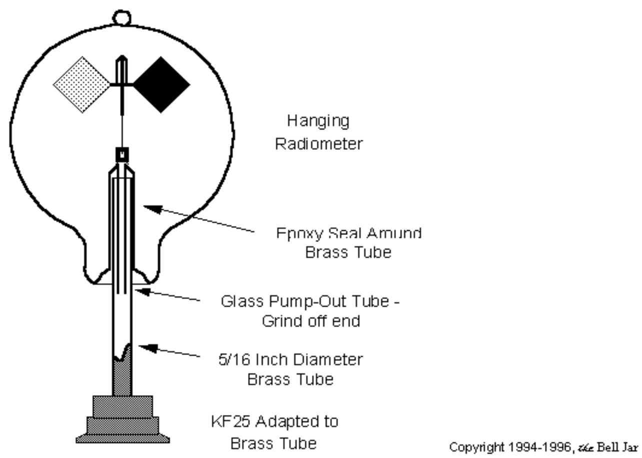
Introduction: Light is energy, capable of being transformed and used

1) Handcrank Generator(work energy can be converted to light energy)

We'll bring in a handcrank generator to illustrate the point that mechanical energy that they exert with their arms can be transferred into light energy. We will use a simple circuit with the generator and a small light bulb which will enable the students to see that the harder they crank, the brighter the light from the bulb will be.

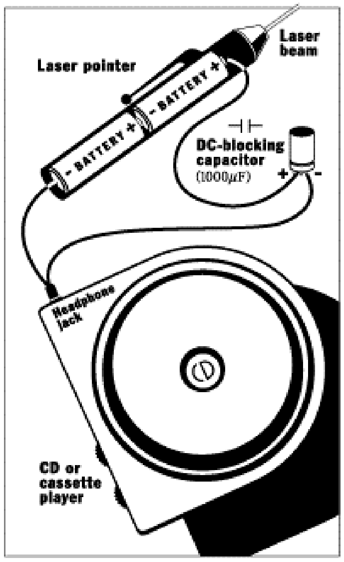
2) Spinning light vein(light energy can be converted back to work energy)

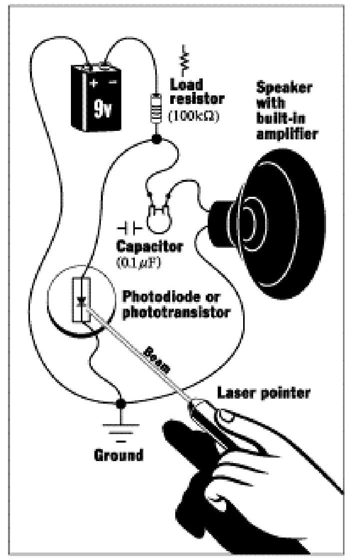
Figure 1 - Radiometer Adaptation



A radiometer consists of a set of vanes, each shiny on one side and blackened on the other, that is mounted in an evacuated vessel. When exposed to light, the vanes revolve. The first radiometer was constructed to settle the controversy regarding whether light exerts a force. The idea was that a reflecting surface would experience a greater force from the light than an absorbing one. The instrument was therefore made in the now familiar form. Unexpectedly, the opposite effect was observed. The blackened vane retreated from the light source. We now know that the black surface is warmer than the shiny one and that gas molecules will recoil faster from the hot surface. The slight difference in molecule recoil is what causes the device to spin.
(Information here from http://www.tiac.net/users/shansen/belljar/radio.htm)

3) Laser carrying sound(Light energy can be used to perform AMAZING feats like carrying your voice from one side of the room to the other)





(Information gathered from http://www.eweek.org/2002/DiscoverE/activities/hearinglight.shtml)

People are familiar with lasers as special types of light sources. Common non-military applications of lasers include their use in CD players, laser pointers, supermarket scanners, optical character recognition, and surgery.

Another very important and widespread use of lasers is in optical communications. Most of the long distance transmission of information, from phone calls to internet data, is done with laser beams traveling over fiber optics networks.

