Experiment #: 18

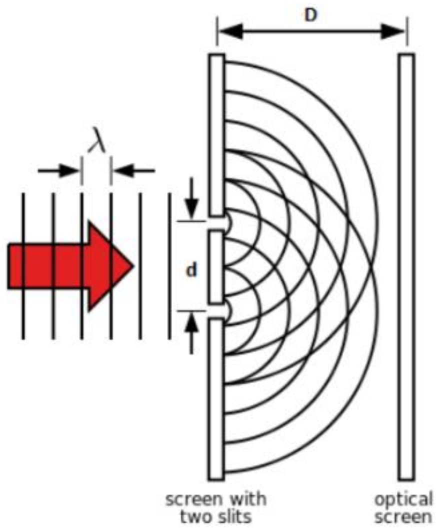
Experiment Title: Young's Double Slit Experiment

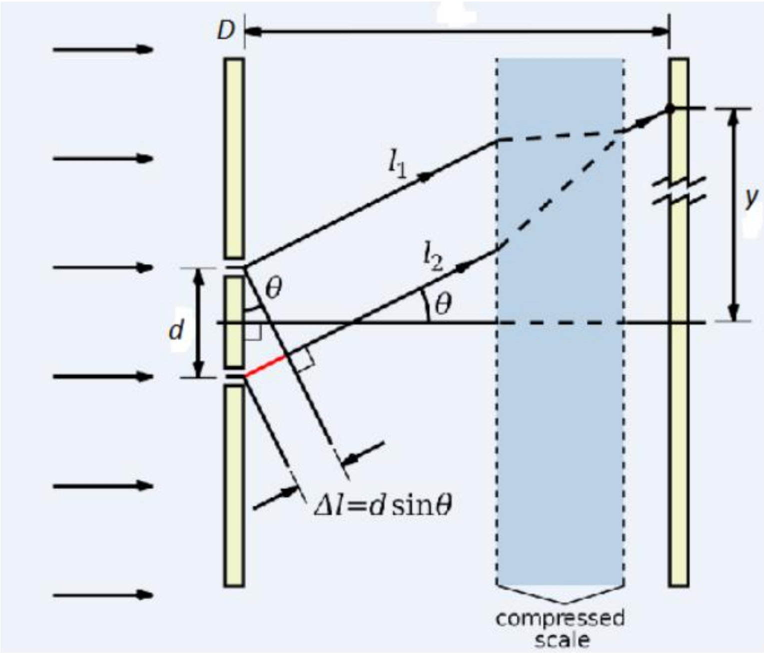
Objectives:

Theory:

In 1801 Thomas Young conducted an experiment in which he shone light from a single light source onto two slits, thus creating two beams of light which, when recombined, displayed the interference phenomenon. The classical investigation delivered final proof of the wave nature of light. In the first experiment the students will become familiar with the principle of Young's experiment on interference. In a second experiment they will ascertain the wavelength λ of red light.

Young's double-slit experiment uses two coherent sources of light placed at a small distance apart, usually, only a few orders of magnitude greater than the wavelength of light is used. Young's double-slit experiment helped in understanding the wave theory of light which is explained with the help of a diagram. A screen or photodetector is placed at a large distance 'D' away from the slits as shown.





Young's Double Slit Experiment

Each source can be considered as a source of coherent light waves. At any point on the screen at a distance 'y' from the centre, the waves travel distances l_1 and l_2 to create a path difference of Δl at the point in question. The point approximately subtends an angle of θ at the sources (since the distance D is large there is only a very small difference of the angles subtended at sources).

If light is a particle…

We set up our screen and shine a bunch of monochromatic light onto it.

- If light is a particle, then only the couple of rays of light that hit exactly where the slits are will be able to pass through.
  - Imagine it as being almost as though we are spraying paint from a spray can through the openings.
- Since they are little particles they will make a pattern of two exact lines on the viewing screen (**Figure 1**).

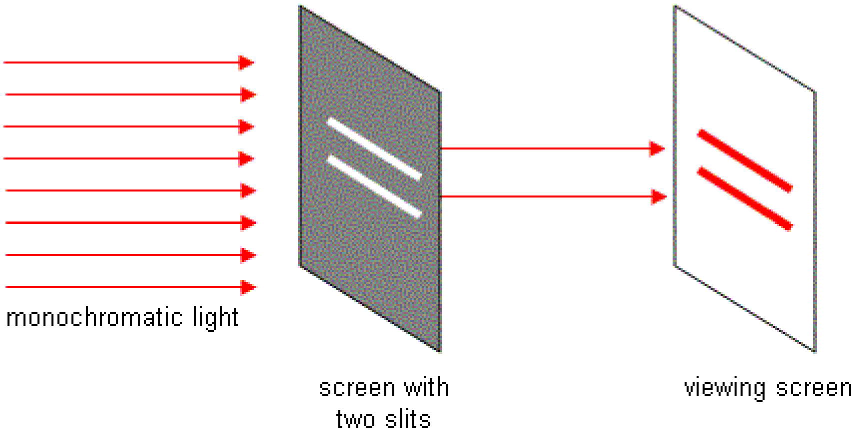


Figure 1

If light is a wave…

If light is a wave, everything starts the same way, but results we get are very different.

- There are still only two light rays that actually go through the slits, but as soon as they pass through they start to **diffract**.
  - Remember, **diffraction** is when light passes through a small opening and starts to spread out. This will happen from **both** openings (**Figure 2**).

