Properties of Waves

Vanderbilt Student Volunteers for Science

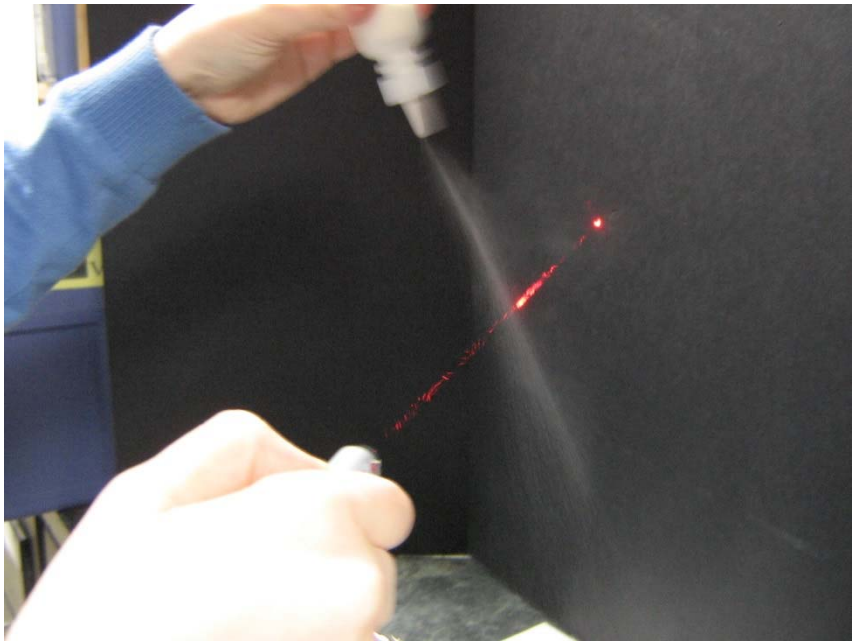
2018-2019 VINSE/VSVS

Safety

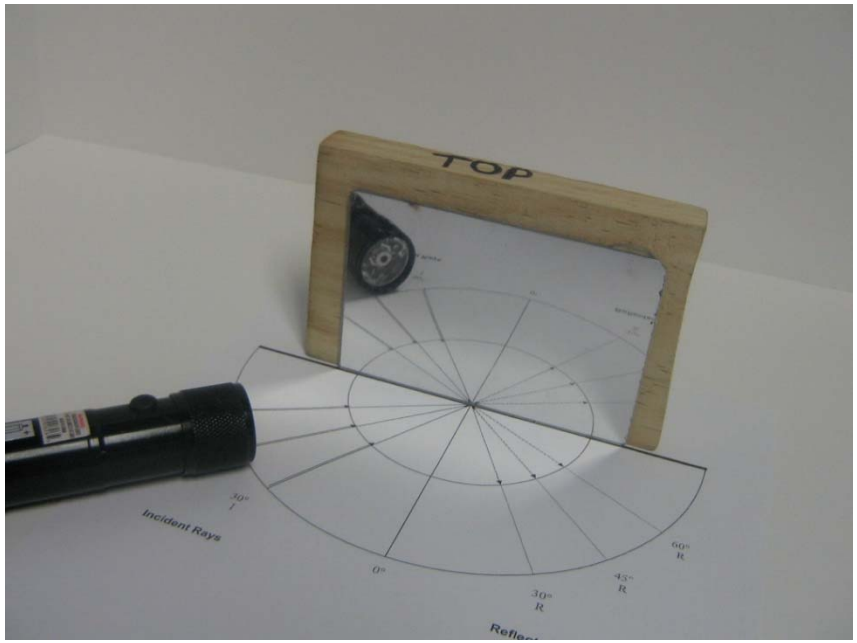
- Tell the students that they will be using lasers to study some properties of light waves, hence several rules that MUST be followed:
  - **Be very careful with the laser pointer.**
  - **Never aim it at anyone.**
  - **When turning it on, always have it pointed away from your eyes and from other persons. Eye damage can occur with direct eye exposure to the laser beam.**

IIA. Behavior of Waves - Light Scattering Using Particulate Matter

- Obtain the bottle of flour from the kit.
- Shine the laser light towards a wall away from the students.
- Compress bottle steadily and lightly so that the flour drops through the path of the laser light in a constant stream.
- Students should be able to see the laser light reflected upon the particles of flour.

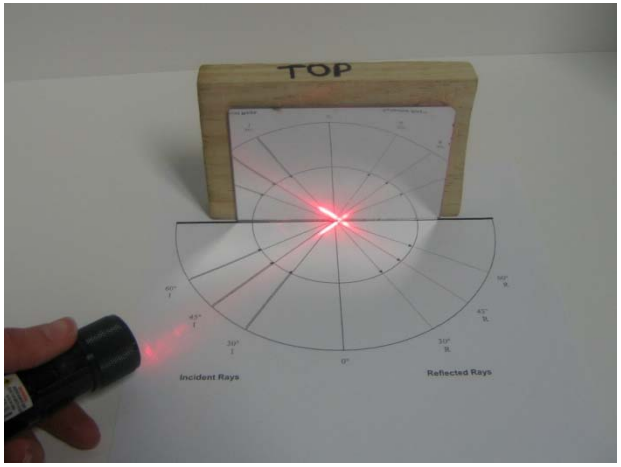


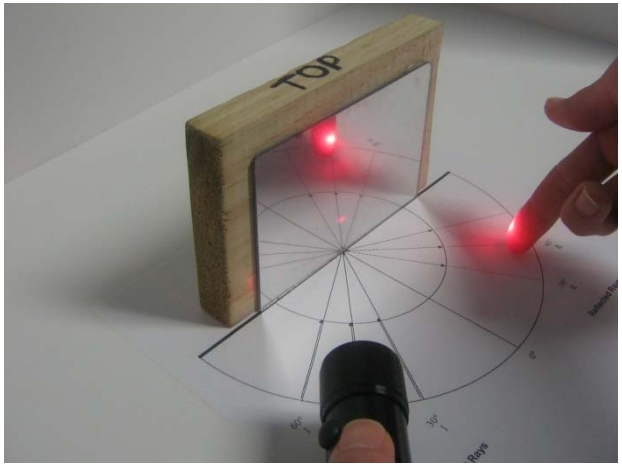
IIb. Behavior of Waves -Reflection



- Place the block of wood with the mirror on the marked line on the observation sheet. The mirror must be flush with the sheet and line up EXACTLY with the black line.
- Designate one student to hold the laser pen. Remind the students to NEVER look directly into a laser beam.
- Place the laser in the groove of the ruler and place it so that the beam from laser shines along the **solid 45° line and is pointed to the "X"**

IIb. Behavior of Waves – Reflection



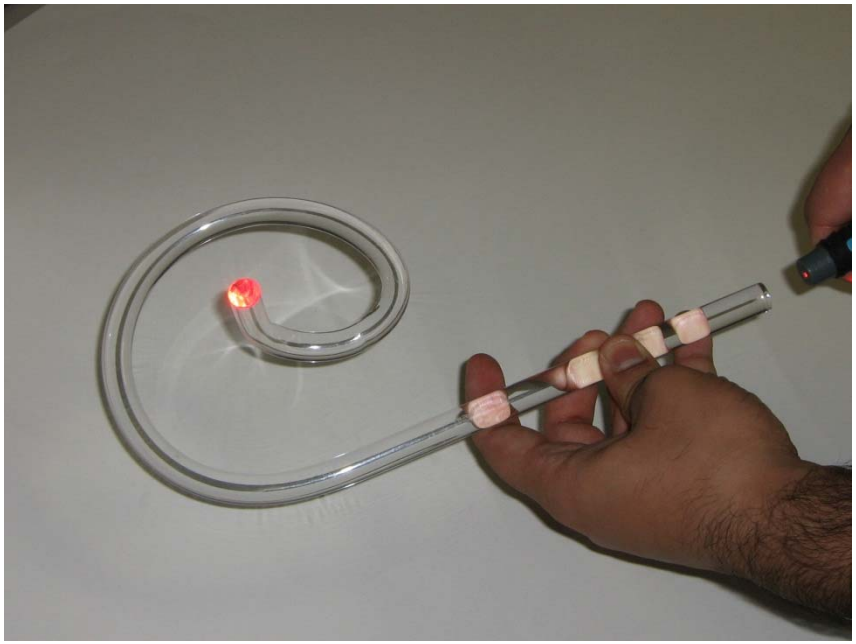


- Hold a finger in the path of the laser beam, so that the red dot is visible on the finger. Have the students “trace” the laser beam along the 45° line in towards the mirror. Adjust the position of the laser if necessary. (The laser can be tilted down so that the beam shines on the paper.)
- Trace the **reflected** beam with the finger and to note which line the finger moves along. (It should be close to the **dotted** 45° line.)
- Tell the students that the light from the laser to the mirror is called the **incident ray** and the light from the mirror is the **reflected ray**.
- Explain that when light goes in at an angle on one side (left or right) it comes out at the same angle on the other side. (Draw this concept on a board)
- **Remember: The concept the students should learn is that light can bounce or reflect. Light goes in at one angle and comes out on the opposite side at an equal angle.**
- Allow the students to try other angles (moving the ruler and laser) to see what happens. Remind students to aim for the “X” in the center.
- **COLLECT ALL LASER PENS, COUNT AND PLACE IN BOX. DO NOT GO UNTIL YOU HAVE PLACED THE LASER POINTERS IN THE VSVS BOX.**