The output light of a laser, the laser beam, is usually pictured as a continuous beam having constant power. But for laser communications, the beam can be changed, i.e. modulated, in a controlled manner. This modulation can be in the form of amplitude modulation, i.e., AM, which changes the strength or power of the beam, or frequency modulation, i.e., FM, which changes the frequency, or color of the beam. Such modulation adds information to the beam, information that can be carried by the beam and transmitted to a distant location, where it can be extracted and used. For example, a telephone conversation can be encoded in a modulated laser beam and sent across the United States or undersea to Europe or Asia, where the conversation is decoded and heard as a spoken voice.

Explaining the goal of the demonstration:

To add information to a laser beam by "modulating" the beam. Explain that telephone, television, and internet data are transmitted over fiber optics cables by modulated laser beams.

Show the students a laser pointer. Explain that it is powered by batteries. The laser converts the electrical energy from the batteries into light energy. Show the students the photodetector. Explain that it converts light energy into electrical energy.

Connect the photodetector to the speaker/ amplifier (see circuitA) and turn on the amplifier. Direct the laser beam into the photodetector.

Block and unblock the laser beam with your hand or finger, so the photodetector is alternately illuminated and dark. A clicking sound will be heard from the speaker. Explain that you are modulating the power of the laser beam and the speaker is demodulating it to produce sound.

Ask a student to come up to the setup and modulate the laser beam. Give the student a comb and ask him/her to use the comb as a modulator. Help the student to discover how to move the comb so the teeth alternately block and transmit the laser beam. By drawing the teeth of the comb through the laser beam at various speeds, sounds of various frequencies can be produced from the speaker. Invite several students to use several combs to simultaneously modulate the laser beam.

Invite another student to modulate the laser beam using talcum powder or chalk dust. Dim the room lights. When the student throws the powder/dust into the beam, one hears a rushing sound, like thunder, from the speaker, while simultaneously seeing light scattering from the powder/dust particle.

Connect a microphone to the laser using a minicoaxial cable, one end plugged into the microphone jack and the other end connected across the batteries power the laser (see circuit B).

Have a student speak into the microphone. The sound will emerge from the speaker. Block the laser beam, and the sound will stop. Explain that this is the way information (conversation, music, TV, internet data) is sent around the world, with fiber optics cables guiding the light along utility poles, underground, and underwater rather than the light traveling through free space. Ask the students what might go wrong if the light traveled through free space (bad weather, clouds, rain, dust).

In the last part, we will use a piece of optical fiber to transmit the laser.

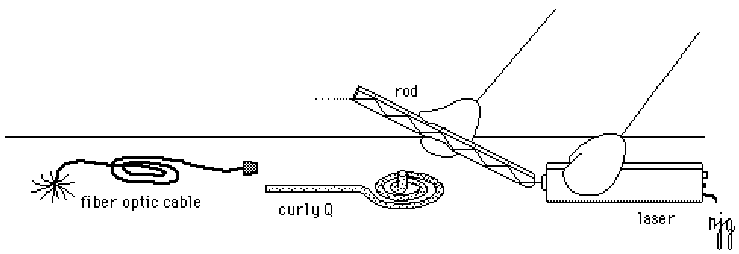
Conclusion:

Laser communications systems are conceived of, designed and built by engineers. They ask questions, develop a theory or a model, test out their ideas, create designs, build working models, and refine them until they meet performance standards. In order to do this, they need a strong background in math and science.

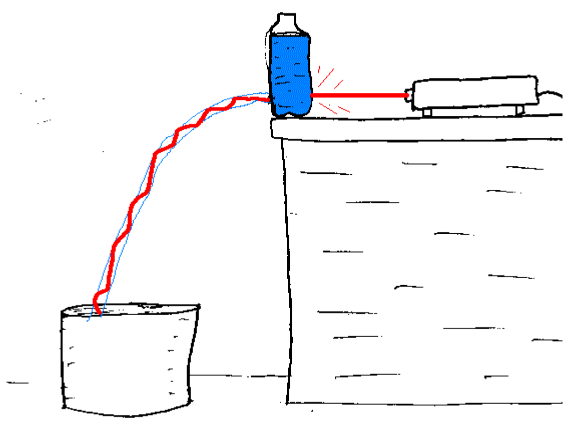
Interactive demonstration #1: The Refraction Station

1) Light pipe:

A laser is shined through a bent glass tube and is totally internally refracted. We'll probably bring in the curly-Q one as well as some fiber optic cable.

