Physics
Notes: Light and Wave Behaviors

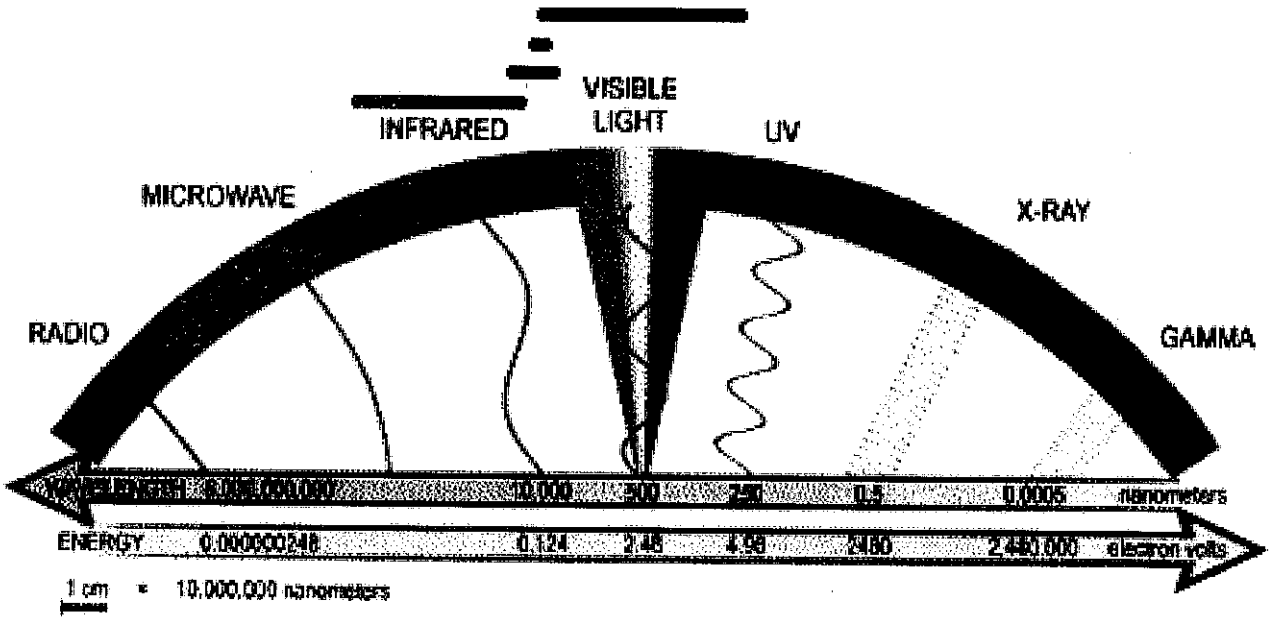
Name: Key

1. What is light? Electromagnetic waves with wavelengths between 3.9×10^{-7} m and 7.4×10^{-7} m

The "wave-particle duality" of light (and all electromagnetic radiation):

2. How is light like a particle?
   - It's made up of particles called "photons"
   - It has momentum; it can push things
   - Light is pulled by gravity
   - Light can travel in a vacuum
3. How is light is like a wave?
   - It has an oscillation with a wavelength and frequency
   - It demonstrates wave behaviors, like reflection, refraction, and scattering

The Electromagnetic Spectrum



4. The color of light depends on its wavelength. List the colors of light from longest to shortest wavelength:

Red, Orange, Yellow, Green, Blue, Indigo, Violet

ROY G. BIV

5. Nicknames for The Two Ends Of The Spectrum:

- The long-wavelength end of the visible spectrum is called the red end.
- The short-wavelength end of the visible spectrum is called the blue end.

