Laser Benders

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QUESTION

What is the effect of the wavelength of light on the angle of diffraction when it is passed through a slit?

ABSTRACT

Diffraction is the bending of light around partial barriers or through an narrow opening. Diffraction is used to understand atomic structure and measure very small objects. Light travels in oscillating waves. The length of each wave is called wavelength. This is different for different types of light. The objective of this experiment is to find the effect of wavelength of light on the angle of bending due to diffraction.

Light from two laser light sources, red with wavelength 635nm and green with wavelength 532nm, was passed through a 0.1mm slit grating and the width of the central light blob on a screen at distances of 2m, 2.5m and 3m are measured. The angle of diffraction is calculated from these widths. Results confirm the hypothesis that larger wavelengths result in increased angle of diffraction.

HYPOTHESIS

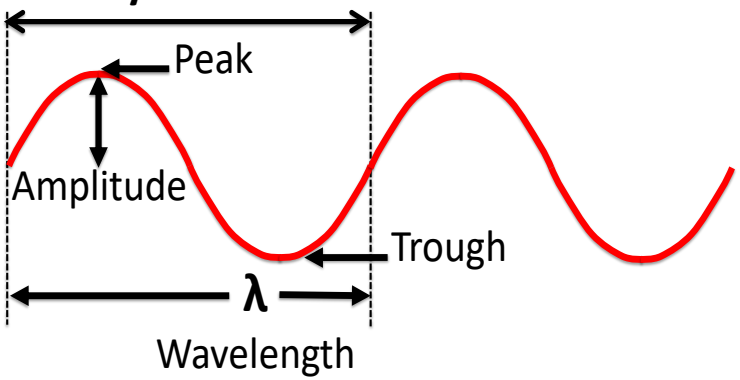
If wavelength of light ↑

→ then angle of diffraction ↑

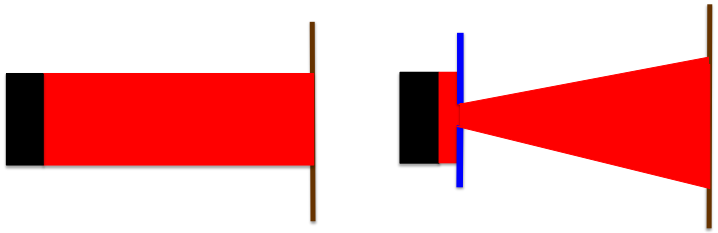
RESEARCH

Light travels in cycles of waves

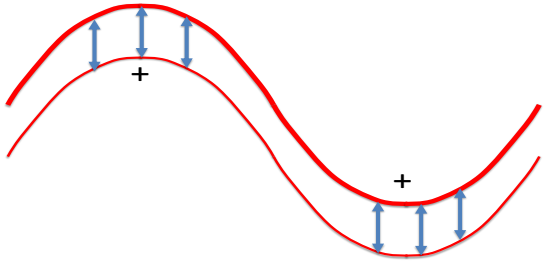
One cycle of wave



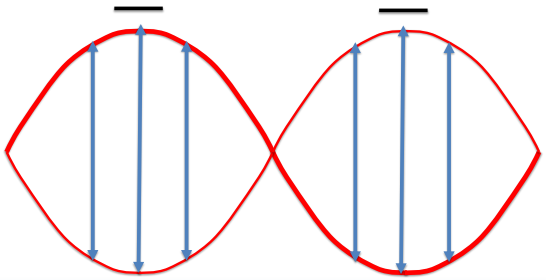
Diffraction is bending of light
Around barrier or through slit

