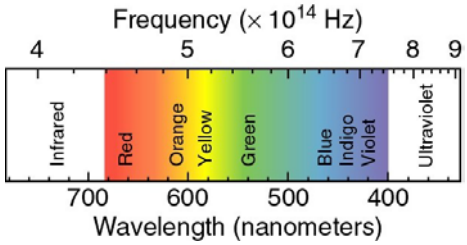
L 32 Light and Optics [2]

- Measurements of the speed of light ←
- The bending of light – refraction ←
  - Total internal reflection ←
  - Dispersion
- Dispersion
  - Rainbows
- Atmospheric scattering
  - Blue sky and red sunsets
- Mirrors

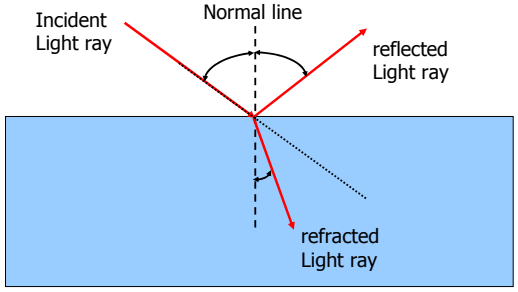
VISIBLE LIGHT



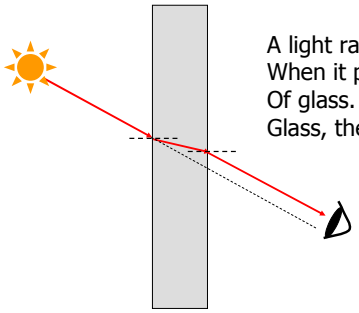
Color ➔ WAVELENGTH OR FREQUENCY

Wavelength × Frequency = c (speed of light)
= 3 x 10^8 m/s

Reflection and refraction at a surface



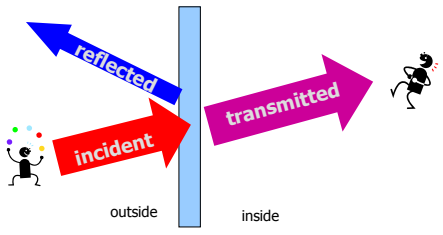
Seeing through the window



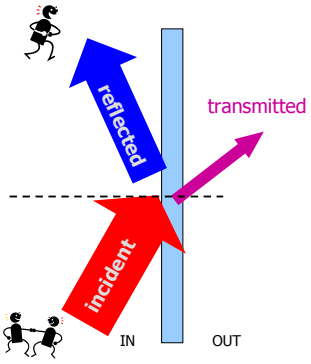
A light ray is offset slightly When it passes thru a pane Of glass. The thinner the Glass, the smaller the offset.

Seeing through a window

When the angle of incidence is small, most of the incident light passes thru the glass, only a small amount is reflected.



Windows behaving as mirrors



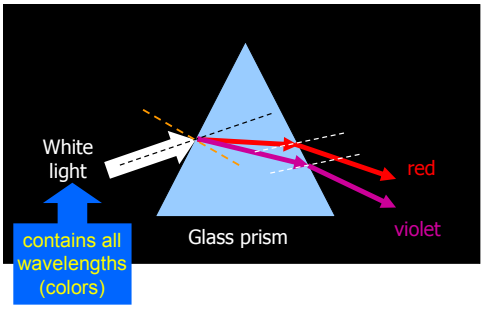
When the angle of incidence is large (grazing incidence) more light is reflected, the window is like a mirror.

The index of refraction (n) depends of the color (wavelength) of the light

color	Wavelength (nm)	n
Red	660	1.520
orange	610	1.522
yellow	580	1.523
green	550	1.526
blue	470	1.531
violet	410	1.538

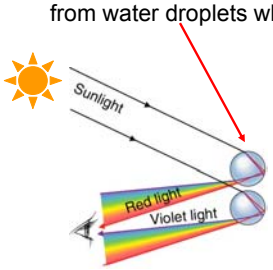
1 nanometer (nm) = 1×10^{-9} m

Different colors are refracted (bent) by different amounts this effect is called << DISPERSION >>



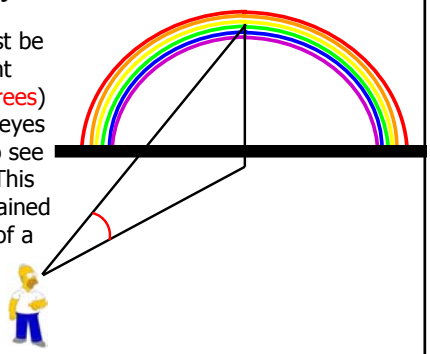
The rainbow

- Rainbows are caused by dispersion of sunlight from water droplets which act as tiny prisms



Why is it a rain BOW ?

The drops must be At just the right Angle (42 degrees) Between your eyes And the sun to see The rainbow. This Angle is maintained Along the arc of a Circle.

