❖ **What is Reflection?**
  o When light strikes a ___shiny, smooth___ surface it bounces off the surface at the same angle it struck the surface
  o Imagine a line ___perpendicular___ to the reflecting surface
    ▪ The "normal"
  o Angle between the path of an incoming ray and the normal = ___Angle of Incidence___ = θ
  o Reflected ray makes the same angle, but on the other side of the normal
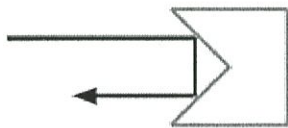   ▪ The Law of ___Reflection___

$\theta \quad \theta'$

$\theta = \theta'$
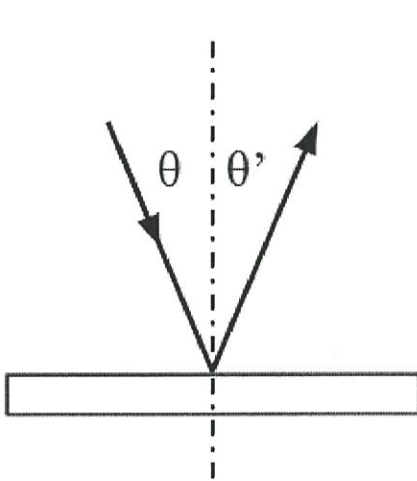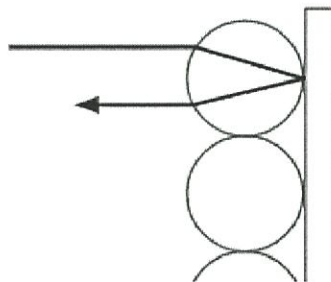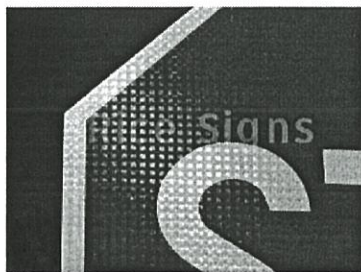
Angle of Incidence = Angle of Reflection

❖ **Reflection in real life**
  o Retroreflector
    ▪ Reflects light at the same ___angle___, regardless of orientation
    ▪ Used for surveying, for precise measurements of distance

* reflects light right back to the source

    ▪ Glass beads on traffic signs, license plates, painted stripes on roads, clothing, running shoes

    ▪ Eyes are retroreflective

❖ We know that reflection of light occurs when light strikes a surface that is not shiny and smooth?
  o Light can be ___*absorbed*___, ___*refracted*___, or ___*transmitted*___
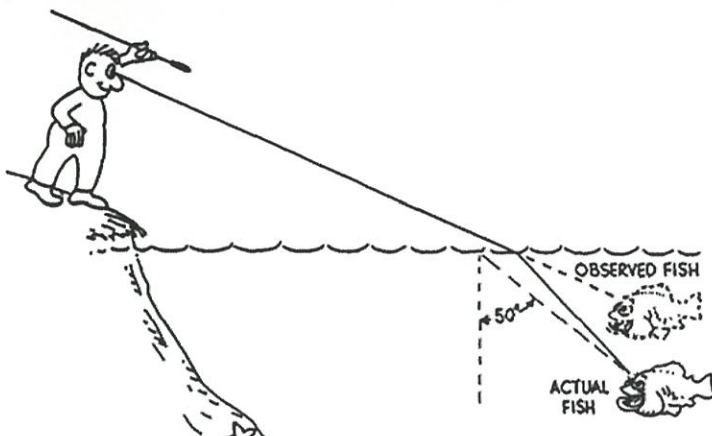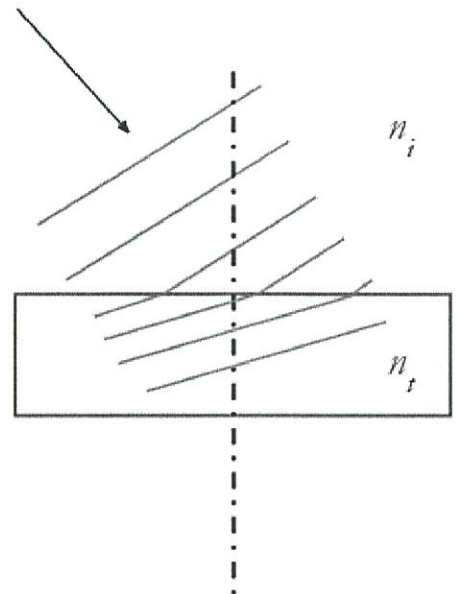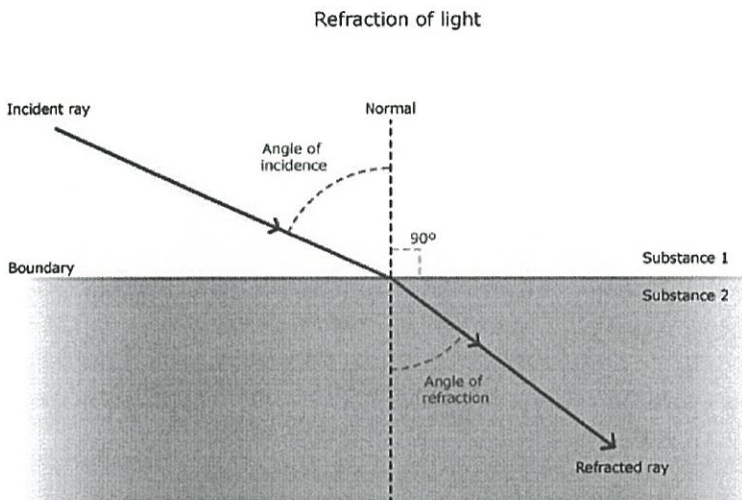   ▪ some materials transmit more than they reflect or absorb

    ▪ **Explain what's happening in the image to the left:**

    Light traveling through the air hits surface of pond; some of the light is reflected, most is transmitted
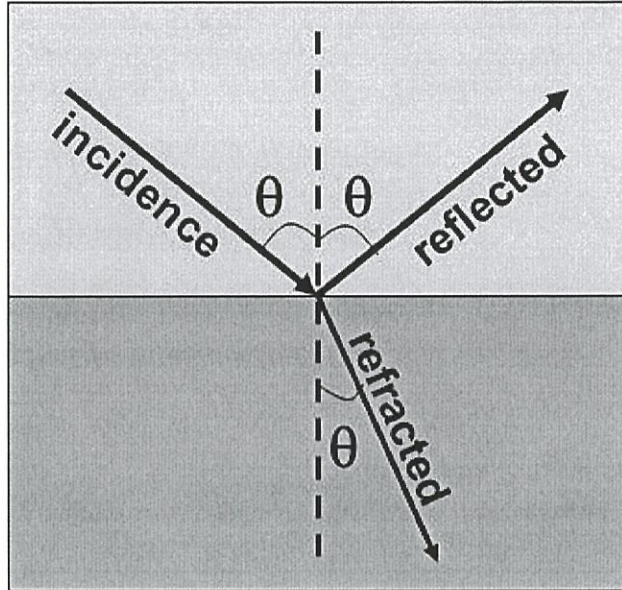
❖ Refraction
  o It is the ___*bending*___ of light at an interface between two different materials
  o Results from a change in ___*speed*___ as light travels from one material to another
    ▪ Light travels ___*the fastest*___ in a vacuum (empty space), and different speeds in different materials
    ▪ Wave fronts slow down when entering a different material

Refraction of light

Incident ray

Normal

Angle of incidence

90°

Boundary

Substance 1
Substance 2

Angle of refraction

Refracted ray

n_i

n_t

OBSERVED FISH

50°

ACTUAL FISH

* The speed of light in a material is determined by a factor called the:
  * ___index___ of refraction (or refractive index), n
  * c = speed of light in vacuum
  * v = speed of light in the material
* The greater the index of refraction, the ___slower___ light travels in the material
  * According to the table below, in which material does light travel the slowest? ___diamond___

Absolute Indices of Refraction

$(f = 5.09 \times 10^{14} \text{ Hz})$

Air	1.00
Corn oil	1.47
Diamond	2.42
Ethyl alcohol	1.36
Glass, crown	1.52
Glass, flint	1.66
Glycerol	1.47
Lucite	1.50
Quartz, fused	1.46
Sodium chloride	1.54
Water	1.33
Zircon	1.92

* Snell's Law
  * Also known as the Law of ___Refraction___
  * Used to determine the angle of refraction

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

  * n_1 = index of refraction for medium 1
  * n_2 = index of refraction for medium 2
  * θ_1 = angle of incidence
  * θ_2 = angle of refraction

1. A ray of light ($f = 5.09 \times 10^{14}$ Hz) traveling in air strikes a block of sodium chloride at an angle of incidence of 30.°. What is the angle of refraction for the light ray in the sodium chloride?
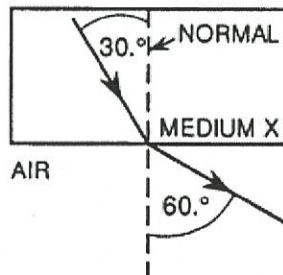
A) 19°   B) 25°   C) 40.°   D) 49°

$$\frac{(1.00)\sin 30 = (1.54)\sin \theta_2}{1.54 \qquad \qquad 1.54}$$

$$0.3247 = \sin \theta_2$$

$$\theta_2 = 18.9$$

2. The diagram below shows a ray of light passing from medium X into air.

30.° ← NORMAL

MEDIUM X

AIR

60.°

$$\frac{(x)\sin 30 = (1)\sin 60}{\sin 30}$$

$$x = 1.73$$

What is the absolute index of refraction of medium X?

A) 0.500 B) 2.00 C) 1.73 D) 0.577

❖ We know that…
  o Light can be _____reflected_____ by a shiny, smooth surface
  o Light can be _____refracted_____ at an interface between two different materials
❖ Today we will see that…
  o Light can also be _____reflected_____ at an interface between two different materials
    ▪ When light travels from a material of _____higher_____ n (denser material) to a material of _____lower_____ n (less dense)
    ▪ As the angle of incidence _____increases_____, the angle of refraction _____increases_____
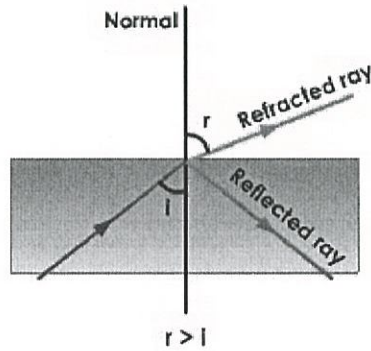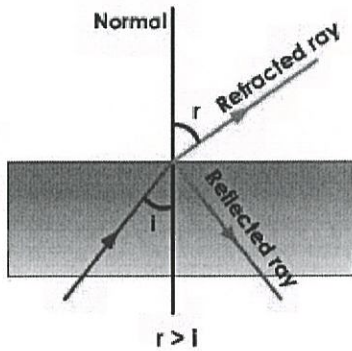
    ▪ When the angle of refraction is 90°, the angle of incidence is called the _____Critical angle_____
    ▪ At this point, if you continue to increase the angle of incidence, then all of the light will be reflected within the denser medium. This is known as:

    TOTAL INTERNAL REFLECTION
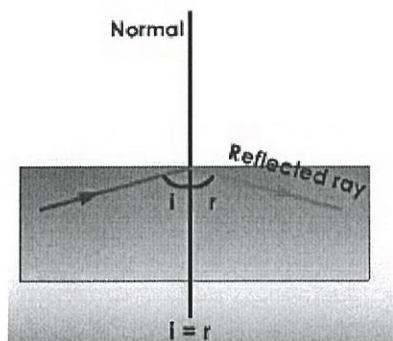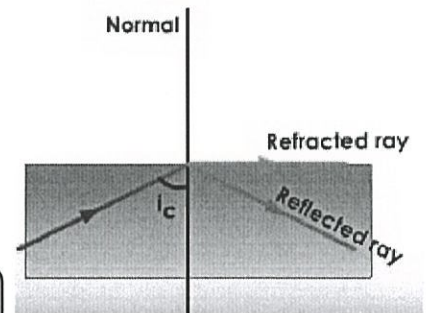
❖ To summarize, in order for total internal reflection to take place
  o The ray of light must travel from a _____denser_____ medium to a less dense medium
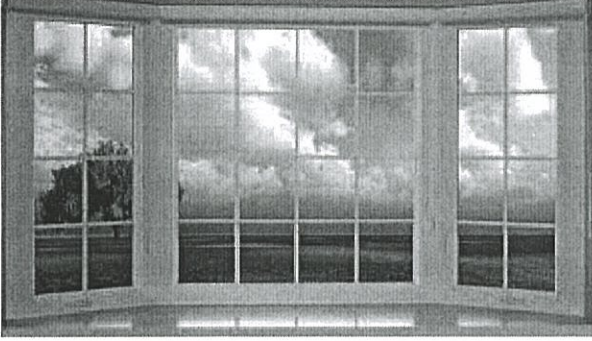 o The angle of incidence must be _____greater_____ than the critical angle

