De Anza College

Optics
Ray Optics

Lana Sheridan

De Anza College

June 9, 2020

Last time

- nature of light
- speed of light

Overview

- ray optics
- reflection
- refraction

Medium in Optics

medium (for mechanical waves)

a material substance that carries waves. The constituent particles are temporarily displaced as the wave passes, but they return to their original position.

We will also use the word "medium" in optics, but we mean something slightly different:

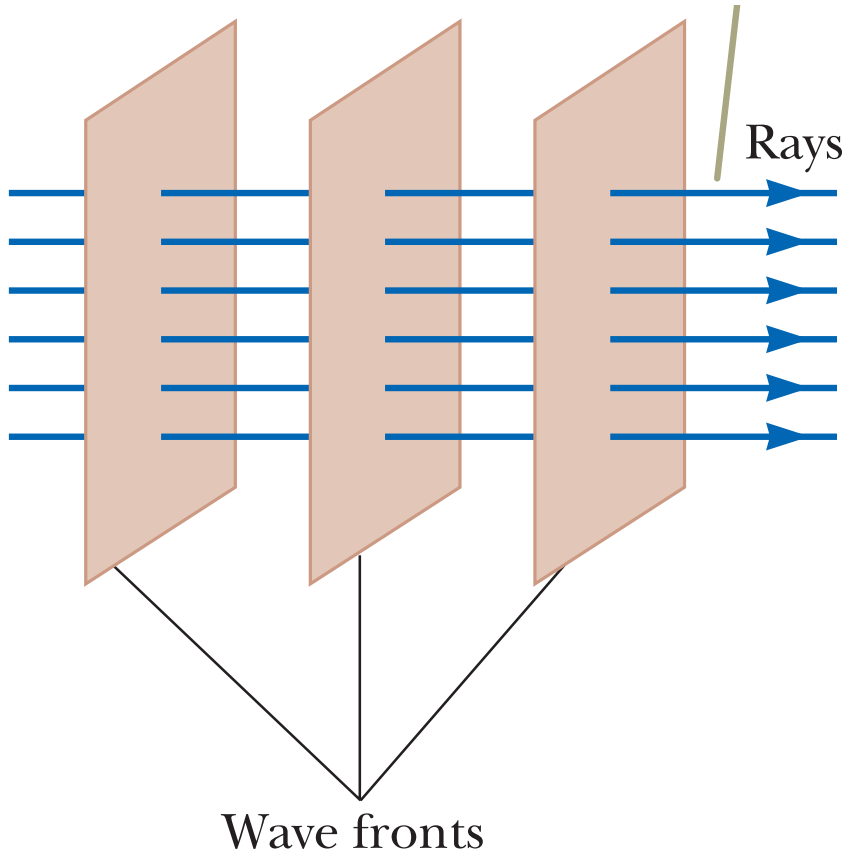
medium (in the case of light)

a material substance that light travels through. The electric field in light can interact with constituent charged particles in the substance.

Light can travel without a medium, so the medium does not "carry" light, it just interacts with the light.

Ray Optics

To study the behavior of light, we represent light as **rays** pointed in the direction of the light's travel.