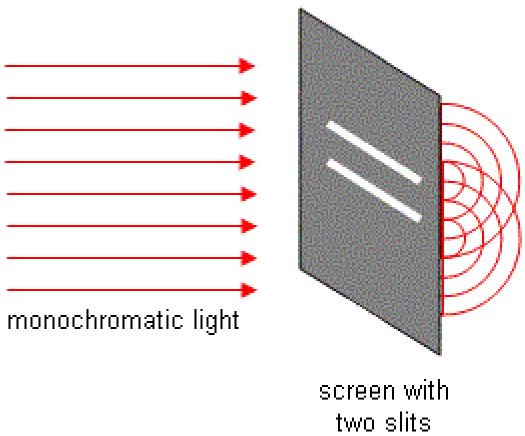


Figure 2

- Notice that at some points the two sets of waves will meet **crest** to **crest**, at other spots **crest** meets **trough**.
  - Where **crest** meets **crest**, there will be **constructive interference** and the waves will make it to the viewing screen as a **bright spot**.
  - Where **crest** meets **trough** there will be **destructive interference** that cancel each other out… a black spot will appear on the screen.
- When this experiment is performed we actually see this, as shown in **Figure 3**.

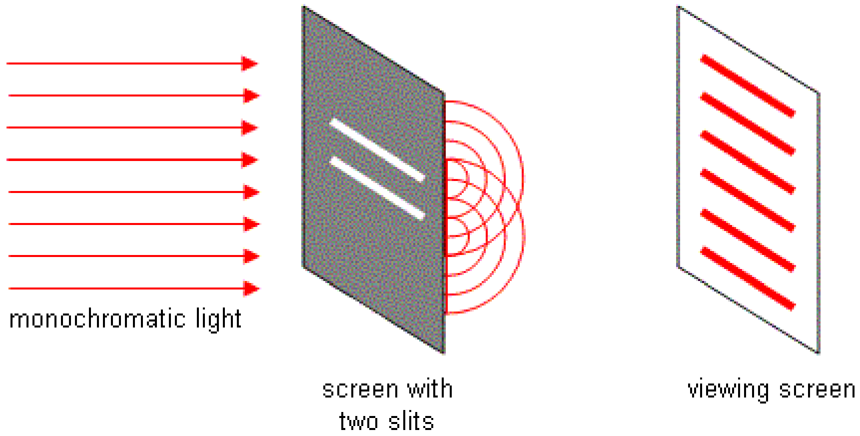


Figure 3

We must conclude that light is made up of waves, since particles can not diffract.

List of Equipment:

Apparatus

Circuit Diagram:

Procedure:

Design a double slit experiment to find the wavelength of a He-Ne laser light. Your setup may include the He-Ne laser, a glass plate with two slits, paper, measurement apparatus, and a light intensity recorder. Write a step-by-step procedure for the experiment, draw a diagram of the set-up, and describe the steps followed to calculate the wavelength of the laser light.

Data Collection:

Calculation:

When you set up this sort of an apparatus, there is actually a way for you to calculate where the bright lines (called **fringes**) will appear.

- There is always a middle line, which is the brightest. We call it the **central fringe**.

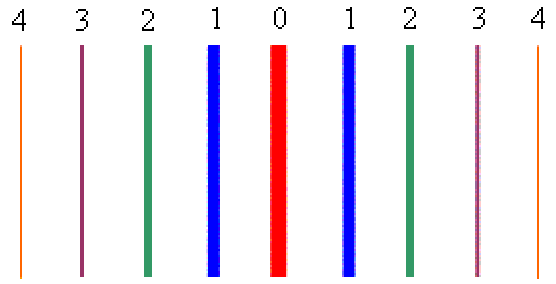


Figure 4: Note I've only coloured the lines differently here so that they will stand out better. For monochromatic light they would all have the same colour… that of the original light.

- In the formula we will use, there is a variable, "n", that is a count of how many bright fringes you are away from the **central fringe**.
    - The **central fringe** is **n = 0**.
    - The fringe to either side of the central fringe has an order of **n = 1** (the **first order fringe**).
    - The order of the next fringe out on either side is **n = 2** (the **second order fringe**).
    - And so on, as shown in **Figure 4**.

The formula that we will use to figure out problems involving double slit experiments is easy to mix up, so make sure you study it carefully.

$$\lambda = \frac{xd}{nL}$$

λ = wavelength of light used (m)
x = distance from central fringe (m)
d = distance between the slits (m)
n = the order of the fringe
L = length from the screen with slits to the viewing screen (m)

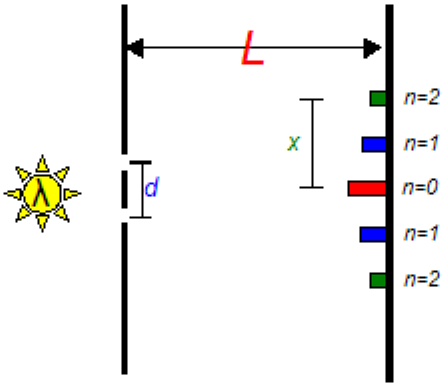


Figure 5

It is very easy to mix up the measurements of x, d, and L.

- Make sure to look at **Figure 5** and see the different things each is measuring.
- If you mix up x and d it's not so bad, since they are both on top in the formula. If you were to mix them up with L, you would get the wrong answer.
- Almost all questions that you will see for this formula just involve sorting out what each variable is... you might find it helpful to write out a list of givens.

Result: