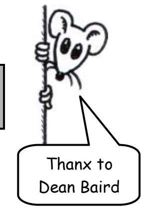
Name_________________________________ Period_________ Date_________



CONCEPTUAL PHYSICS	Activity

31.4 Diffraction and Interference: Diffraction Gratings

LASER TREE

Purpose
In this activity, you will investigate the splitting of a light beam that occurs when the beam passes through a diffraction grating. You will determine the role of wavelength and line spacing in the resulting pattern.

Required Equipment and Supplies
light beam viewing tank (or equivalent)
access to water
access to scattering agent (Mop-N-Glo™, Pine-Sol™, powdered milk, or equivalent)
stirring rod
long-wavelength laser pointer (red)
short-wavelength laser pointer (green)
low-density diffraction grating (500±100 lines/millimeter)
high-density diffraction grating (1000±100 lines/millimeter)
access to adhesive tape

LASER LIGHT WARNING: TO AVOID INJURY, DO NOT EXPOSE EYES TO DIRECT LASER LIGHT. DO NOT AIM THE LASER AT PEOPLE OR ANIMALS.

Optional Equipment and Supplies
diffraction (“rainbow”) glasses
airborne scattering agent (“fog in a can,” or equivalent)

Discussion
When light passes through a pair of thin slits, an interference pattern reveals the wave nature of light. A diffraction grating is a film with thousands of slits. Light waves passing through a diffraction grating also produce an interference pattern. The geometry of the pattern depends on the spacing of the slits and the wavelength of the light.

Procedure
Step 1: Fill the tank with water to within about an inch of its full capacity.

Step 2: Add a small amount of scattering agent to the water and stir to mix it thoroughly.

Step 3: Tape the **high-density** diffraction grating to one end of the tank as shown in figure 1. The grating lines must be horizontal so that light passing through them spreads out vertically.

Note: the slits are very close together on the high-density grating: more lines per millimeter means less space between the lines.

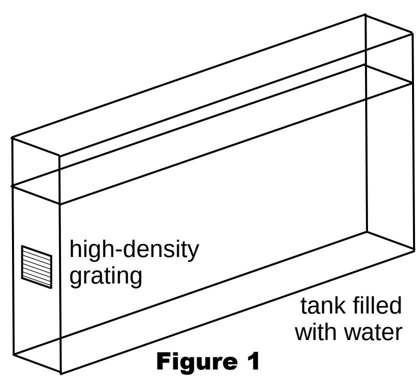


Figure 1

Step 4: Shine the short-wavelength (green) laser through the grating and observe the pattern in the tank. Sketch the pattern in figure 2.

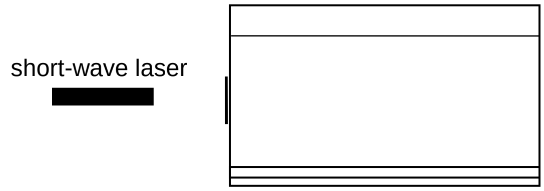


Figure 2

Step 5: Shine the long-wavelength (red) laser through the grating and observe the resulting pattern. Sketch the pattern in figure 3.

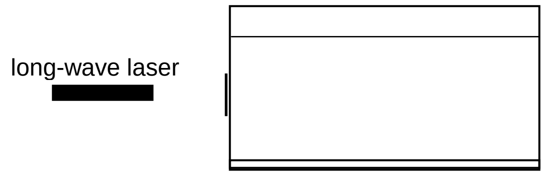


Figure 3

How is the geometry of the long-wavelength diffraction pattern different from that of the short-wavelength pattern?

Step 6: Replace the high-density grating with the **low-density** grating. The space between the slits is greater on the low-density grating.

Step 7: Shine the short-wavelength (green) laser through the grating and observe the pattern in the tank. Sketch the pattern in figure 4.

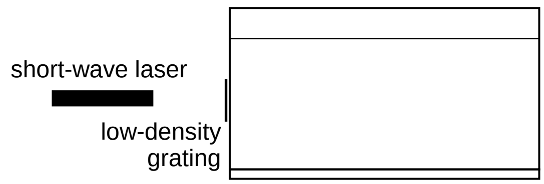


Figure 4

How is the geometry of the high-density grating diffraction pattern different from that of the low-density grating pattern?