Topic 5: Scattering

❖ When light rays strike atoms, molecules, other tiny particles or
__rough__ surfaces, the rays of light are sent off in
__new__ directions (__scatter__)
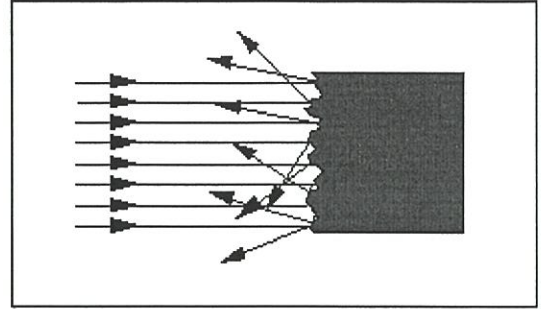
❖ __Transparent__ materials let light pass through with little
scattering
   o We can see through such a material

❖ __Translucent__ materials allow light to pass through it, but the material scatters each wave in
many directions
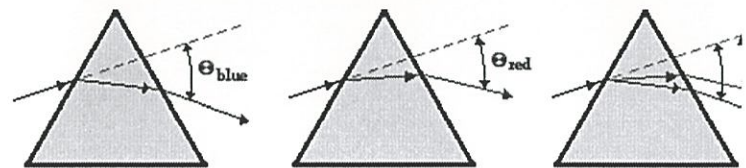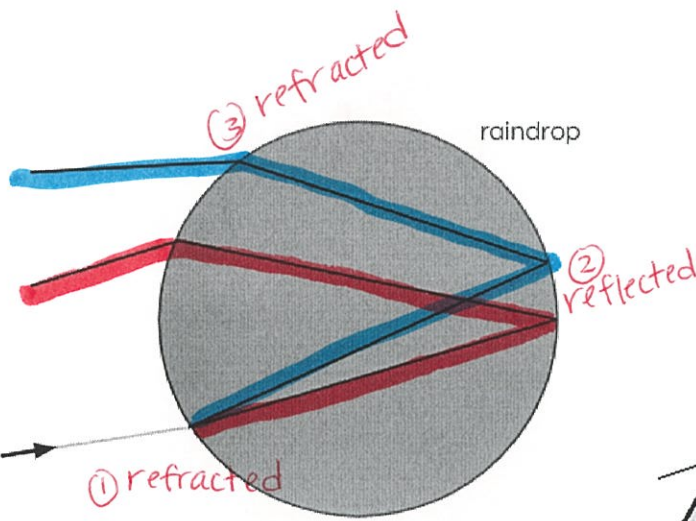   o We cannot see through such a material (example: frosted window)

❖ __Opaque__ materials block all light

❖ How is a rainbow formed?

raindrop

③ refracted

② reflected

① refracted

sun

Blue light refracts more than red light due to the difference in wavelength. This cause blue light to deviate from its original path by a greater angle than the red light.

*each color of light slows down
differently (each has a unique
index of refraction - n)

❖ How is a double rainbow formed?

Refraction

raindrop

Reflection

Reflection

Refraction
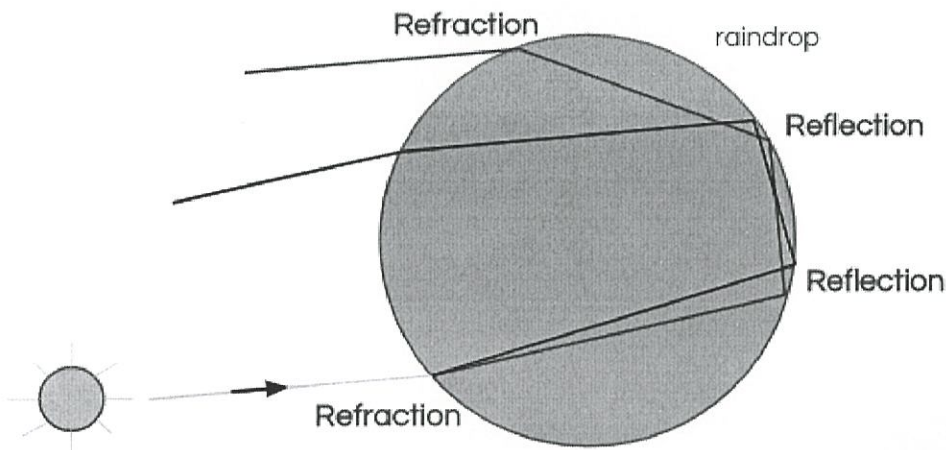
❖ What do you observe about the colors in the double rainbow?

The 2nd reflection
reverses the colors b/c
there are 2 reflections,
and the 2nd rainbow
is dimmer