A cheap and Easy Way to do the Double Slit Experiment

By Scott Little

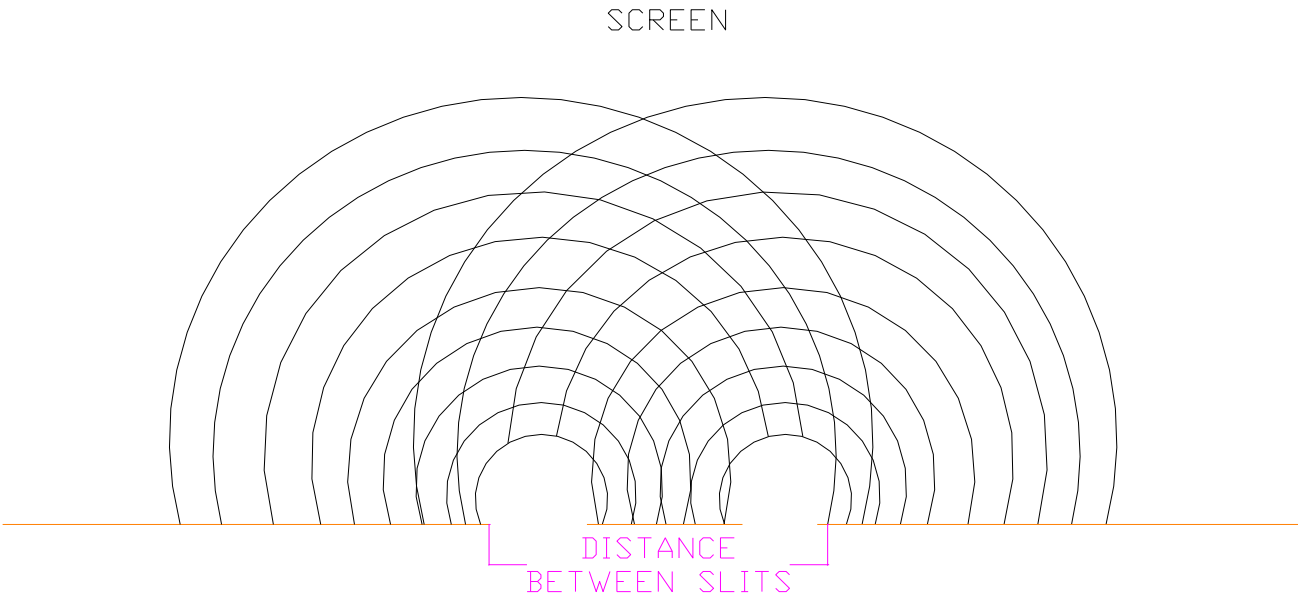
This was an article that I had originally written for the Society for Amateur Scientists https://en.wikipedia.org/wiki/Society_for_Amateur_Scientists June 2007 and concluded with a presentation for the Pomona Valley Amateur Astronomers http://www.pvaa.us/

Introduction

I am always looking for an easier and hopefully less expensive way to do things. Some of my favorite things to experiment with are the properties of light. I was Googling around and found a web site URL(1) that explained a very simple way to do the famous Young Double Slit Experiment. It was first performed by Thomas Young in 1803 when he presented his findings to the Royal Society of London. By asserting that light has both the properties of a wave as well as a particle he helped lay the foundation for what is known today as Quantum Mechanics. This experiment is one of the most duplicated in all of Physics, and it is considered by many to be the most elegant.

In its' most basic form, the Double Slit Experiment consists of directing a beam of light through a pin hole, then through two slits in a sheet of opaque paper, then finally projecting the beam onto a screen of some sort. During the time of Young, there were no forms of non-natural light, so what he did was direct a beam of sunlight through a hole in a window shutter, then through a plate of "looking glass", and finally split it in two by a horizontally held card. The card was around 1/30 of an inch, a good approximation of a modern-day 3"x5" index card.

What formed on the screen were a series of interference patterns resembling a wave hitting an obstruction. When dealing with the properties of light, we say that it has been interfered constructively, which means that one crest of one wave meets a crest from another wave (2). An image of such an interference is shown below.



(1) Fig. 1. image courtesy of Scott Little

Mathematically speaking, we can demonstrate the interference with the following equation:

$$\lambda\eta/d=x/L$$

where
λ=the wave length of light,
d= the separation of the slits,
η=the order of maxima observed, central=0
x= distance between with bands of light and the central maximum-fringe distance
L= the distance from the slits to the screen

Even though this equation is an approximation, it still can be used to calculate some of the quantities important to the Double Slit Experiment. For example, if you do not know the wave length of the light, but are able to measure the separation of the slits, the fringe distance from the center and the edge of the visible light (which will also give you the maxima) and the distance form the slits to the screen, you can determine the wavelength by $\lambda = dx/L\eta$.

My Version

I decided to build my own apparatus. The materials I used were the cheapest and most simple I could possibly find. Most of these items, with the exception of the wood mounting, can be found at the average stationary store and cost less than $20. I used a standard laser diode pointer at 630-680 nanometers, which is the wave length of red light. A word of safety: please never look directly into any laser beam, even one as weak at this.

For the card I used a standard 3”x5” stationary card, and for the pin hole a piece of cardboard with an approximate 1/8” hole in the center. I have the actual bill of material including dimensions at the end of article. As with most all of my projects, I always try to include my kids and have an element of teaching involved. My Son Isaiah, age 8, aimed the laser through the pin hole.

We set up the experiment as follows:

Distance from the experimenter end of the board to the pin hole card: 6 3/4”.
Distance from the laser position to the pin hole card: 3”.
Distance from the far edge of the 3”x5” card to the screen: 7”

We position the screen close enough to be able to see the light projected, but far enough away to create some form of interference pattern. Please see the next page for a diagram of the apparatus showing all the measurements set up for the experiment.