6. Black and white are not really colors. What are they, in terms of wavelengths of light?

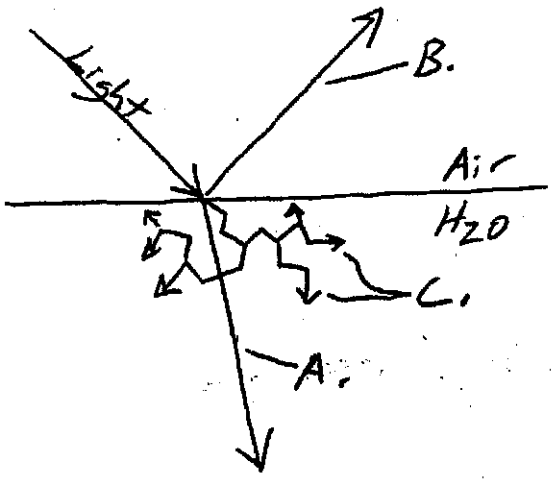
Black: No light

White: All wavelengths of light, mixed together.

7. Describe two ways to show that white light is actually made up of a rainbow of colors?

1) Shine white light through a prism.
2) Stare at a color. Then stare at a white screen.

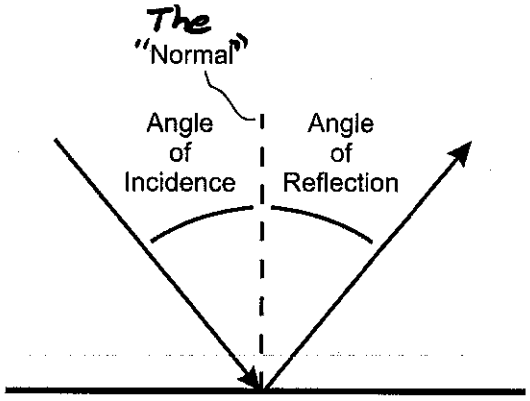
Wave Behaviors:



A. Refraction
B. Reflection
C. Scattering

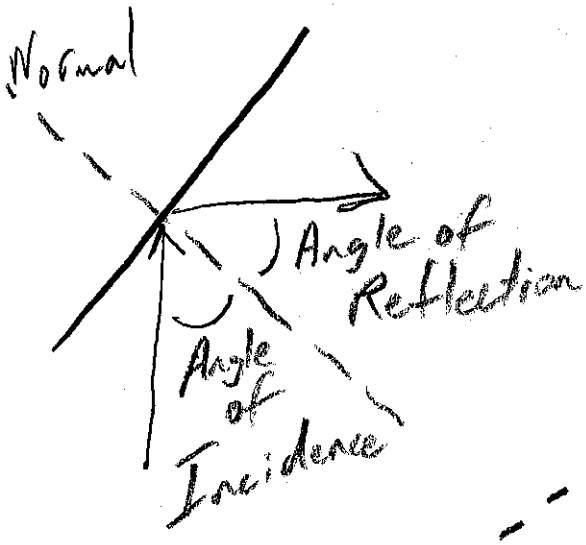
Reflection of waves:

The Law of Reflection: Angle of incidence = angle of reflection

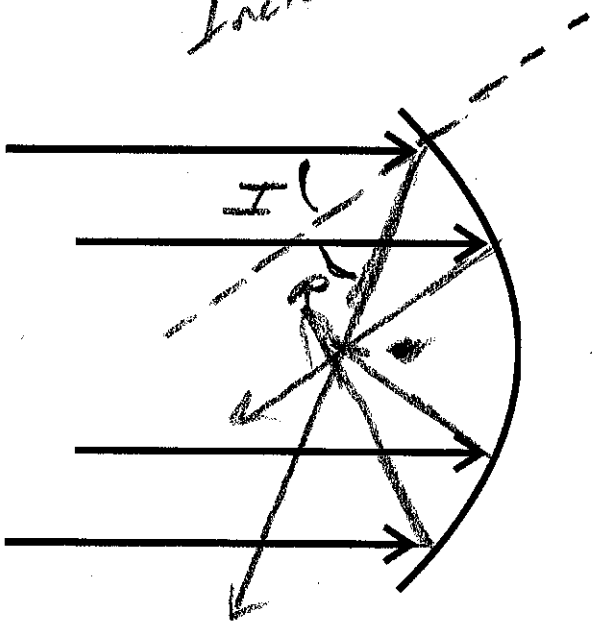


Reflection Practice:

- Show how a light ray is reflected when it hits the mirror.
- Draw and label the "normal."
- Label the angle of incidence and the angle of reflection.



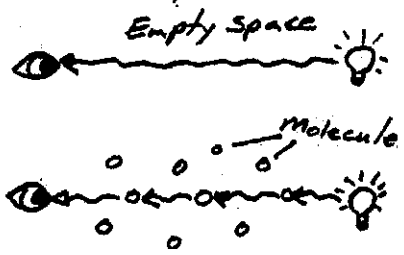
- Show how light reflects off of the parabolic mirror on the right. For one light ray, label the "normal," the angle of incidence, and the angle of reflection.



Refraction (Bending) of Light

0. The speed of light in a vacuum = C = 3×10^8 m/s = 300,000,000 m/s

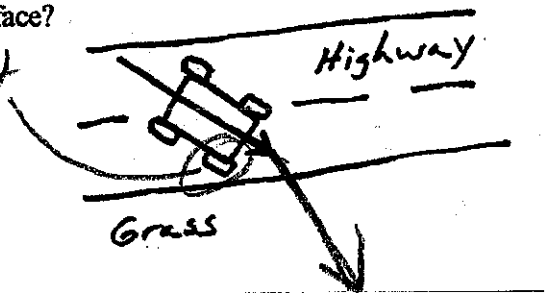
In a vacuum (empty space) electromagnetic waves, including visible (light) waves, travel at 650 million mph. In a vacuum, there are no molecules with which the photons of light can collide.



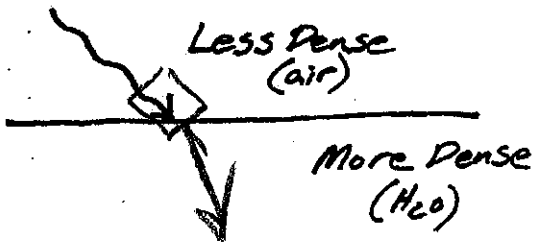
1. When a photon hits a molecule, that molecule can take-in the photon's energy, and then give off another photon. This takes time. When light is travelling through space which is full of molecules, its photons are constantly being absorbed and re-emitted. It travels from one molecule to the next at 650 million mph, but then it has to wait for the molecule to release a photon so that the light can keep going. Do you think light travels faster through a vacuum or through a solid?

2. In general, do you think light travels better through dense things or things which are less dense?

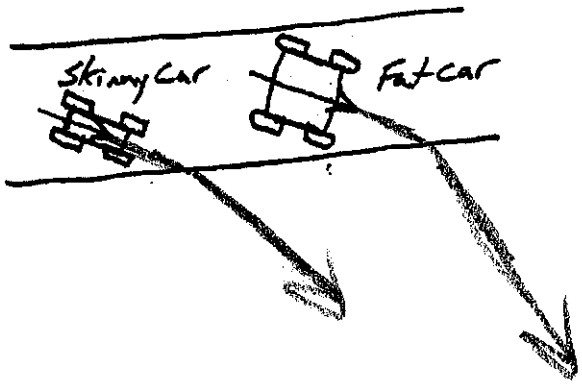
3. Does a car travel faster on a smooth highway or on a grassy surface?
4. The path of a car [redacted] is shown. As it hits the shoulder of the highway, which front tire will touch the grass first? Right
5. When that happens, which front tire will begin to move more slowly? Right
6. Is this going to cause the car to turn to its right or its left?
7. Use an arrow to draw the new path of the car.



