Name ______________________________ Date _________

Partners ____

Two-slit Interference (Colors): Lab #13

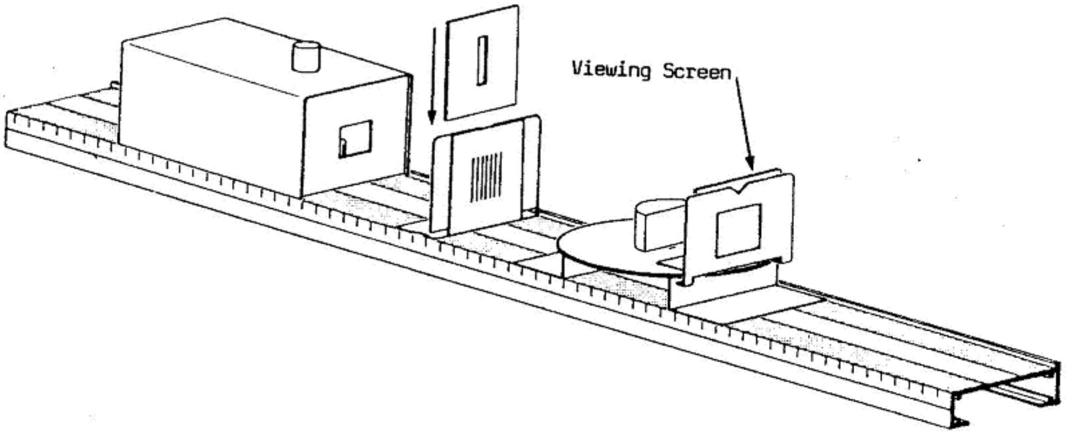
Background: What is light? There may be no complete answer to this question, but in certain circumstances light behaves as a wave does. We can measure the wavelength of this wave and see how the wavelength correlates with the "color" we perceive with our eyes.

Equipment: Pasco optical kit, flashlight

Procedure:

1. Color separation by refraction

Set up the optical bench with the lamp at one end. Close to it (20 mm or so) put the slit plate and the mask on one holder so that only one ray of light can get through. Then place the circular ray table on its slightly tilted base close to them. On the ray table put the cylindrical lens with its rounded side facing the lamp. On the side of the ray table farthest from the lamp put the holder with "tiny feet" and attach the viewing screen to it.



Slowly rotate the ray table so that you increase the angle of incidence of the light ray on the lens. Carefully watch the refracted ray on the viewing screen. Notice the color separation at large angles of refraction. At what angle is this first noticeable? _____________

Sketch from a top view:

2. Color mixing

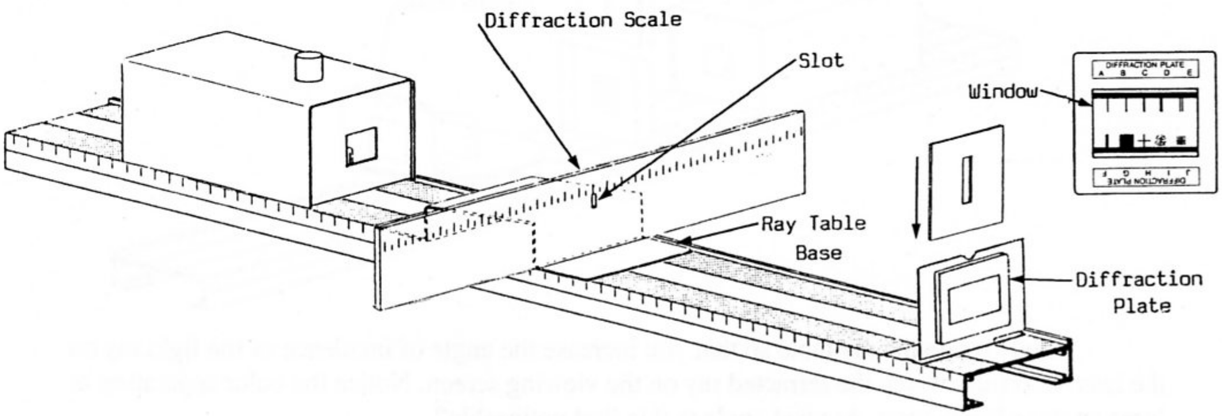
Remove the slit mask and replace it with the red filter and the blue/green filter butted next to each other so that the three central light rays are red, green, and blue. Rotate the ray table with the cylindrical lens so that these three central rays all intersect at the same point on the ray table.

Remove the viewing screen and its holder from the ray table. Remove the viewing screen from the holder and hold the screen in your hand. Carefully move the viewing screen outwards from the lens toward this point of intersection. Describe the results:

3. Interference of light waves

A light wave going through two closely spaced openings in an opaque barrier can interfere with itself. (Or you can think of this as the interference of new Huygens wavelets spreading out from each slit.) This interference can be constructive (bright, large amplitude) or destructive (dark, low amplitude). You can view the slit openings from a large distance away and see the pattern of alternating bright and dark "fringes." A scale will allow you to measure the positions of the fringes, and then you can calculate what the wavelength of the light wave must be.

Put the lamp at one end of the optical bench. Attach the red filter to the front of the lamp. Then the ray table base with the large diffraction scale attached to it on the side away from the lamp. Put a holder about 40 cm (this will be L) further along the optical bench and attach the slit mask to it. Align things so that you can see the lamp's filament through the slit mask and the tiny slot window in the diffraction scale. Attach the small diffraction plate to the other side of the same holder as the slit mask. Line up pattern "D" with its tiny slits vertical in the center of the slit mask.



Look through the tiny slits. By carefully centering your eye you should be able to look through both slits and also the window of the diffraction plate at the same time. You should see clearly both the interference pattern and the illuminated scale on the large diffraction scale.

At the zeroth maximum, light rays from slit A and from slit B have traveled the same distance, so they are in phase and interfere constructively, giving a bright band. At the first order maxima, light from one slit has traveled a distance of one extra wavelength further than the light from the other slit, so constructive interference occurs again. At the mth order maxima, the light has traveled m wavelengths further from one slit than from the other slit. Constructive interference means that the extra distance = m * λ . From the geometry, this distance is = a * sin (theta) where a is the spacing between the slits, and theta is the angle at which you see the mth maximum. The spacing between these slits is .125 mm = __________________________ meters.

Therefore you need only measure theta for a particular m to determine the wavelength of the light.

To measure angle theta we notice which number y the pattern coincides with on the large diffraction scale. It is easiest to count as a group all of the distinct fringes you can see (usually 5 to 10 of them) and then record the total y distance they take up. (For instance if the fringes go from y = -.5 cm to y = +.7 cm then the total y is 1.2 cm.)

If the distance from the diffraction scale to the slits is L, then theta = arctan (y/L).

So $m * \lambda = a * \sin(\text{theta}) = a * \sin(\arctan(y/L))$

$$\text{So, wavelength } \lambda = \frac{a * \sin(\arctan(y/L))}{m}$$

Looking through the pair of slits at the light source, measure y to calculate the wavelength. Use the red, green, and blue filters in turn over the light source opening.

Measurements **Calculations**

Color	m	y, cm	L, cm	Calculated wavelength, λ, meters	Reasonable?
Red					
Green					
Blue					

Red light has a wavelength from 630 to 700 nm, green light has a wavelength from 480 to 560 nm, and blue light has a wavelength from 440 to 480 nm.

Are the wavelengths you calculated from your measurements reasonable?

Conclusions:

Discussion of Errors:

Future work in this field: