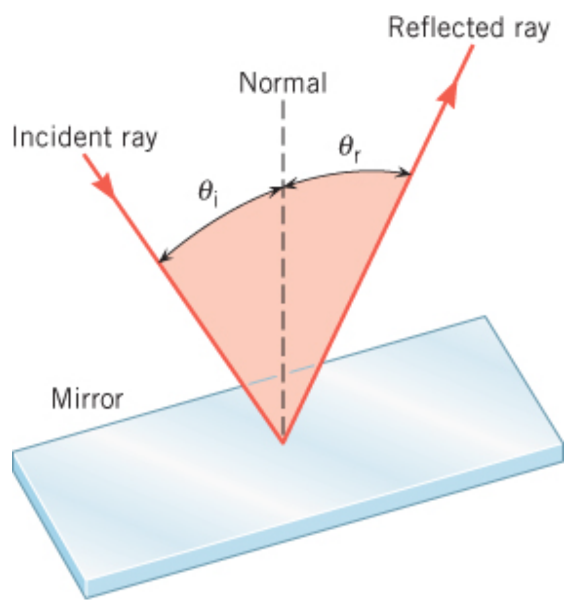

Reflected ray
Normal
Incident ray
θ_r
θ_i
Mirror

LAW OF REFLECTION FROM FLAT MIRRORS

The incident ray, the reflected ray, and the normal to the surface all lie in the same plane.

The angle of incidence, θ_i, equals the angle of reflection, θ_r.

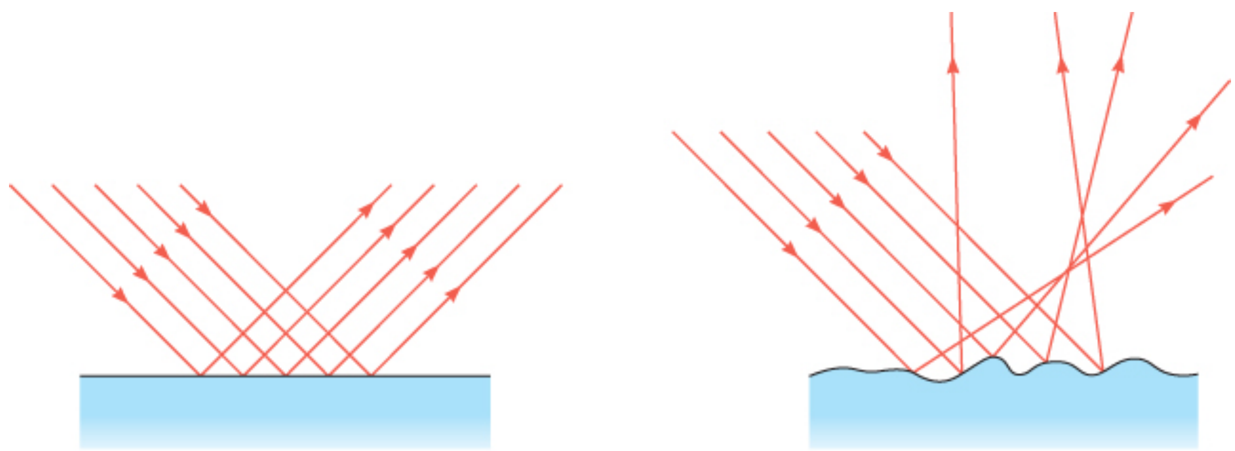
$$\theta_i = \theta_r$$



SPECULAR REFLECTION, DIFFUSE REFLECTION

In specular reflection, the reflected rays are parallel to each other (figure a below). Examples of flat, reflective surfaces are mirrors, polished metal, surface of a calm pond of water.

In diffuse reflection, light is reflected in random directions (figure b, below). Examples of rough surfaces are paper, wood, unpolished metal, surface of a pond on a windy day.



(a) Specular reflection

(b) Diffuse reflection

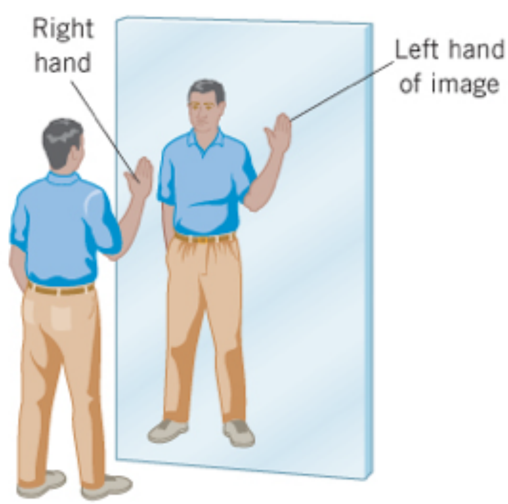
FORMATION OF AN IMAGE BY A PLANE MIRROR

The characteristics of an image are its orientation, size, and type (real or virtual).