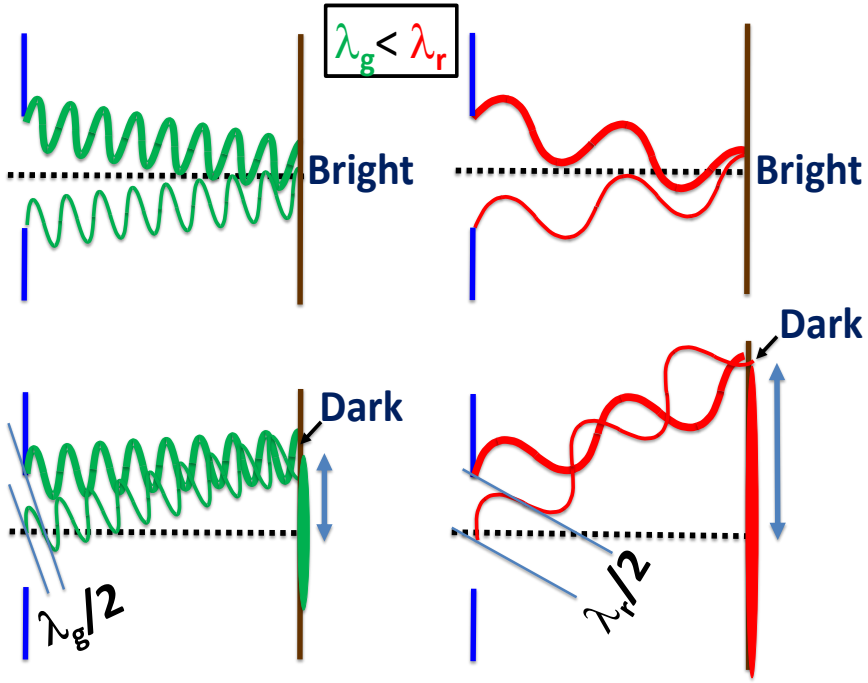


Waves Add ⇒ Bright
Constructive Interference

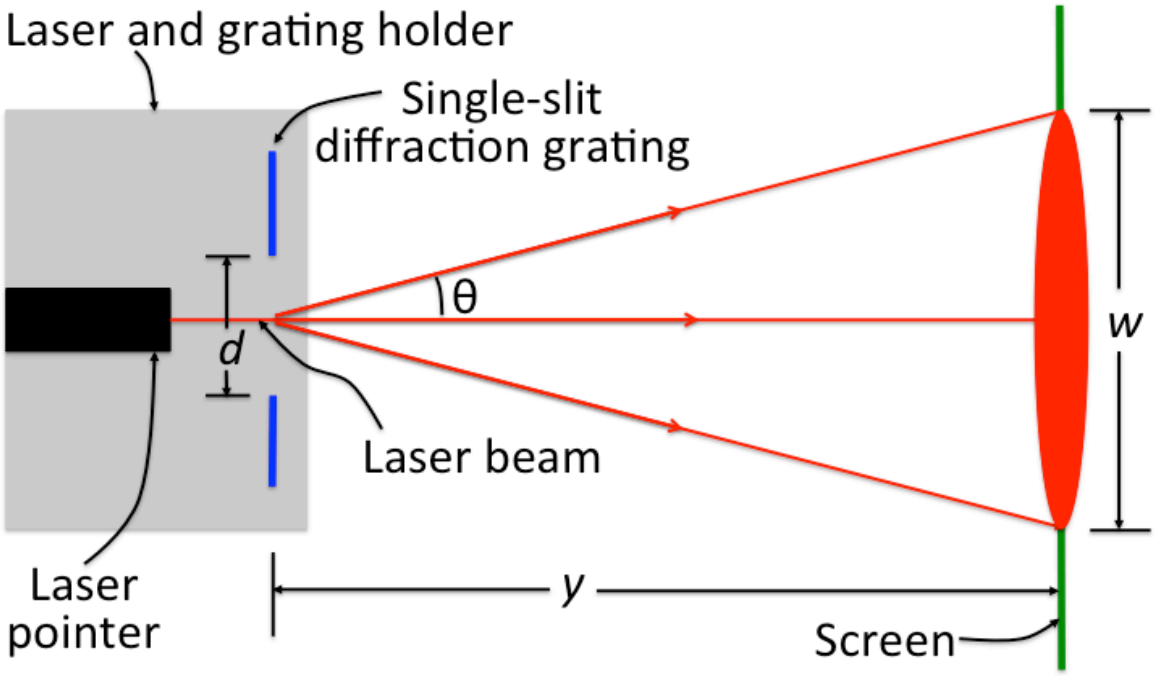


Waves Subtract ⇒ Dark
Destructive Interference

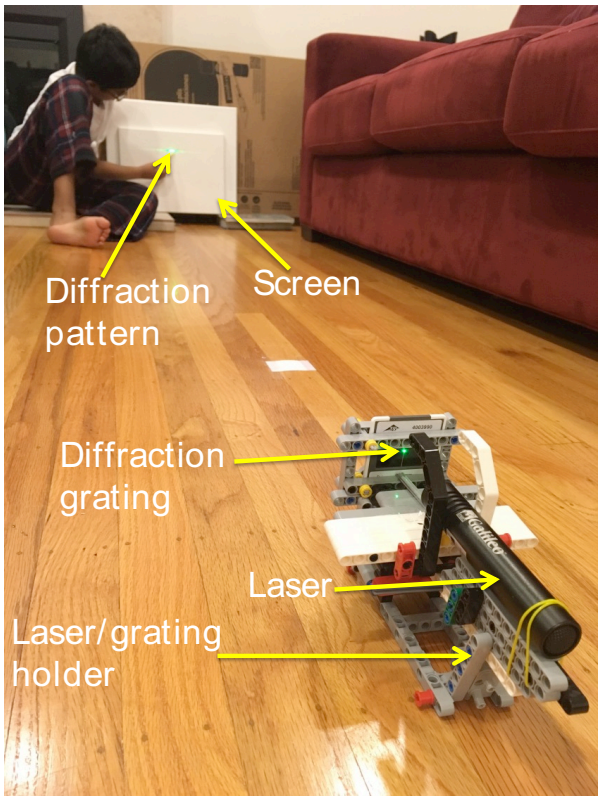


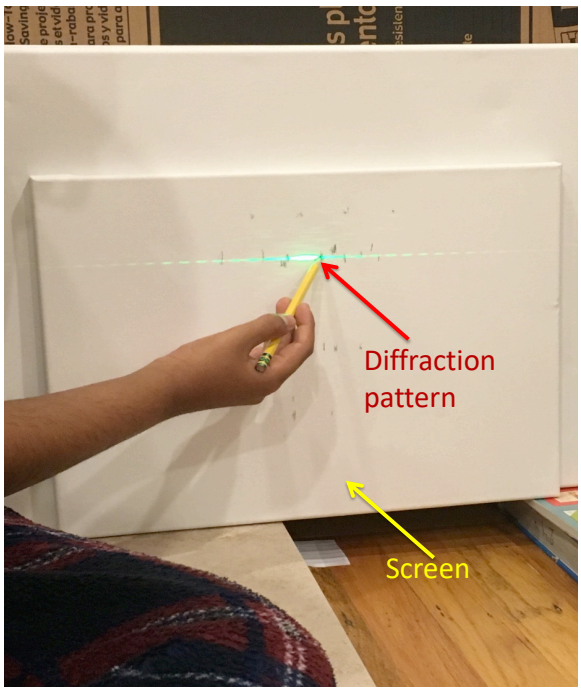


SETUP



d – width of slit y – distance of screen from slit
w – width of light blob θ – angle of diffraction





MATERIALS

- 532nm green laser source
- 635nm red laser source
- 0.1mm single-slit diffraction grating
- Pencil
- Laser/grating holder
- Calculator
- Canvas screen
- Measuring tape
- Ruler

PROCEDURE

1. Place red laser on holder at 2m from screen
2. Turn on laser
3. Mark ends of central light blob with pencil
4. Turn off laser
5. Measure distance between marks on screen with a ruler and record is as w
6. Use calculator to find angle as $\tan^{-1}((w/2)/y)$ and record it
7. Repeat steps 2 to 6 for 3 trials
8. Repeat steps 2 to 7 with the grating in the holder as shown in the setup
9. Remove the grating and repeat steps 2 to 8 for laser positions at 2.5m and 3m from screen
10. Remove the grating and repeat steps 2 to 9 with green laser

DATA

Measurement of width of central light blob

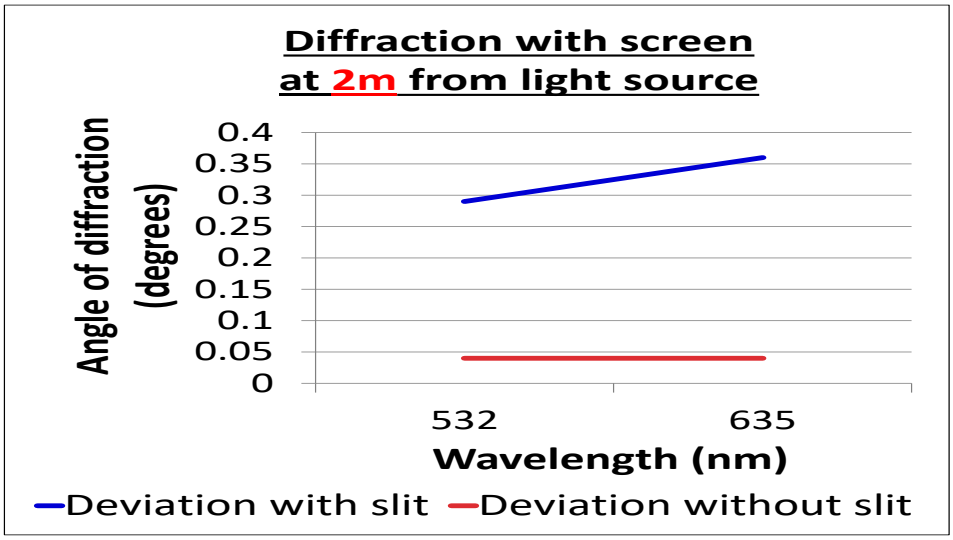
Wavelength of light source (nm)	Distance of screen from light source (m)	Width of central blob of light with no slit (cm)			Width of central blob of light with slit (cm)		
		Trials			Trials		
		1	2	3	1	2	3
532	2.0	0.3	0.3	0.3	2.0	2.0	2.0
532	2.5	0.4	0.35	0.4	2.6	2.7	2.5
532	3.0	0.5	0.4	0.45	3.0	3.1	3.1
635	2.0	0.3	0.3	0.3	2.4	2.5	2.6
635	2.5	0.4	0.4	0.4	3.1	3.2	3.2
635	3.0	0.3	0.4	0.4	3.8	3.9	3.9

