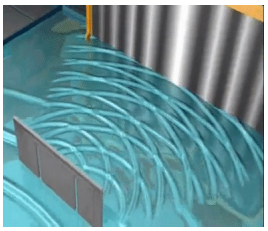
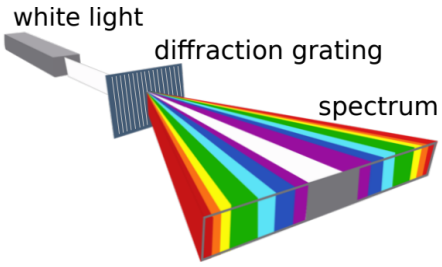
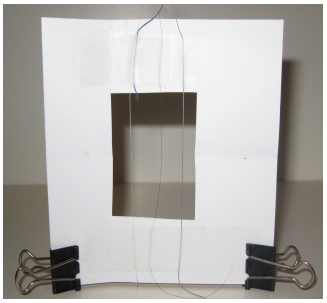
Slits and Rainbows: Diffraction Spectra

- When light waves go around a thin obstacle or through thin slits ,they make a "diffraction pattern" with dark and bright spots
- Different colors of light make wider or narrower patterns.
- White light has many colors mixed together. When passing through a grating of slits, it splits into a rainbow.





Part 1: Diffraction around an obstacle



1. Find a volunteer with medium-to-long hair willing to donate 1 hair. Cut out a square of cardstock with a hole in the middle. Tape the piece of hair stretched tight across the hole. Use binder clips to make it stand.

2. Shine a laser pointer at a blank screen (paper with binder clips), about 3 ft away. Place the hair in the path of the laser pointer.

Can you make a diffraction pattern, with alternating light and dark bands?
Sketch the diffraction pattern if the hair is oriented vertically:

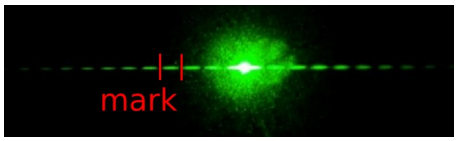
3. Make a prediction: what would the pattern look like if the hair is turned horizontally?
Predicted: Observed:

4. What happens to the pattern bands if you move the laser closer to the hair?
Circle one: further apart closer together unchanged

What happens to the pattern bands if you move the hair closer to the screen?
Circle one: further apart closer together unchanged

For the rest of the activity, pick a particular distance between hair and screen. Do not change that distance.

3. Mark with a pencil the position of two nearby dark spots in the pattern. Measure the distance between the two marks with a ruler.



Separation between two nearby dark spots for human hair: _____ cm

4. Repeat the experiment with a horse hair instead of human hair. Tape both on the same square of cardboard, shine a laser, measure the diffraction pattern on the screen.

Separation between two nearby dark spots for horse hair: _____ cm

Discuss: What changes when comparing horse hair and human hair? Which hair do you think is thickest, and which one makes more separated bands?

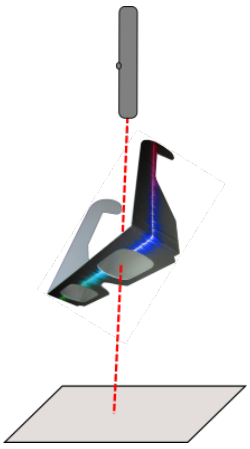
Fill in the general rule for diffraction:

A wider obstacle will make a diffraction pattern with bright and dark bands spaced _____ (farther apart / closer together?)

5. Optional: borrow a hair from a friend. Repeat the measurement.
Can you use the spacing in the diffraction pattern to tell who has thicker hair?

Part 2: Diffraction Grating

1. Place a piece of cardstock on the table to serve as your screen.
2. Hold the diffraction glasses a couple of fee above the screen, and shine the red laser pointer through them.
Draw the diffraction pattern you see:



What happens to the pattern dots if you move the glasses closer to the screen?

further apart closer together unchanged

4. Make a prediction: sketch what you think the pattern will look like if you shine the laser through 2 glasses, one after the other. Test your prediction!
Predicted: Observed:

5. Shine a green laser **and** a red laser through **one pair** of glasses, at the same time. Line up one red dot with one green dot.