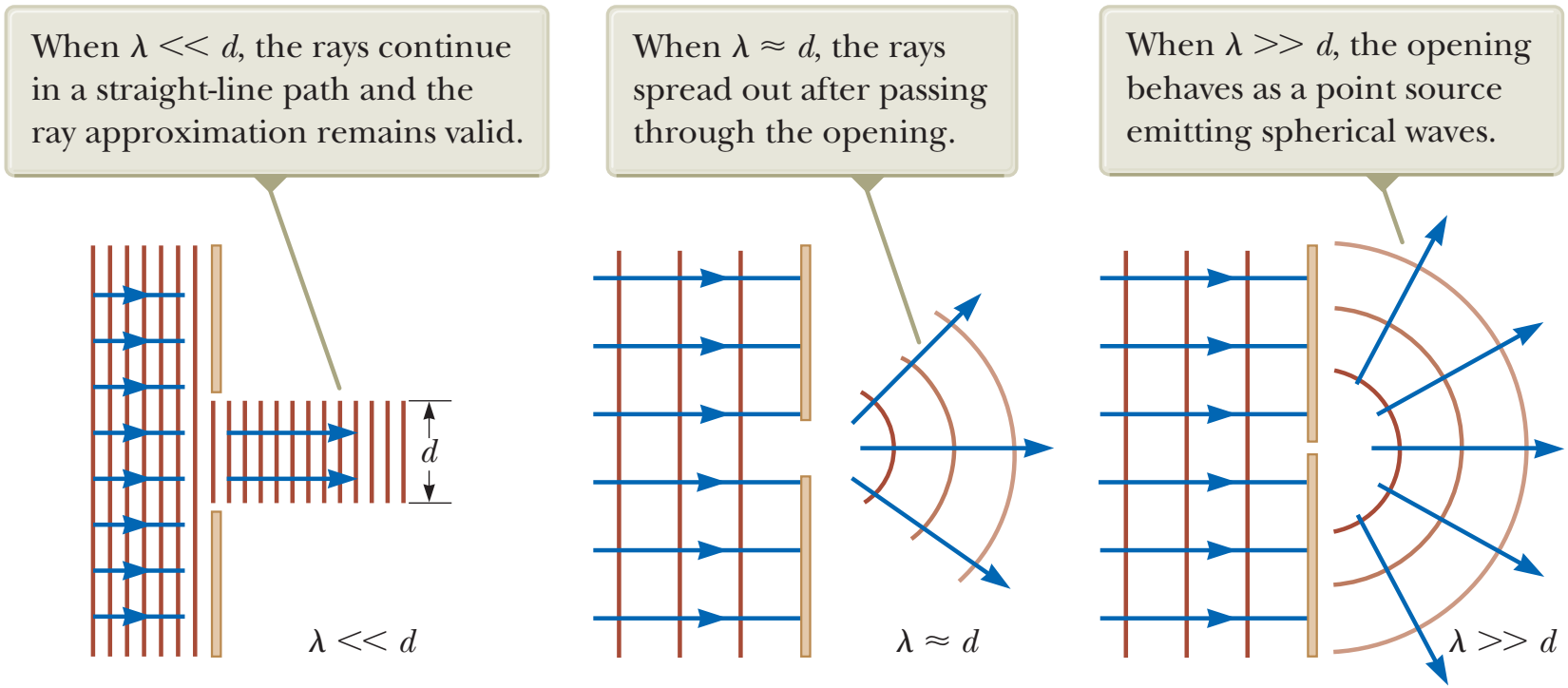


The wavefronts are perpendicular to the rays.

Ray Optics

In ray optics, we assume that light travels in a **straight line** as long as it is in a constant, uniform medium. It can only change direction on reflection, or when it changes medium.

This is not always true, however:



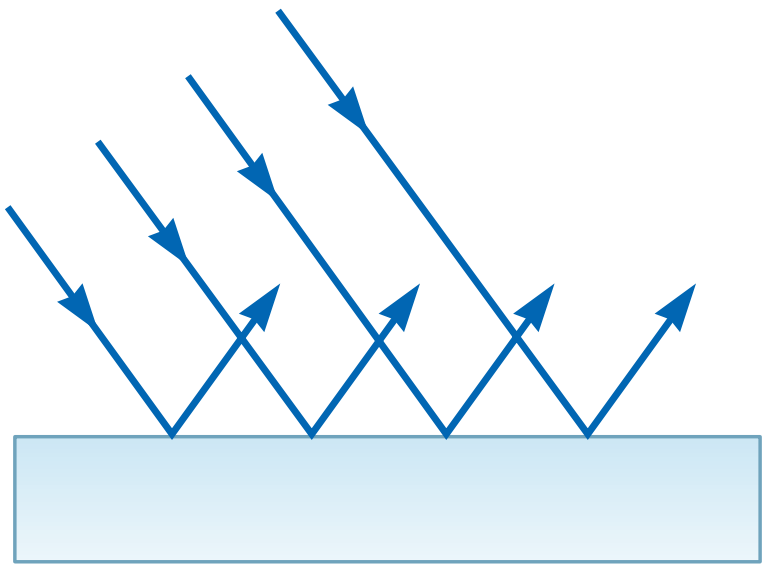
We use ray optics when we can ignore diffraction and interference effects.

Reflection

Just as pulses on strings can be reflected from a fixed or free end of the string, light can be reflected from a surface when there is a sudden change of medium.

When the surface is smooth, we see specular (mirror-like) reflection. If the incoming rays are parallel, so are the reflected rays.

Specular reflection:



[1]Figure from Serway & Jewett, page 1062.

Reflection

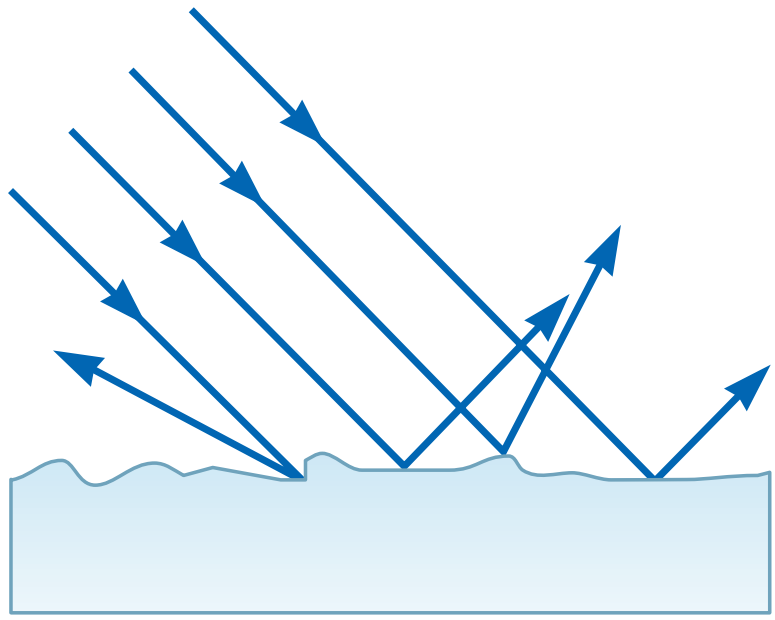
Specular (mirror-like) reflection:

Courtesy of Henry Leap and Jim Lehman

Reflection

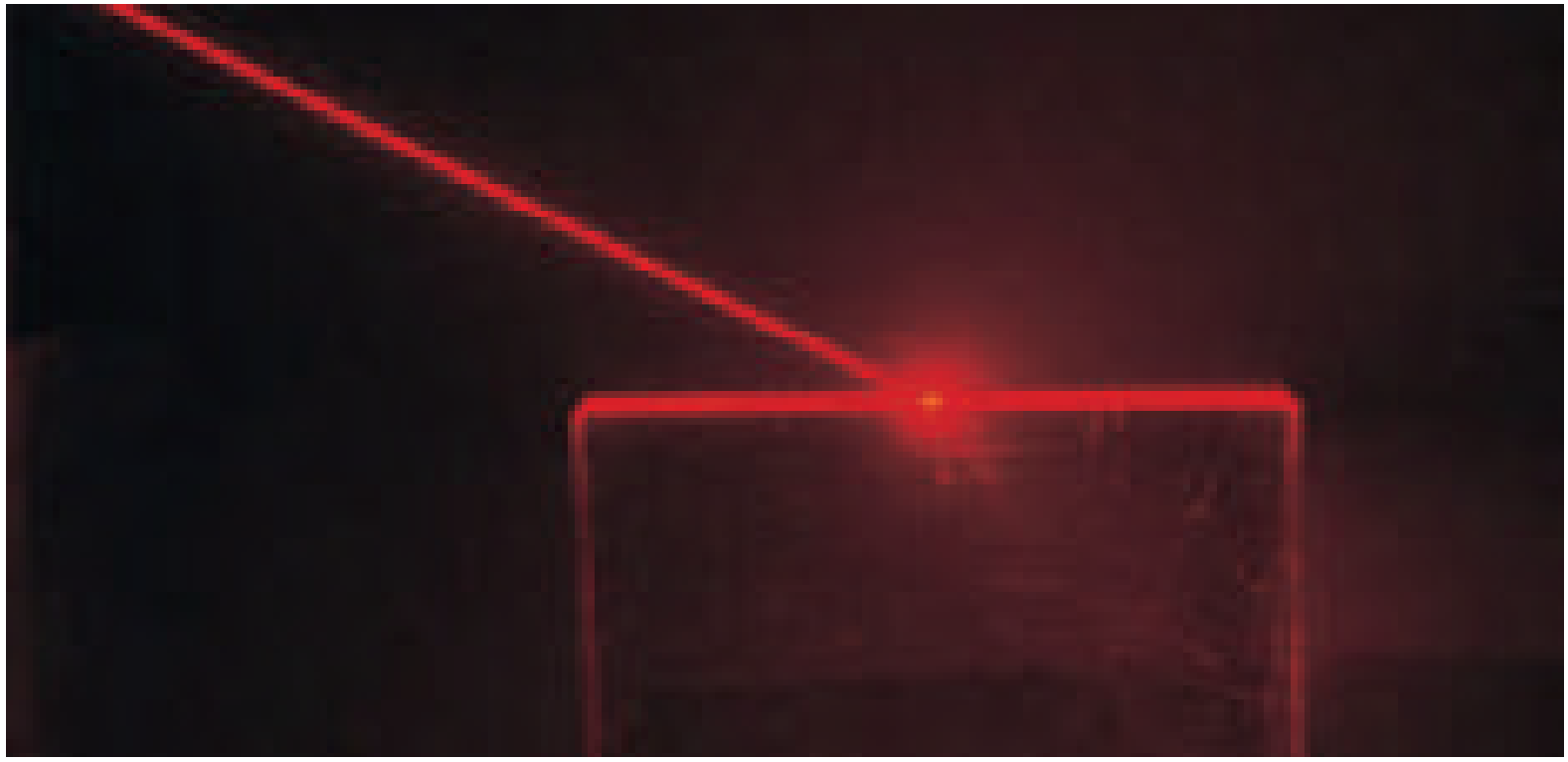
When the surface is rough, we see diffuse reflection. Even when the incoming rays are parallel, the reflected rays are not.

Diffuse reflection:



Reflection

Diffuse reflection:



Courtesy of Henry Leap and Jim Lehman

Why does reflection of light happen?

Incident light is composed of oscillating electromagnetic fields.

This causes oscillating polarizations of individual atoms or molecules (the distribution of their electron clouds change).

The atoms or molecules act like tiny dipole antennas that re-emit electromagnetic waves.

These re-emited waves are the reflected rays.

Metals make particularly good mirrors because the electrons in a metal are free to flow: they form better antennas.

Law of Reflection

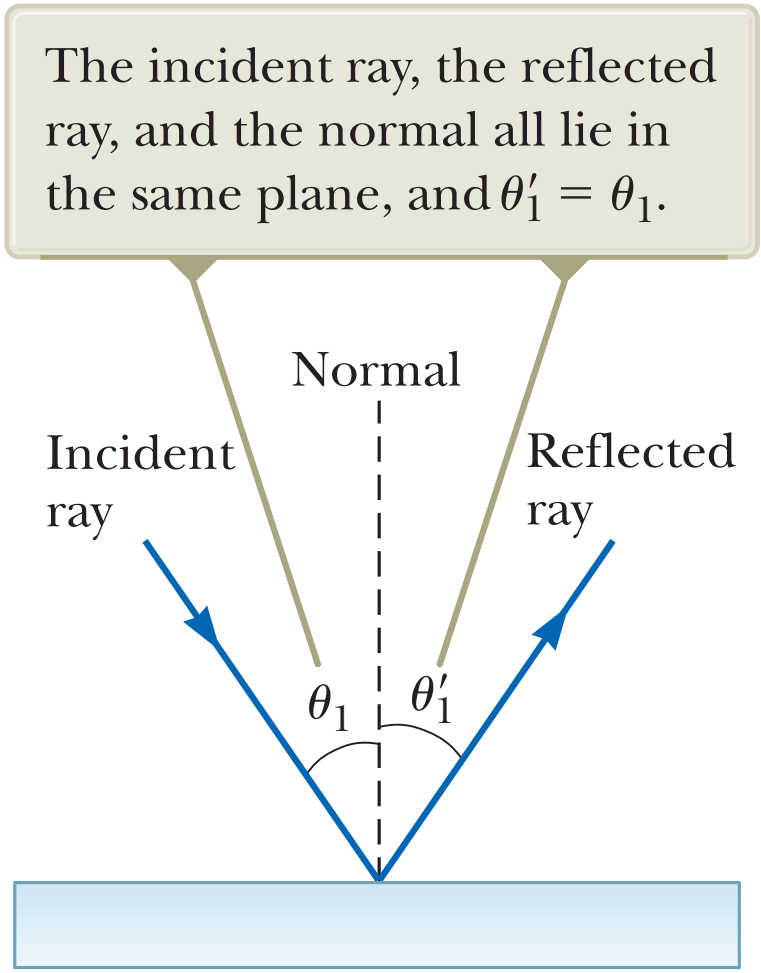
In this course (and in the textbook) "reflection" will refer to specular reflection.

