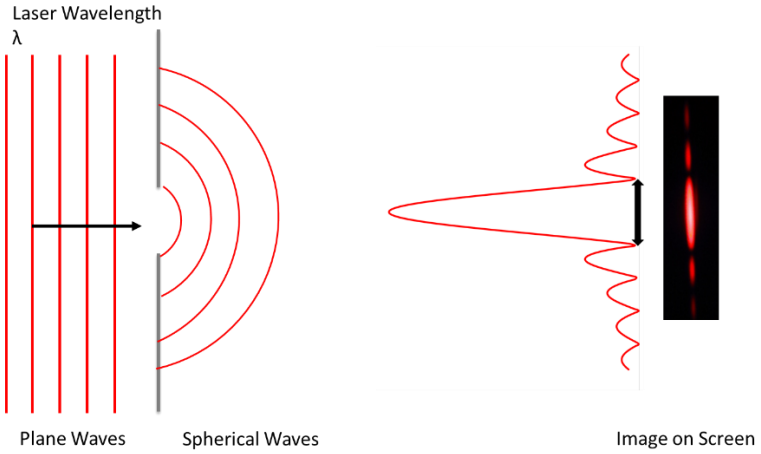
Optical Forensics

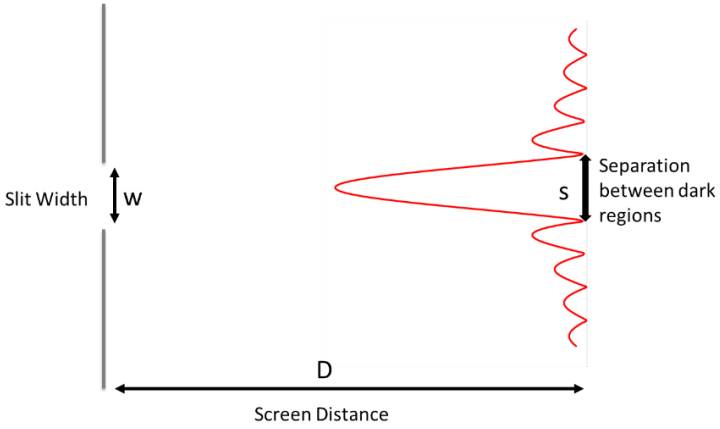
DIFFRACTION

Various threads and hair samples have been collected at our crime scene. It would be extremely difficult to accurately measure the thickness of these samples and identify their origin with ordinary tools. However, we can use a laser source and analyze diffraction patterns to accurately measure the diameter of any fiber.

Diffraction is a consequence of the wave nature of light and blocking a laser with a fiber creates an interference pattern as shown below.



We can use this knowledge of the pattern to calculate the width of the fiber:



$$Width\ of\ Sample = \frac{Laser\ Wavelength\ *\ Distance\ to\ Screen}{Separation\ between\ dark\ regions}$$

$$w = \frac{\lambda * D}{s}$$

NOTE: Never look directly into a laser! Practice safe procedures by directing the lasers towards the walls and well below eye height.

Setup

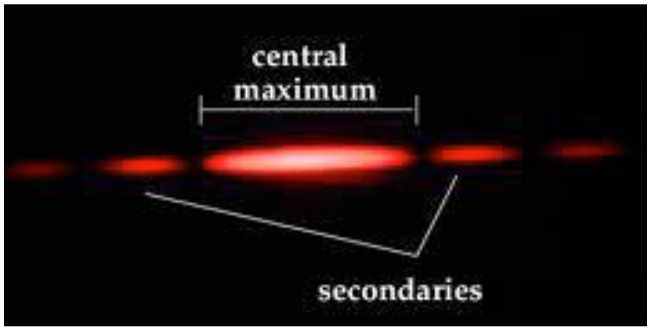
1) Mount the laser to the optical bench and adjust the height so the beam is parallel to the table.
2) Use tape to fix a single fiber to the front of the laser.
3) Turn the laser on and tape a piece of paper to the wall to act as the screen.

Measurement

1) Using a tape measure, record the distance from the laser to the screen.

D = _____

2) Mark the center of the dark regions on either side of the central bright spot on the paper screen with a pencil.
3) Move the paper, and repeat step 2 with different lab partners recording the dark regions.



4) Remove the paper from the wall, and measure the distance between the marks, repeating the measurement several times to get an average.

S = _____
S = _____
S = _____
S = _____
S = _____

5) Calculate the width of the sample, using λ = 633nm for a red laser or λ = 532nm for a green laser. (Remember to convert your units!)

$$w = \frac{\lambda * D}{s}$$

6) Repeat steps 1-5 for the other samples and record your results in the below table.

Sample	Wavelength (λ)	Screen Distance (D)	Separation between zeros (s)	Average Spacing ($\bar{s}$)	Width (w)
1					
2					
3					
4					

Using the chart on page 4, what types of fibers are possible sources for your sample?

Start with a sample of a known thickness. What should the diffraction pattern look like? (i.e. what is the distance between the +/-1 dark regions?)

Use: $s = \frac{\lambda * d}{w}$

For a thicker sample, how would the distance between the minima (dark regions) change?

Source	Low Value	Mean	High Value
	Values in microns		
Animal			
Cow	141	150	159
Goat	87	100	113
Buffalo	98	110	122
Dog	19	25	31
Sheep	80	90	100
Pig	107	120	133
Donkey	34	50	66
Rat	36	40	44
Cat	28	30	32
Horse	81	90	99
Squirrel	37	50	63
Camel	57	80	103
Human Scalp Hair	38	50	62
Fabrics			
Cotton	6	10	14
Silk	12	15	18
Rayon	18	20	22
Wool	11.5	18	24
Other Materials			
Copper wire	60	80	100
Paper Fibers	50	60	70
Plant Fibers	45	50	60

SPECTRAL ANALYSIS

In this section, we use various wavelengths of light to our advantage to examine different pieces of evidence.

A) Spectrometer – "Soil sample"
   i. Diffraction glasses
   ii. Ocean Optics / Vernier Spectrometer

🔍 *Describe what you observe while wearing diffraction glasses and compare this to the Ocean Optics / Vernier Spectrometer results.*

🔍 *What element can you identify in our "soil" sample? What are the peak wavelengths?*

B) UV Analysis – "Footprint"
A piece of carpet from the crime scene was removed and brought to our lab for further examination. Different materials will fluoresce when illuminated with an ultraviolet (UV) light source.

🔍 *Do you see anything with the naked eye?*

🔍 *What do you see when looking at the sample with the UV lamp?*

C) Near IR – "Money"
Some dollar bills were left at the crime scene and could be pieces of evidence. Real money has identifying features to protect against counterfeiting.

🔍 *Do the dollar bills appear different when using a near-IR camera?*

🔍 *Can you identify any micro-images using a macro lens (i.e. pixel viewer) or microscope?*

D) Sodium lamp – "Red shirt"
An eyewitness claims to have spotted someone leaving the crime scene that wearing a red shirt. The street was lit with sodium lamps, which have a yellow appearance.

🔍 *Which of the three shirts was likely the one that our suspect was wearing? Can you trust the eyewitness testimony?*

➢ **From all the data you have gathered, can you identify any characteristics of a potential suspect?**