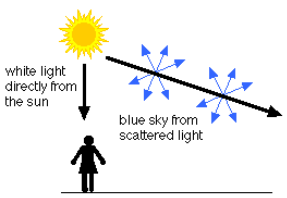


Atmospheric scattering

- Why is the sky blue and sunsets red?
- It is due to the way that sunlight is scattered by the atmosphere (N_2 and O_2)
- *Scattering → atoms absorb light energy and re-emit it but not at the same wavelength*
- Sunlight contains a full range of wavelengths in the visible region

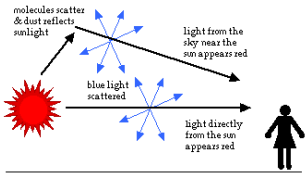
Atmospheric scattering: blue sky

- Short wavelengths are scattered more than long wavelengths
- Blue light (short) is scattered 10 times more than red light
- The light that we see in the sky when not looking directly at the sun is scattered blue light



Atmospheric scattering: red sunset

- At sunset, the sun is low on the horizon
- When looking at the sun it appears red because much of the blue light is scattered out leaving only the red

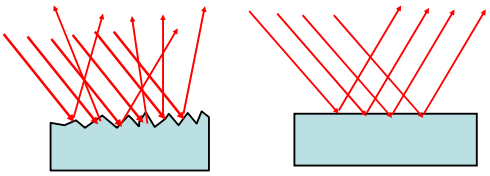


Why are clouds white?

- Clouds consist of *water droplets* and *very tiny ice particles*
- The water and ice scatter the sunlight
- Scattering by water and ice (particles) is very different from scattering by molecules
- The atoms are smaller than the wavelength of light, but the ice and water particles are larger
- Scattering by particles does not favor any particular wavelength so the white light from the sun is scattered equally → clouds are white!

Mirrors ➔ reflection

- Light does not pass thru metals – it is reflected at the surface
- Two types of reflection: diffuse and specular



Diffuse reflection: Fuzzy or no image

Specular reflection: Sharp image

The law of reflection

- The angle of reflection = angle of incidence
- Incident ray, reflected ray and normal all lie in the same plane

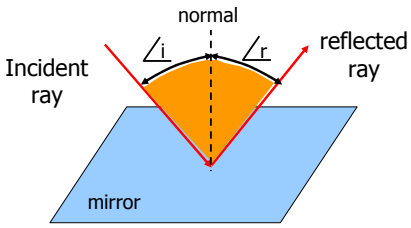
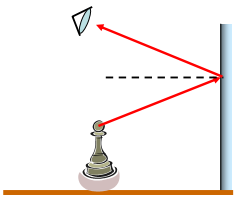
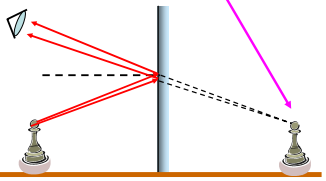


image formation by plane mirrors

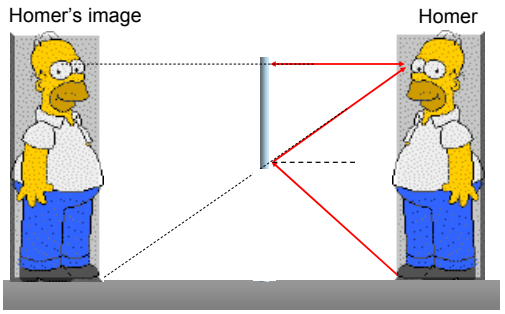


The rays appear to originate from the image **behind** the mirror. Of course, there is no light behind the mirror → this is called a **virtual image**

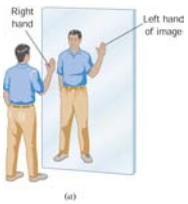


Mirrors appear to make rooms look larger.

You only need a mirror half as tall as you are to see your whole self



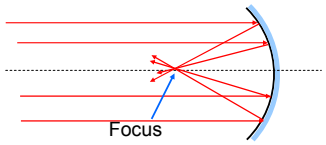
The image of your right hand is your left hand



AMBULANCE is painted backward so that you see it correctly in your real-view mirror

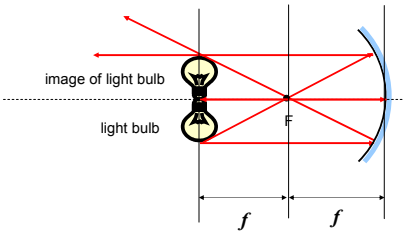
Spherical or curved mirrors

Concave mirror



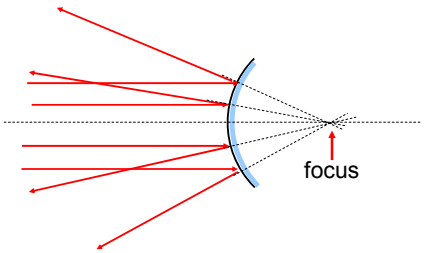
parallel light rays are focused to one point

Where is the light bulb?



A concave mirror will form a *real* image of an object placed at twice its focal length at a distance of twice the focal length. It will be inverted and the same size as the object.

convex mirror



parallel rays diverge from a focus behind the mirror

Dish antennas

signal from satellite

detector at the focal point of the dish

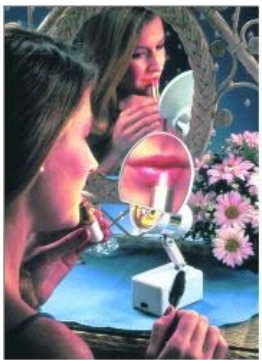
Magnifying mirrors

Homer

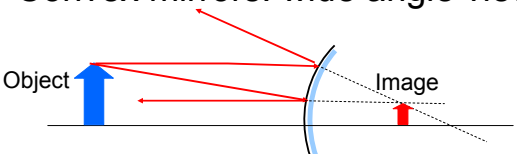
Homer's image

when something placed within the focus of a concave mirror, an enlarged, upright image is formed.
this principle is used in a shaving or makeup mirror

A concave mirror can provide a magnified image as used in this cosmetic mirror.



Convex mirrors: wide angle view



A convex lens provides a wide angle view. Since it sees more, the images are reduced in size. Passenger side mirrors are often of this type with the warning: "objects appear further than they actually are". Because they appear smaller they look further away.