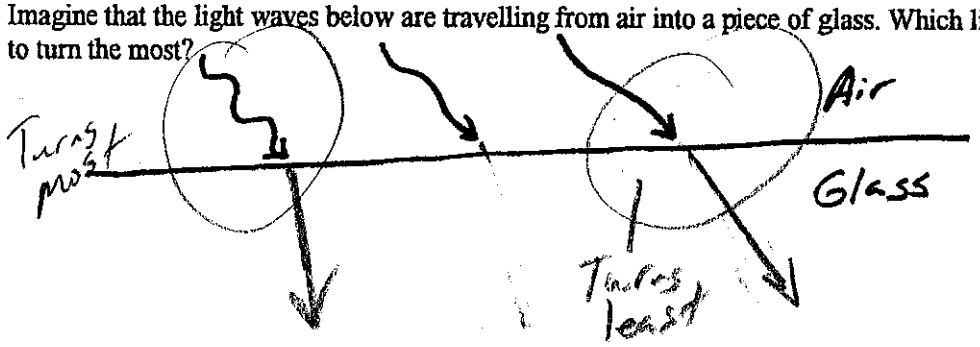
8. Light waves are like that car. The light wave on the right is travelling from air into water. In which substance will it travel faster? Air
9. Show how entering a more dense substance will affect the path of the light (by drawing the new path on the diagram.)



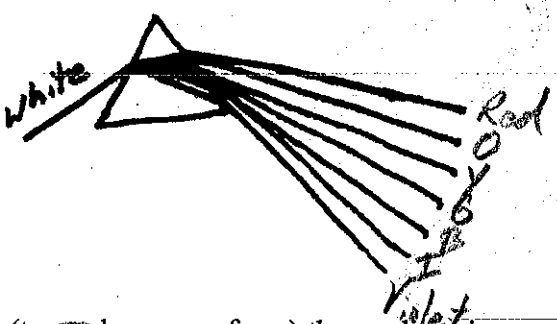
10. The two cars shown on the right are going to turn when they hit the grass because, for a short time, one side will be going faster than the other side. Which car will probably turn the most? Why?



11. Imagine that the light waves below are travelling from air into a piece of glass. Which light waves would you expect to turn the most?



12. The diagram on the rights shows white light hitting a prism. The prism causes the various wavelengths of light to bend. Some bend more than others, so a color spectrum (rainbow) is produced. Label the paths shown with the appropriate colors. [Remember Roy G. Biv. Red has the longest wavelength. Blue has the shortest.]



13. When light refracts (bends), it turns _____ (toward or away from) the medium in which it travels more slowly.

14. **Index of Refraction:** Tells us how much light slows down in a material. Symbol = "n"

15. Higher n = light travels _____ (faster, more slowly).

Lower n = light travels _____ (faster, more slowly).

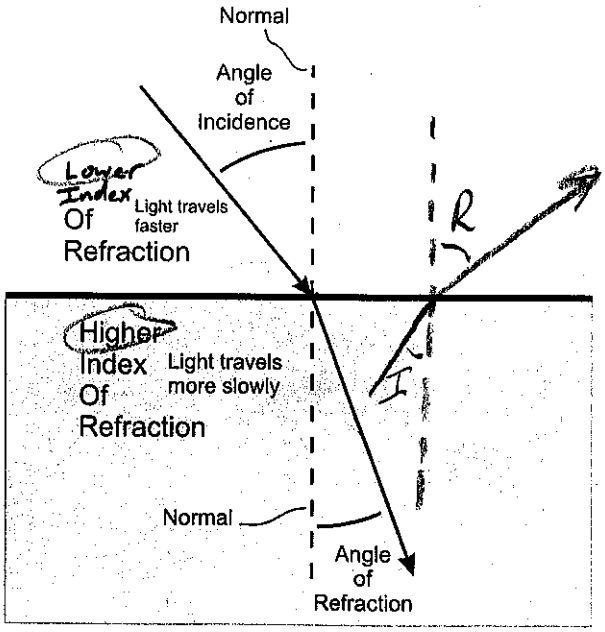
TABLE 23.1 Indices of refraction

Medium	n
Vacuum	1.00 exactly
Air (actual)	1.0003
Air (accepted)	1.00
Water	1.33
Ethyl alcohol	1.36
Oil	1.46
Glass (typical)	1.50
Polystyrene plastic	1.59
Cubic zirconia	2.18
Diamond	2.41
Silicon (infrared)	3.50