IIb. Total Internal Reflection

Light Pipe: Demonstration

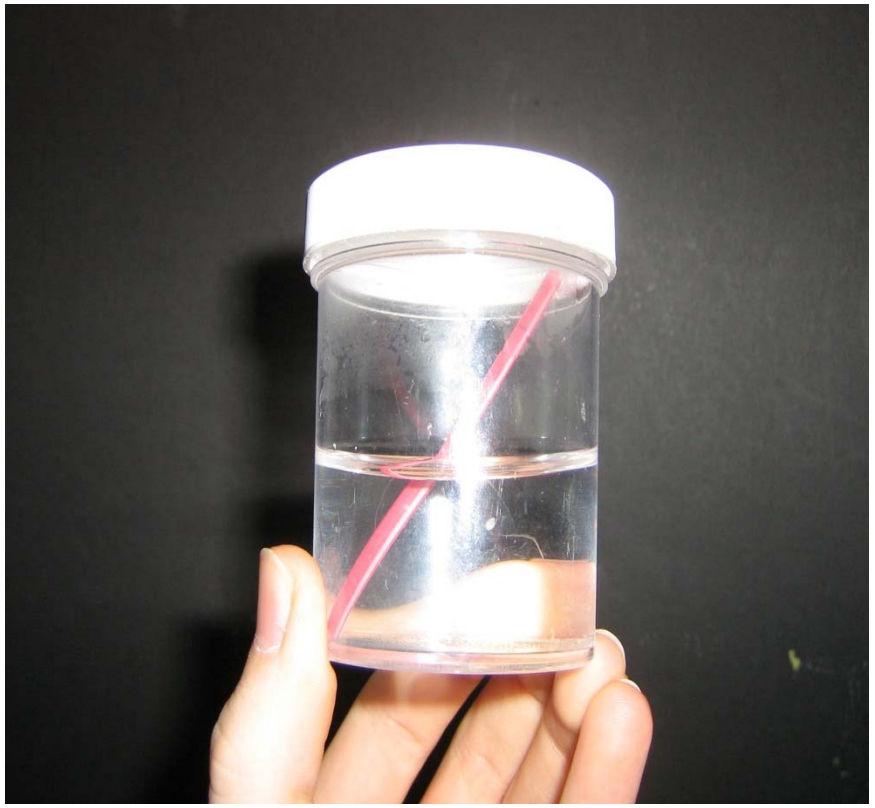
- Hold the light pipe so that the long part is vertical and the small horizontal part is pointing towards the class (but not directly at any person's eyes).
- Shine the red laser beam up towards the ceiling and have the students notice the red color on the ceiling.
- Turn off the classroom lights, and ask students what they think they will see when the red laser is shone through the long end of the pipe.
- Shine the laser through the long horizontal end of the pipe.
- Show students that the red light can be seen at the other end, but that no light escapes along the pipe.
- If the room is dark enough, the red light can be seen traveling around the tube.

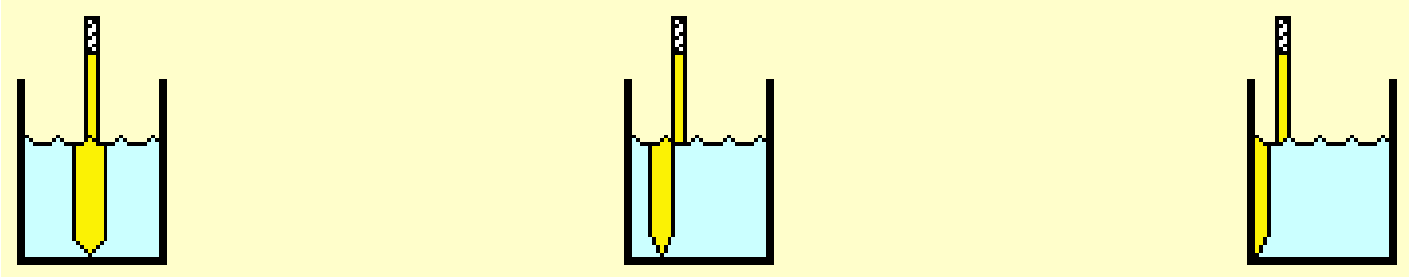


- **Explanation:** When the angle of incidence is high enough (above a critical angle characteristic of the substance; 42° for glass), the incident light is totally reflected inside the medium

IIIc. Wave Behavior - Refraction

- Give each group of students a jar containing water and a straw lying at an angle in the jar
- Tell students to rotate the jar while looking at the straw and ask them what they observe
- Tell students to unscrew the lid and to hold the straw vertically in the center of the jar so that it is half in/out of the water
- Have them look at the straw through the side of the jar and slowly move the straw to either side of the jar (do not move the jar or your head)
- Explain that the bending of light (refraction) occurs when light waves pass from one medium to another





IIc. Wave Behavior – Refraction(cont'd)

- Tell students to hold their observation sheet behind the jar and shine the laser through the water in the jar. Note where the red beam is on the paper.
- Tell students to move the laser up so that the beam now shines through the air in the jar. Note where the beam moves to on the observation sheet.
- Explanation:
- The bending of light or **refraction** occurs when light waves pass from one medium (or substance) to another.
- The speed of a wave depends on the substance that it is traveling through. Since light is a wave, its speed changes when it changes medium. In this example, the speed of light is slower in water than in air.
- As the wave slows down, it also changes its direction. So the light wave "bends" as it enters the water.
- **Refraction only occurs when light waves pass into a different medium, at an angle**.
- The straw did not appear to be "broken" when viewed in the center of the jar. (When you look at it "straight-on".)
- The straw becomes more "broken" as it moves across the jar. (When you look at it from different angles.)

IMPORTANT

- Collect **all** laser pointers and count them to make sure you have them all. **Do not continue with the lesson until you have placed the laser pointers in the VSVS box**. Also, make sure the laser pointers are not left on in the cases. If one is on in the case, open it and rotate the pointer so the button is to one side, not straight up.

IId. Wave Behavior – Diffraction

“Looking Through a Diffraction Grating”

Note: A VSVS volunteer should demonstrate the proper use of a diffraction grating slide.

- Tell students to hold the slide by the cardboard only.
- Do not touch the clear film in the cardboard holder.
- Hold the diffraction grating close to (but not touching) the eye and look at any lights or windows in the room.
- Several rainbows should appear.

- **CAUTION: DO NOT LOOK DIRECTLY AT THE SUN THROUGH A DIFFRACTION GRATING**

IIId. Wave Behavior – Diffraction (cont'd)

- Explanation: :
  - Diffraction grating slides consist of many equally spaced parallel grooves -- typically about 1500 lines per centimeter.
  - Each space between two grooves acts as a slit through which light can pass.
  - The light bends around the edges of the grooves.
  - When illuminated with white light, the diffraction grating has the same effect as a prism in that it separates white light into a spectrum of colors.
  - However, the order of the colors is opposite from that seen in a spectrum made by a prism.

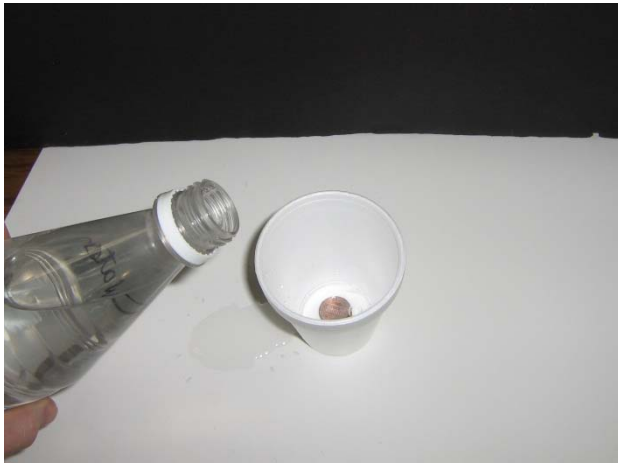
IId. Wave Behavior – Diffraction (cont'd)

"CD"

- Tell the students to pick up the CD and notice the "rainbow" pattern from the room lights.
- Explanation: CDs have many parallel grooves so the CD acts as a diffraction grating.

IIe. Wave Behavior – The Appearing Coin (Optional)

- Place the styrofoam cup with the penny on the desk
- Select one student in each group to pour the water while the other students in the group stand and observe the coin
- Tell them to stand in a position where they can easily see the coin
- Now have the students slowly back up until the coin has just disappeared from sight
- Tell the designated student to slowly pour water into the cup
- Tell students to raise their hands as soon as they can see the coin again



IIe. Wave Behavior – The Appearing Coin (Cont.)

- Explain that refraction causes this effect
- When water is added, the light is bent so that the coin becomes visible (light travels through one medium to another)