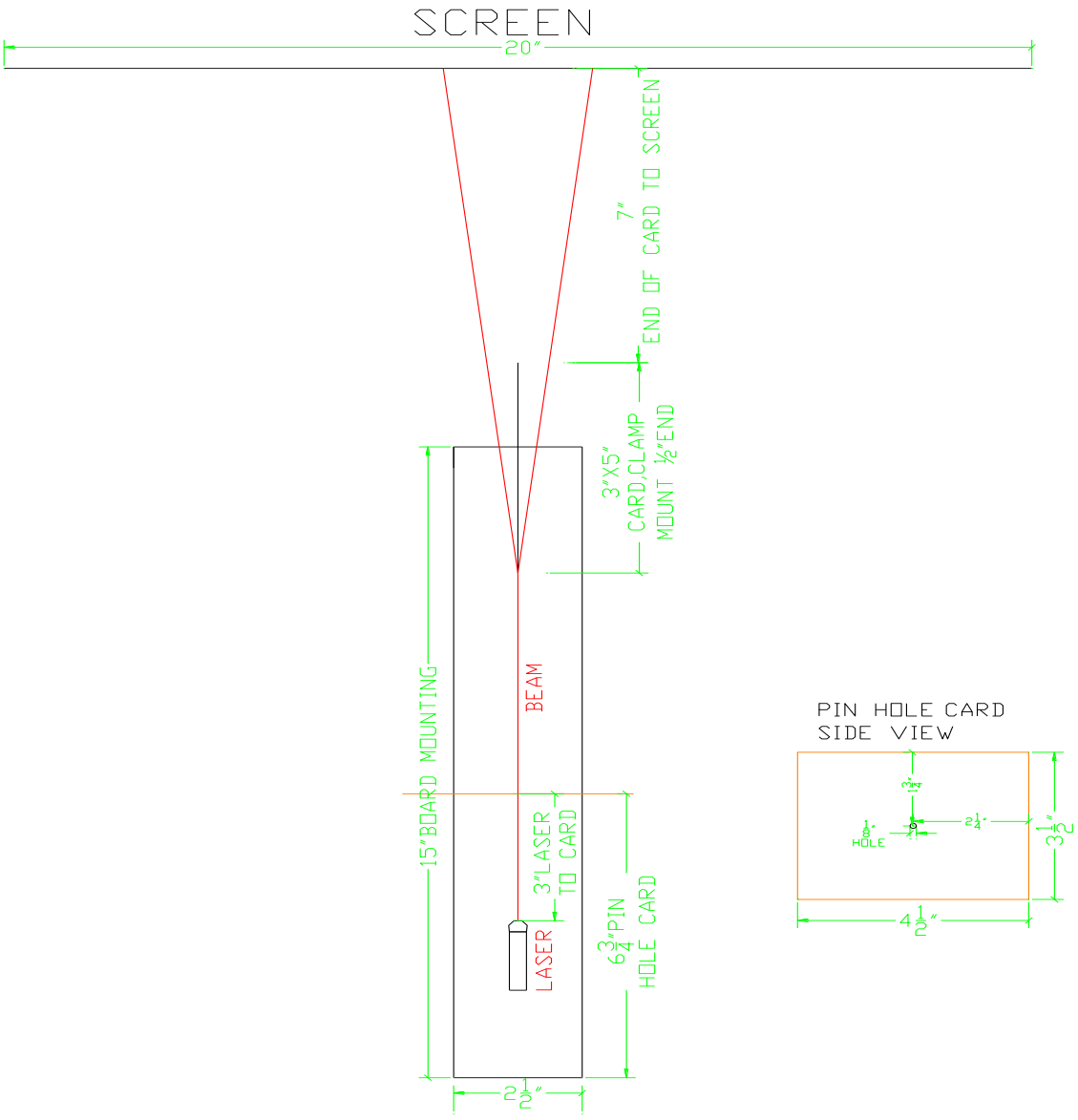


Fig.3 courtesy of Scott Little

I secured the 3”x5” card using a standard paper clamp, and wrapped rubber bands around it to hold it in place. For the pin hole card I used black electrical tape on both sides to hold it upright. There are also screws protruding form the bottom of the board at the mounting points of the pin hole and card that I used for a base.

The most difficult part of the experiment was to keep the card in the correct position with the pin hole, which required constant adjusting. Another difficulty was the fact that we held the laser in our hands and did not have a mounting for it. This was necessary to hold activation button down.

Knowing the wave length of light, measuring the distance from the slits to the screen, and approximating the fringe distance and the maxima, I used our equation to determine the separation of the slits. With a little Algebra I got:

$$d = \lambda\eta L / x$$

λ=the wave length of light= 630 NM.
η=the order of maxima observed=1 approx.
x= fringe distance= 6" approx.
L= the distance from the slits (pin hole card) to the screen=7"

Now all the units need to be uniform, so I converted everything to meters:

1 nanometer=1x10-9M
1 inch.=0.0254M
1M=3.28 ft.

$$d = \lambda\eta L / x = (630\text{x}10\text{-}9)(1)(7\text{x}.0254)/(6\text{x}.0254)=7.35\text{x}10\text{-}7\text{M}= 2.9\text{x}10\text{-}5\text{in}.$$

This seems like a small number, but the screen was close and the order of maxima was 1. Other derivations can be performed with this experiment, and there are literally hundreds of different versions of the Double Slit Experiment existing today.

Many utilize expensive equipment and measure the path of one photon going through the screen at a time. In fact, in 2002 a more modern version of performed by Claus Jönsson was voted the "most beautiful experiment" by the readers of *Physics World* (2). These versions may be out of reach to average Citizen Scientists, but we can still duplicate the original in its' elegance and simplicity.

Bill of Materials

(1) Plywood board: 15”Lx 2-1/2”Wx1/2”Thk. Nails placed at mounting points 6-3/4” for pin hole, 1/2” for 3”x5” card from same end.
(1) Laser diode pointer: 630-680 Nm wavelength Class 2, <1mW.
(1) Stationary note card: 3”Wx5”L x1/30”Thk.
(1) Cardboard pin hole: 4-1/2”Wx3-1/2”Tall; 1/8’ hole at 2”x2” center.
(1) Screen: 20”Wx30”Lx3/16”Thk white foam board. Purchase at art supplies store.

References

(1)http://www.cavendishscience.org/phys/tyoung/tyoung.htm

(2)1http://en.wikipedia.org/wiki/double-slit_experiment.