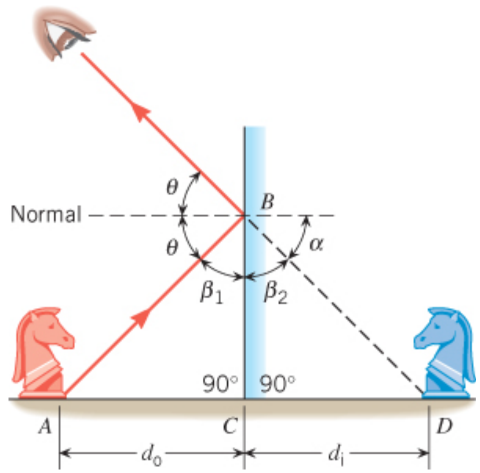
Your image in a flat mirror is virtual and has four properties:

1. It is upright.
2. It is the same size as you are.
3. The image is as far behind the mirror as you are in front of it.
4. It is reversed, left <--> right

The person’s right hand becomes the image’s left hand.



(a)

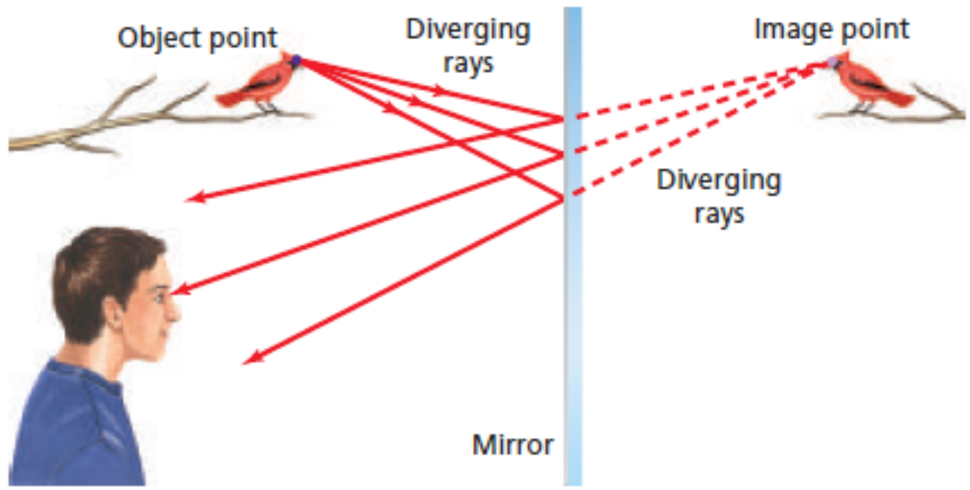


A ray of light leaves the base of the real object (red horse), strikes the mirror at the angle of incidence and is reflected at the same angle. To the eye, this ray appears to come from the base of the image (blue horse). The image is virtual because the light do not actually come from the image. The image is located at the same perpendicular distance behind the mirror as the object is in front of it.

$$d_o = d_i$$

$$\theta = \alpha$$

$$\beta_1 = \beta_2.$$



The reflected rays that enter the eye do not intersect in front of the mirror, but appear to originate at a point behind the mirror. The image can be located behind the mirror by extending the reflected ray backward as dotted lines. The extended rays intersect at the image. Therefore, the image formed is virtual. This virtual image can not be projected onto a screen.

To be able to see the object, the eye has to be in an appropriate location to catch the rays that form the image.

Example 1: *Sunlight from the sun to Earth;*

The average distance from the sun to the Earth is 1.5×10^{11} m. How long (in minutes) does it take for sunlight to reach the Earth? The speed of light (S_{light}) is 3.00×10^{8} m/s.

Data Table		
d	S_{light}	t
1.5×10^{11} m	3.00×10^{8} m/s	?

Speed = Distance / Time

or

Time = Distance / Speed

Time = Distance / Speed = $1.5 \times 10^{11} / 3.00 \times 10^{8} = 5.0 \times 10^{2}$ s, or 8.3 minutes.

