



Chapter 4: Quick Activities

Subatomic Particles

The Quantized Whistle

Matter is made of tiny particles. Each particle is a distinct quantity of matter, which is why we say that matter is quantized. When we say something is quantized, we mean that it is made of fundamental units. Light energy comes to us in extremely tiny packets called photons and is therefore also quantized. But how can energy be quantized? What does this really mean? The following activity provides an analogy.

PROCEDURE

1. Ask someone who knows how to whistle to whistle from a high pitch to a low pitch in one continuous breath. If you can whistle, then you can do the exercise yourself. Notice that the change in pitch is smooth.
2. Have the whistler repeat the same whistle into one end of a long tube, such as the cardboard tube inside wrapping paper or some piping. Notice that the whistler's smooth continuous whistle is forced into distinct steps. The whistle is quantized!

ANALYZE AND CONCLUDE

1. Try experimenting with tubes of different lengths. To hear yourself more clearly, use a flexible plastic tube and twist the outer end toward your ear.
2. Does a longer tube create fewer or more steps than a shorter tube? Why is it so difficult to whistle down a garden hose?
3. What musical instruments work by changes in the length of a tube?



Rubber Waves

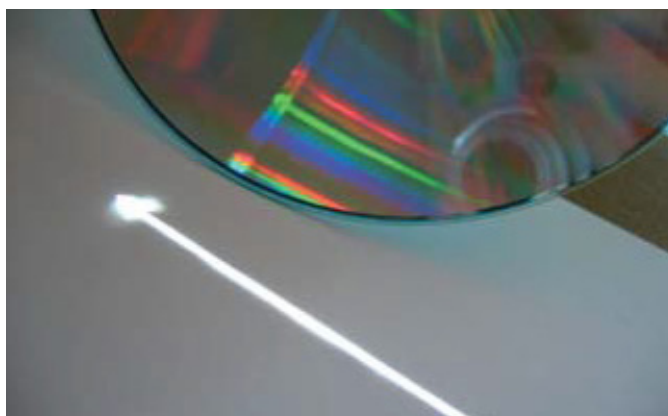
Stretch a rubber band between your two thumbs and pluck one length of it. Note that no matter where along the length you pluck, the area of greatest oscillation is always at the midpoint. This is a self-reinforcing wave that occurs as overlapping waves bounce back and forth from thumb to thumb.



A self-reinforcing wave may sound beautiful on a guitar, but it can spell disaster for a bridge. In 1940, light winds across the Tacoma Narrows in the state of Washington caused the newly constructed Tacoma Narrows Bridge to start oscillating at a frequency that allowed the waves to be self-reinforcing. As the energy of the wind was absorbed by the bridge, the waves grew stronger (over the course of several days), to the point where the bridge collapsed. The video is easily found online with the keywords "Tacoma Narrows Bridge". One of the tasks of building a durable structure, therefore, is to design it such that self-reinforcing waves are not likely to form.

Spectral Lights

Fluorescent lights contain spectral lines from the light emission of mercury atoms. Special coatings on the inner surface of the bulb help to accentuate visible frequencies, which can be seen through the diffraction grating reflection of a compact disc. Cut a narrow slit through some thick paper (or thin cardboard) and place over a bright fluorescent bulb. View this slit at an oblique angle against a CD and look for spectral lines. Place the slit over an incandescent bulb and you'll see a smooth continuous spectrum (no lines) because the incandescent filament glows at all visible frequencies. Try looking at different brands of fluorescent bulbs. You'll also be able to see spectral lines in street lights and fireworks. For those it is best to use "rainbow" glasses available from a nature, toy, or hobby store.





Author Responses to Quick Activities

The Quantized Whistle

1. No question asked.
2. A longer tube creates fewer steps, which is why it becomes so difficult to whistle down an exceedingly long garden hose.
3. The trombone. Of course, different pitches can also be made by punching holes in the tube, which is the principle behind other wind instruments, such as the flute or saxophone.

Rubber Waves

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Spectral Lights

To the naked eye, a glowing element appears as only a single color. However, this color is an average of the many different visible frequencies the element is emitting. Only with a device such as a spectroscope are you able to discern the different frequencies. So when you look at an atomic spectrum, don't get confused and think that each frequency of light (color) corresponds to a different element. Instead, remember that what you are looking at is all the frequencies of light emitted by a single element as its electrons make transitions back and forth between energy levels.