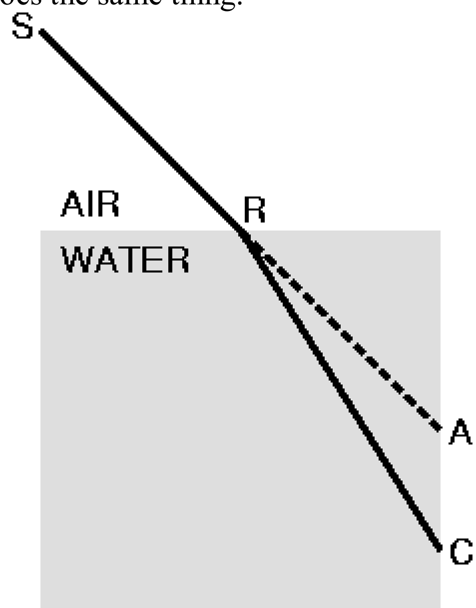


2) Water pouring out of a jug also totally internally refracts light



3) Spearfishing Demonstration:

Students will first try to “fish” in a refraction tank, but will miss because they don’t compensate for refraction. Then a laser will be set up so students can see the path of a laser in a refraction tank and make the connection that the light their eyes are seeing does the same thing.



4) In addition to the three demonstrations listed above, we will also bring in some very large prisms and glass bocks to demonstrate internal reflection, refraction in glass, etc.

Interactive Demonstration #2: Reflection

1) Simple reflection practice

Students align a ball launcher to hit a target by bouncing the ball off a piece of metal. They should be able to do this intuitively. Then, with the same alignment, replace the launcher with a laser. Have students measure the incident angle and the reflected angle of the laser.

Allows students to visualize the concept of reflection using a reflection they are familiar with (a ball bouncing) and then broadening that intuitive understanding to light and mirrors.

2) Multiple reflections

Using a laser and a variety of mirrors, students will attempt to use as many mirrors as possible, or as is necessary, to hit a target(made of Hershey kisses☺). Puts laser reflection to practical purposes!

The Exciting Conclusion: Lissajou figures…a homemade laser light show!

Equipment:

Several lasers of different colored light
Several small mirrors -- these mirrors are glued to a neoprene sheet and stretched over a small speaker box
Boom box

Step 1:

The lasers are turned on and aligned to strike the mirrors.

Step 2:

The general properties of lasers are discussed and blackboard erasers are clapped, producing chalk dust in the air. The laser beams can then be seen in the air. (Sometimes the "steam" from the Liquid Nitrogen is used instead of chalk dust)

Step 3:

Finally, the boom box is turned on and music is played. The dots of the laser endpoints on the wall bounce and move in rhythm with the music. The light apparently "dances" to the tune of the music, forming circles and doodles which move to the music.

Basic Idea:

The sound caused by the small stereo creates longitudinal waves of air. When these waves reach the neoprene with the mirrors attached, the air molecules cause not only other air molecules to vibrate, but they cause the neoprene to vibrate as well. This is due to the fact that neoprene is a very pliable solid. Since the sound waves cause the neoprene to vibrate, the neoprene moves in various directions. The vibrating neoprene moves the mirrors, causing the laser beams to be reflected in a slightly different direction. This change in reflection will correspond to the dots moving around on the wall. Due to the rhythmic nature of music, the dots will move in a more orderly fashion than complete randomness, creating the exciting effect of circles and doodles and lines. The reason that one sees the shapes rather than simply the dots moving in a circular fashion is the persistence of vision. The dots are moving so fast that the human eye perceives them all at the same time, even though at any given time, there is only one dot per laser shining on the wall.

Wrap up…

On Monday, or whenever you have the students in class again, we would very much appreciate their feedback. It would be great if you could arrange to have them spend five minutes writing

1) What their favorite demonstration was and why?
2) What piece of physics did they see that they would be interested in learning more about?