Interference of light

Olympic College, Phys 256

# Overview

In this lab, you’ll use simulations look at two examples of interference: double-slit interference and thin-film interference.

## Double-slit interference

When a wave passes through a double-slit, the waves diffracted by each slit will interfere with each other. With something water waves, you can see this directly. For light waves, you need to place a viewing screen behind the slits to see where the diffracted waves interfere constructively and destructively. We usually talk about the bright spots and dark spots (also known as “fringes”) in terms of angle made by a ray going from the slits to the fringe. For bright fringes, we have , and for dark fringes where *d* is the separation between the slits, and *m* is the *order number*. The position *y* of each fringe on the screen is measured from the central bright maximum.

You will use the simulation [thephysicsaviary.com/Physics/Programs/Labs/DiffractionLab/index.html](https://www.thephysicsaviary.com/Physics/Programs/Labs/DiffractionLab/index.html). Take some time to play around with it before doing the lab, to get a sense of how the simulation functions.

## Thin-film interference

When light is incident on a thin film, a wave that is reflected from the top interface of the film interferes with a wave that is reflected from the bottom interface of the film. The path length difference between these two waves is twice the thickness of the film. We know that how this path length difference relates to the wavelength of light will determine how the waves interfere.

There are some additional considerations, however:

1. The wavelength of light in a given medium is different from the wavelength of light in air:
2. A reflected light wave has a 90° phase shift when it is reflected off a medium that has a higher index of refraction. In other words, if the medium it is being reflected off of has a higher index of refraction than the medium it’s incident from, the reflected wave is inverted.

You will use the simulation [loganms.github.io/ThinFilmInterferenceSimulation](https://loganms.github.io/ThinFilmInterferenceSimulation/). Take some time to play around with it before doing the lab, to get a sense of how the simulation functions. Don’t worry about the activities listed with the simulation (unless you want to—they’re not bad!) since we’ll be doing different things.

# Investigations

## Double-slit

With the double-slit simulation, you’ll have randomly-generated slit separations and wavelengths.

1. First, choose as slit separation. You’ll need a separation that is wide enough to result in more than one visible bright fringe on the screen; some of the narrower options don’t always facilitate that. For a total of five different wavelengths, determine the angle defined by each bright fringe (hint: measure distances and do trig). Make a plot of order number vs the sine of the angle and include a line of best fit.
2. Then, choose one wavelength and change the slit separation many times. Make a plot of the maximum order number vs slid separation (and include a line of best fit).

## Thin films

In this simulation, the incident light is shown at the very top. The middle shows the wave reflected off the first interface with the thin film, and the bottom shows the wave reflected off the second interface of the film. (The simulation offsets these waves so you can clearly see each.)

1. Start with only the red (660 nm) light source and showing interference for red light, and leave the indices of refraction at their default values. Vary the thickness of the film and find several thicknesses that result in constructive interference of red light. Report both the thickness itself as well as the ratio of the film thickness to the wavelength of red light *in the film*.
2. Now, adjust the indices of refraction such that they get progressively larger (i.e. the index the incident light travels in is less than the index of the film, which is less than the index of the final medium). Once again determine several film thicknesses that result in constructive interference of red light, and report the thickness and the ratio of thickness to wavelength in the film. (Also report the indices you used.)
3. Finally, set the light source to be a combination of two wavelengths. Adjust the film thickness so that only one is reflected and the other is transmitted. Report the following:
   * All indices of refraction
   * Wavelengths of light source
   * Which wavelength was reflected and which was transmitted
   * Film thickness
   * Ratio of film thickness to the wavelength of light in the film, for both reflected and transmitted wavelengths

# Grading

You are not writing a formal lab report for this lab. Instead, include all your data (clearly organized) and graphs, and answer the following questions. Fully explain your reasoning for all questions, referring do your data and graphs when appropriate.

## Double-slit

1. What sort of trendline did you use for the *m* vs. sin*θ* graph? Does this agree with the theoretical relationship? If not, in what ways does it not?
2. How do the trendlines for the different trials of order number vs. sin*θ* relate to each other? How are they similar? How are they different?
3. For a given wavelength, how does the maximum order number relate to the slit separation?

## Thin films

1. For the indices of refraction at their default values, identify a pattern in the ratio of thickness to wavelength.
2. For the progressively increasing indices of refraction, identify a pattern in the ratio of thickness to wavelength.
3. For a light source that is a combination of wavelengths, explain why there can be a single thickness that allows one wavelength to be reflected and the other to be transmitted.