Which diffraction pattern has the dots further apart?: red green

Part 3: Making Rainbows with Diffraction

White light includes light waves of many different colors mixed together. When white light shines through a diffraction grating, different colors will spread out different amounts, and you'll see the colors separate to make a rainbow!

1. Think about what you just saw with the laser, and make a prediction:

When white light goes through a diffraction grating, which rainbow color do you expect to bend farther away from the light source? red green

2. Put on your glasses and look up at the ceiling lights. Which color is farther away from the light source? Were you right?

Different sources of white light mix different combinations of colors.

flame incandescent fluorescent LED

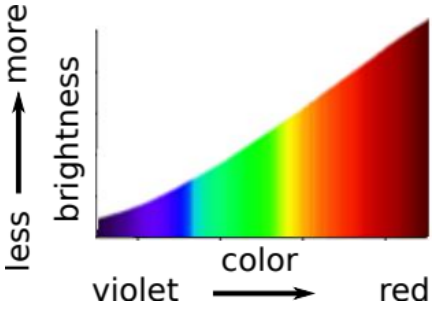



Safety warning: Turn off the lightbulbs once you've looked at them – they will get hot! Only an adult should light the candle at the front of the room

2. Light the candle and look at the flame through the diffraction glasses.

Do you see more **red light** or **blue light**? (Circle one)

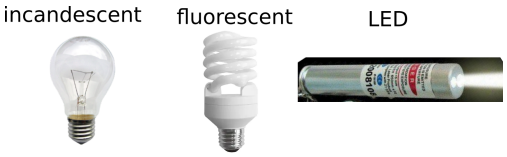
This graph shows the light spectrum of a candle flame:

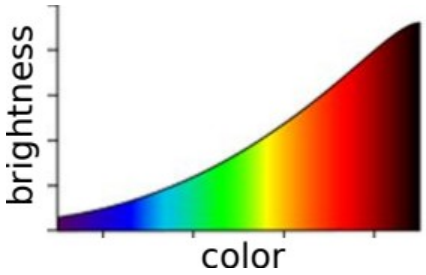


3. Look at the 3 other light sources (**incandescent** bulb, **fluorescent** bulb, white **LED**). Look at each of them from the side, or cover up with your hand and look between your fingers. Do not look straight at the lights.

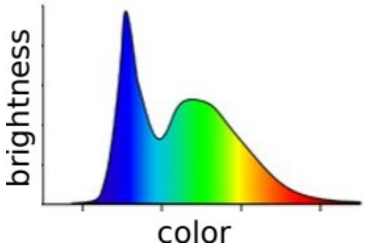
Match each type of bulb with the spectra below. (Circle one for each question)

(a) Which bulb has a spectrum most like candle light?

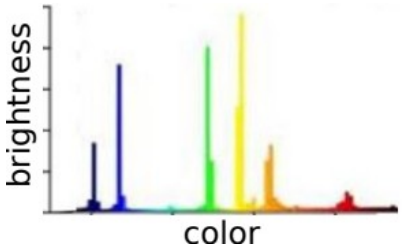


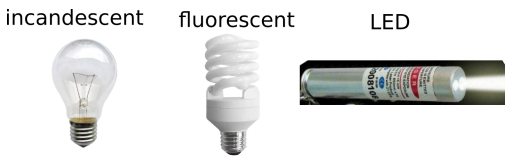


(b) Which bulb has a spectrum that looks like this, with a lot of blue, less cyan and broad spectrum from green to red?



(c) Which bulb has a spectrum that looks like this, with **separate** distinct colors (not the full rainbow blurred together)?





Using your diffraction glasses, can you identify what kind of light-bulbs are in the ceiling lights in the library room? Incandescent fluorescent LED

- Incandescent bulbs make light by heating a metal filament. The light produced by hot objects (candle flame or fliament) is called "blackbody radiation" and has a continuous full rainbow spectrum
- LEDs make blue light when electricity runs through a semiconductor. Special chemicals ("yellow phosphors") inside the bulb absorb this blue light and re-emit it as a broad spectrum around yellow.
- Fluorescent bulbs make violet light by running electricity through mercury gas. The light is absorbed by specific phosphors, each of which emits a particular specific color.