For (specular) reflection, the angle made by the incident (incoming) ray with respect to the normal to the surface is equal to the angle made by the reflected ray with the normal:

$$\theta_i = \theta_r$$

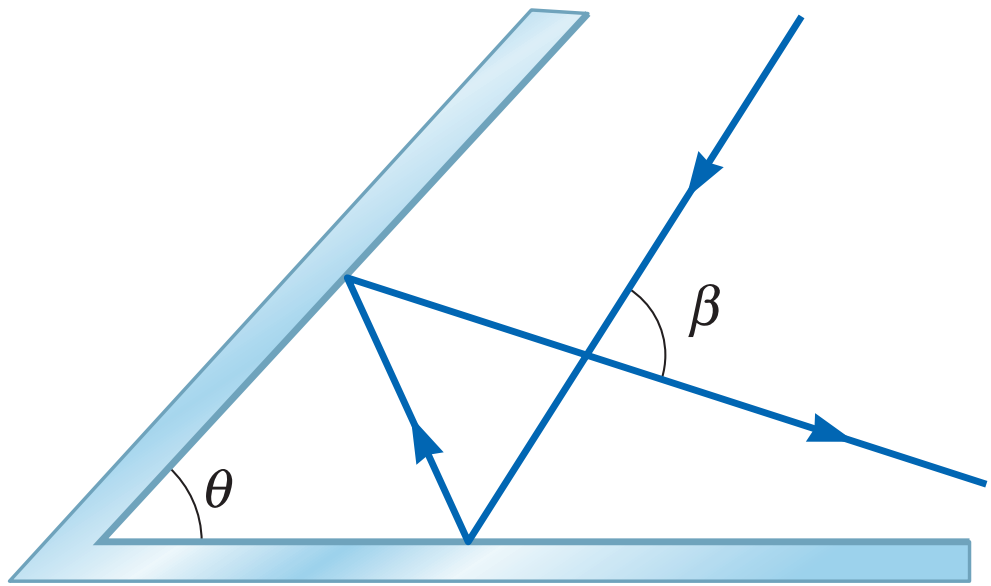
Law of Reflection

$$\theta_i = \theta_r$$



Example, Prob 18, page 1081

The reflecting surfaces of two intersecting flat mirrors are at an angle θ ($0^\circ \leqslant \theta \leqslant 90^\circ$) as shown. For a light ray that strikes the horizontal mirror, show that the emerging ray will intersect the incident ray at an angle $\beta = 180^\circ - 2\theta$.



[1] Compare this problem to example 35.2 in Serway & Jewett.