Example 2: *Emergency Vehicles;*

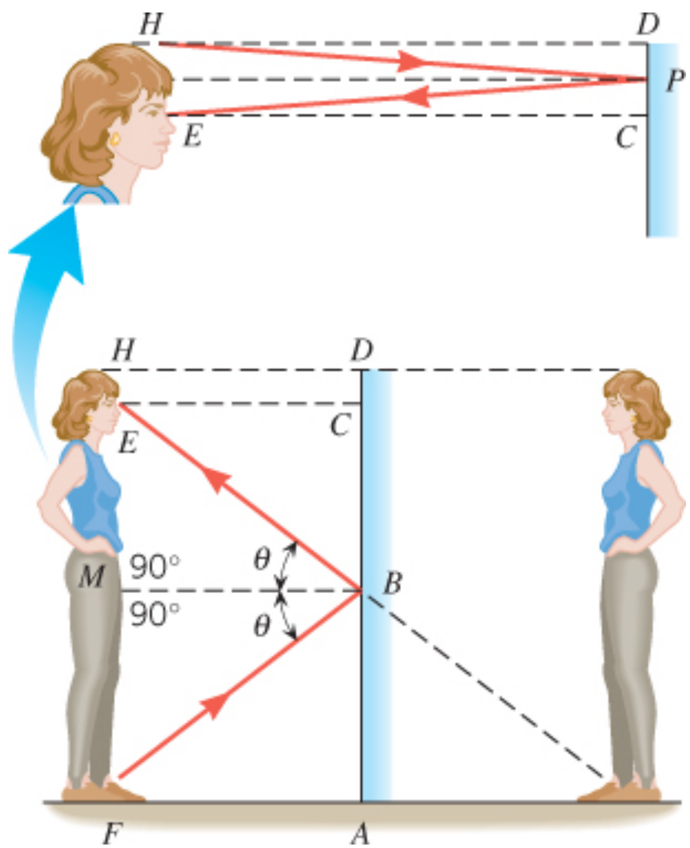
Many emergency vehicles are reverse-lettered (see the word Ambulance in the front of the vehicles in the picture below). The lettering appears normal when viewed through the rearview mirror of a car traveling in front of the emergency vehicle.

Example 3: Minimum Height of a Mirror;

A woman is standing in front of a plane mirror. She needs only a half-length mirror to see her full image.

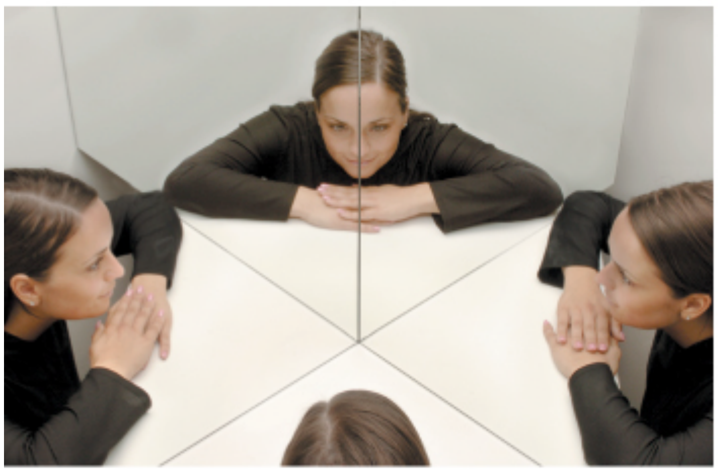
section CP = section PD

section BC = section BA

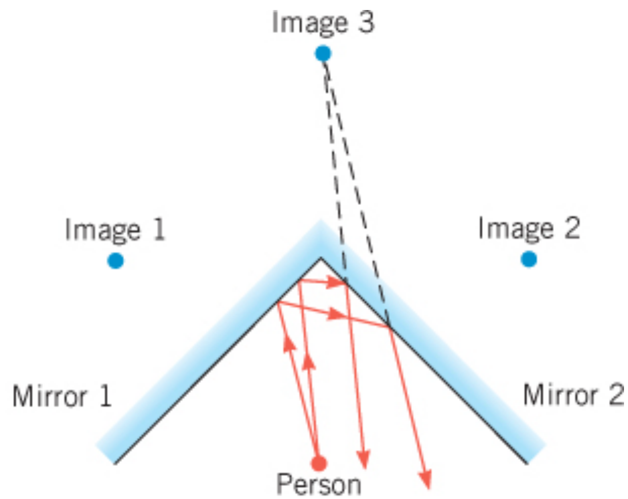


Example 4: *Multiple Images;*

Two or more mirrors produce multiple images. A person is sitting in front of two mirrors that intersect at a right angle. The person sees three images of herself.



(*a*)



(*b*)

References:

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Physics 1200 Lecture Slides: Dr. Thomas Humanic, Professor of Physics, Ohio State University, *2013-2014 and Current.* *www.physics.ohio-state.edu/~humanic/*

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The edition was dedicated to the memory of Stella Kupferberg, Director of the Photo Department:"We miss you, Stella, and shall always remember that a well-chosen photograph should speak for itself, without the need for a lengthy explanation"

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