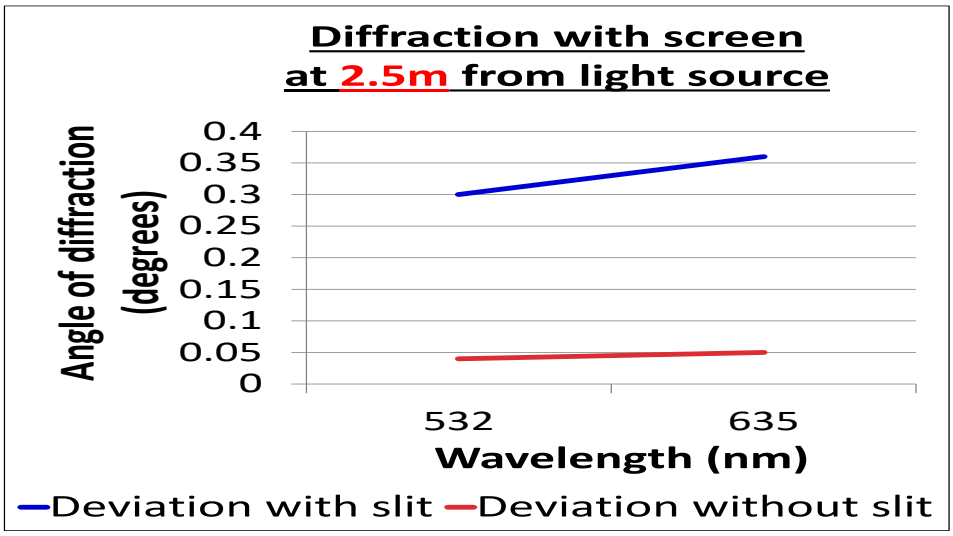
DATA

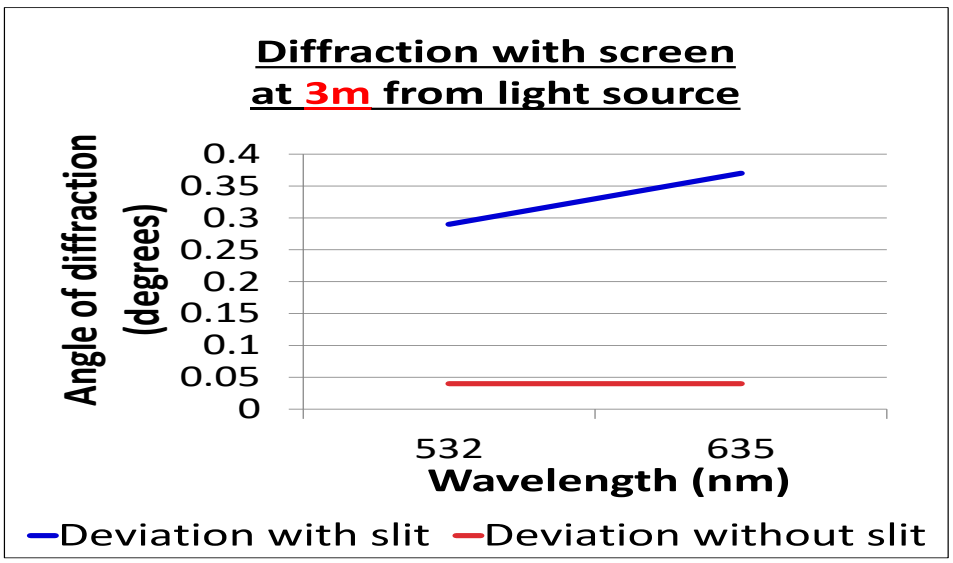
Calculation of angles of diffraction

Wavelength of light source (nm)	Distance of screen from light source (m)	Angle of diffraction with no slit (degrees)				Angle of diffraction with slit (degrees)			
		Trials			Mean	Trials			Mean
		1	2	3		1	2	3	
532	2.0	0.04	0.04	0.04	0.04	0.29	0.29	0.29	0.29
532	2.5	0.05	0.04	0.05	0.04	0.30	0.31	0.29	0.30
532	3.0	0.05	0.04	0.04	0.04	0.29	0.30	0.30	0.29
635	2.0	0.04	0.04	0.04	0.04	0.34	0.36	0.37	0.36
635	2.5	0.05	0.05	0.05	0.05	0.36	0.37	0.37	0.36
635	3.0	0.03	0.04	0.04	0.04	0.36	0.37	0.37	0.37

RESULTS


Diffraction with screen at 2m from light source
Angle of diffraction (degrees)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
532
635
Wavelength (nm)
Deviation with slit
Deviation without slit


Diffraction with screen at 2.5m from light source
Angle of diffraction (degrees)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
532
635
Wavelength (nm)
Deviation with slit
Deviation without slit


Diffraction with screen at 3m from light source
Angle of diffraction (degrees)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
532
635
Wavelength (nm)
Deviation with slit
Deviation without slit

CONCLUSION

- Results show that the hypothesis is correct

- Major conclusions
  - If there is no slit, there is no diffraction for red and green laser
  - Red laser of higher wavelength has larger angle of diffraction
  - Green laser of lower wavelength has smaller angle of diffraction
  - If wavelength increases, angle of diffraction increases

IMPROVEMENTS & FUTURE RESEARCH

- Improvements
  - Improve precision of measurements by building a more robust laser holder

- Future Research
  - Experiment with light sources of diverse wavelengths to find pattern of relationship between wavelength and angle of diffraction
  - Explore the effect of different slit widths on the angle of diffraction