Retroreflectors

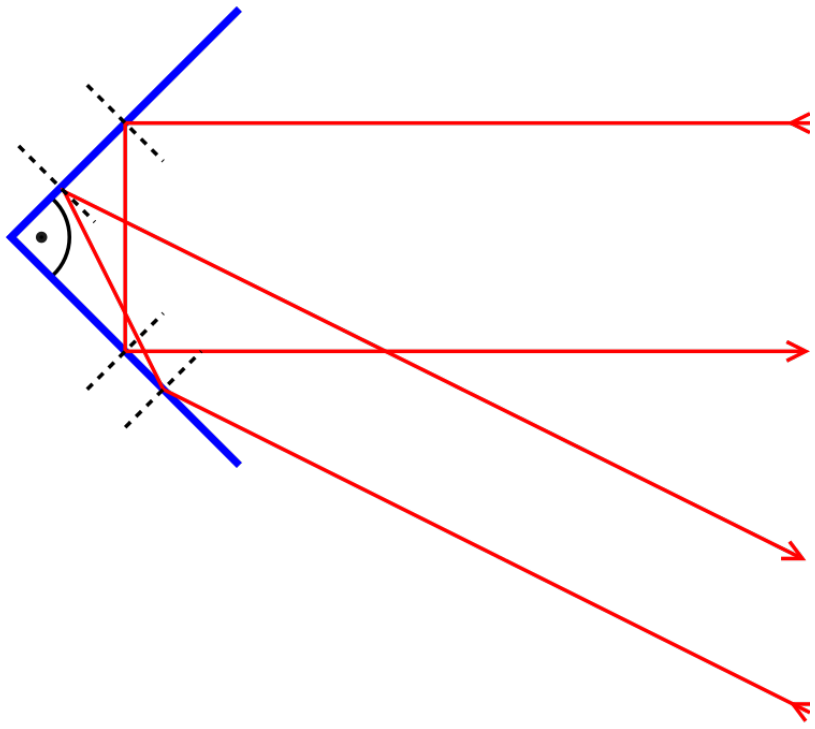
Notice that it doesn't matter at what angle the light strikes the mirror.

Retroreflectors

Notice that it doesn't matter at what angle the light strikes the mirror.

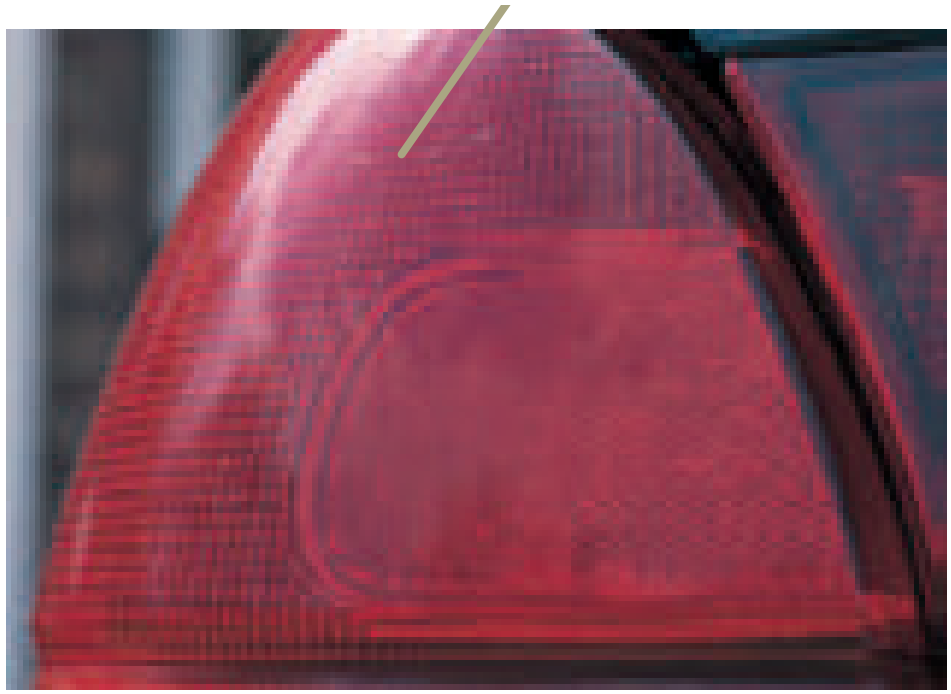
When $\theta = 90°$, $\beta = 0°$.

The reflected light travels back parallel to the incident light, no matter which way the light comes from.



Retroreflectors

A device with mirrors placed like this is called a *retroreflector*.



Summary

- speed of light
- ray optics
- reflection

Homework Serway & Jewett:

- Ch 35, onward from page 1077. OQs: 1, 8; CQs: 4, 15; Probs: 1, 3, 21