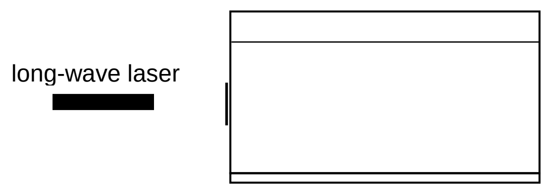


Figure 5

Step 8: Shine the long-wavelength (red) laser through the grating and observe the resulting pattern. Sketch the pattern in figure 5.

Optional Procedure

Step 1: With room lights dimmed or out, create a “cloud” of airborne scattering agent.

Step 2: Shine the green laser through the diffraction (“rainbow”) glasses and into the cloud of scattering agent.

What is the result, and how is it different from the pattern seen in the previous steps? Describe and sketch the pattern in the space below.

Step 3: While the laser is shining through the glasses, rotate the glasses clockwise or counterclockwise.

What effect—if any—does rotating the glasses have on the pattern?

Summing Up

1. Which combination of grating and light produces the widest pattern (that is, the beams are most spread out)?

2. Which combination of grating and light produces the narrowest pattern?

3. As the wavelength of light increases (for example, from green to red), what happens to the width of the pattern?

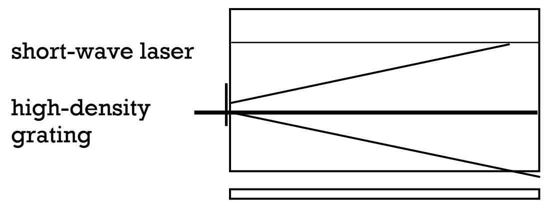
4. As the line spacing on the grating increases (for example, from 1000 lines per millimeter to 500 lines per millimeter), what happens to the width of the pattern?

Laser Tree [Activity]

This activity has a significant "wow" factor because of its visual impact: It's very cool to look at! The optional procedure is extremely cool: don't miss it! While it's common to shine a laser beam through a diffraction grating and see the resulting pattern of dots on a far wall, this activity allows you to see the multiple beams that emerge from the grating. It is possible to use an aquarium for this activity and do it as a demonstration. Be sure to instruct students on safe laser pointer usage.

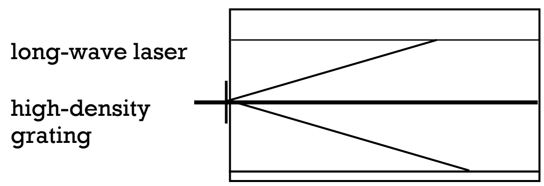
Answers to Procedure Questions

Step 4. Green laser through the 1000 line/mm grating.



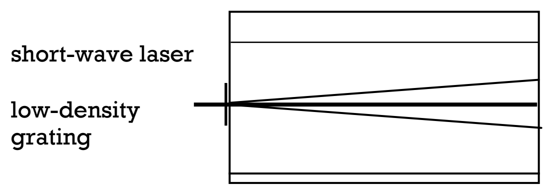
Step 5. Red laser through the 1000 line/mm grating.

The pattern is wider.

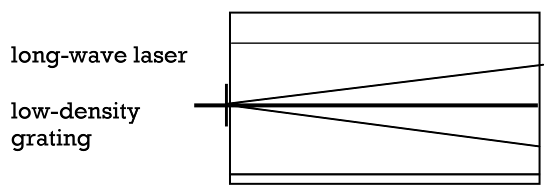


Step 7. Green laser through the 500 line/mm grating.

The pattern is narrower.



Step 8. Red laser through 500 line/mm grating.



Optional Procedure

Step 2. The beam emerges as 9 beams in a three-by-three matrix

Step 3. Rotating the glasses rotates the pattern.

Answers to Summing Up Questions

1. The widest pattern is produced by long wavelength light passing through the high-density grating (red laser through the 1000 line/mm grating).
2. The narrowest pattern is produced by short wavelength light passing through the low-density grating (green laser through the 500 line/mm grating).
3. As the wavelength increases (from green to red), the pattern gets wider.
4. As the line spacing increases (from 1000 lines/mm to 500 lines/mm), the pattern gets narrower.