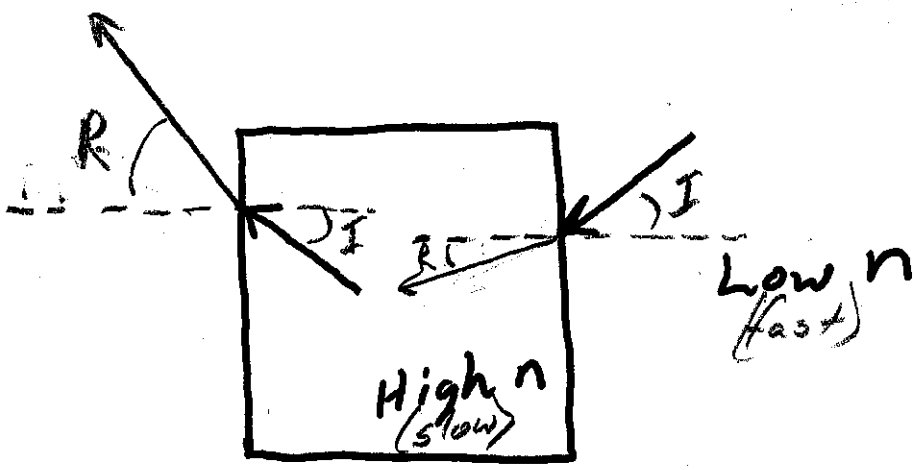
16. The diagram on the right illustrates the Law of Refraction. According to the Law of Refraction…

a. When a light ray travels from a material with a lower n to a material with a higher n, the angle of refraction will be _____ (less than or greater than) the angle of incidence.

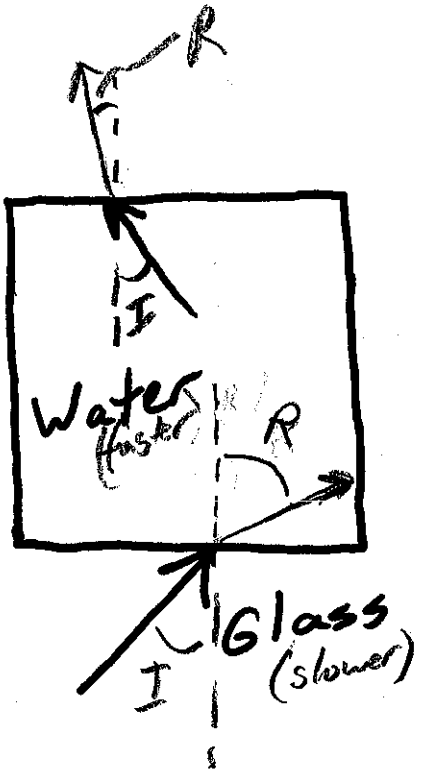
b. When a light ray travels from a material with a higher n to a material with a higher n, the angle of refraction will be _____ (less than or greater than) the angle of incidence.



17. The diagram on the right shows a block of clear material with a high index of refraction surrounded by a material with a low index of refraction. For each light ray…
a. Draw the "normal"
b. Label the angle of incidence
c. Draw the angle of refraction. Make sure that the angle's size is correct (either larger or smaller) compared to the angle of incidence.

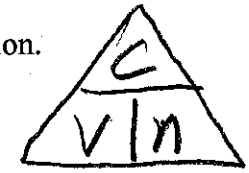


18. Do the same thing on the diagram to the right. Consult the table on the previous page for values of n.



19. The velocity of light in a substance can be found using the equation $v = \frac{c}{n}$, where C is the speed of light (3×10^8 m/s).

a. Create an "algebra triangle." For this equation.



b. Find the speed of light in water.

$$V = \frac{C}{n} = \frac{3 \times 10^8 \text{ m/s}}{1.33 \text{ from table}} = 2.25 \times 10^8 \text{ m/s}$$

c. Light travels through a certain material at a speed of 1.88×10^8 m/s. Find the index of refraction for that material.

$$n = \frac{C}{V} = \frac{3 \times 10^8 \text{ m/s}}{1.89 \times 10^8 \text{ m/s}} = 1.59 = n$$

d. Use the table on the previous page to identify this material.

Polystyrene Plastic