

## **Lab 11: Wave Optics**

### **LEARNING GOALS OF THE LAB:**

- 1) Learn to test a complicated mathematical relationship.
- 2) Learn to apply scientific abilities and physics knowledge to solve a practical problem experimentally.

### **I. Testing experiment: Double slit interference**

You learned that there is a mathematical relationship between the separation of two slits, their distance to the screen and the positions of the bright and dark bands on the screen.

Design experiments to test whether this relationship is applicable to a given system of slits. Try and test two different aspects of this relationship.

*Available equipment:* Laser, a number of plates containing thin double-slits, meter stick, screen.

- a) State what aspects of the relationship you are going to test and what variables you need to control while you are testing a specific aspect. (For example, if you want to test the relationship between the positions of the bright and dark bands and the distance between the slit and the screen, what would be your control variables?)
- b) Brainstorm the task and make a list of possible experiments whose outcome you can predict. Decide which two experiments are best. Briefly explain why.
- c) Briefly describe each of your chosen designs. Include labeled sketches.
- d) Think what data you should initially record in order to make quantitative predictions for the outcomes of your chosen experiments. Record these data in an appropriate format.
- e) Make a prediction about the outcome of each experiment. Include a discussion about any additional assumptions you have to make and how they might affect the results of the experiments.
- f) Perform the experiments. Record the outcomes. Compare your results to your predictions.
- g) Decide if the experimental outcomes supported your predictions including the effects of assumptions and uncertainties.

## **II. Application experiment: Evaluate a company's claim**

You are in food industry working on synthetic foods. Your current assignment is to build a spectroscope used to analyze the chemical composition of a new product. You plan to use a diffraction grating as a major part of the apparatus. You order one from a company and it arrives labeled having 600 slits/mm. Design an experiment to determine whether this claim is reasonable.

*Available equipment:* Diffraction grating, laser, meter stick, screen.

- a) Devise and write an outline of an experimental procedure to evaluate the company's claim.
- b) Draw a labeled diagram of your experiment.
- c) Describe the mathematical procedure you will use.
- d) List the assumptions are you making. Explain how each assumption could affect the outcome.
- e) List sources of experimental uncertainty. Explain how the uncertainties could affect the result. How could you minimize the uncertainties?
- f) Perform the experiment. Record your observations.
- g) Analyze your data.
- h) Decide if the company's claim is reasonable. What criteria will you use to make this decision? That is, if the outcome of your experiment is not identical to the company's claim, how will you decide if it is reasonable?

## **III. Why did we do this lab?**

- a) In the first experiment, in order to test the relationship between two variables, you had to control other variables. (For example, in order to make a prediction about how the interference pattern depends on the distance to the screen, you would have had to keep the distance between the slits constant.) Come up with a situation from your own field of study in which you might have to control one or more variables to test a hypothesis about the function relating two variables of interest (linear, quadratic, etc).
- b) Give an example of a ridiculous claim in mass media that cannot be evaluated for reasonableness. What is the aspect of the claim that makes it impossible to evaluate?
- c) What is the purpose of reflection questions at the end of each lab?

**Postscript: Bread proven dangerous?**

Consider the following well-established facts. They prove that bread is a danger and should be controlled or outlawed. Don't they?

- 1) More than 98 percent of convicted felons are bread users.
- 2) Almost half of all children who grow up in bread-consuming households score below average on standardized tests.
- 3) In the 18th century, when virtually all bread was baked in the home, the average life expectancy was less than 50 years; infant mortality rates were unacceptably high; many women died in childbirth; and diseases such as typhoid, yellow fever, and influenza ravaged whole nations.
- 4) More than 90 percent of violent crimes are committed within 24 hours of eating bread.
- 5) Bread is made from a substance called "dough." It has been proven that as little as 500g of dough can be used to suffocate a mouse. The average American eats more bread than that in one month!
- 6) Primitive tribal societies that have no bread exhibit a low incidence of cancer, Alzheimer's, Parkinson's disease, and osteoporosis.
- 7) Bread has been proven to be addictive. Subjects deprived of bread and given only water to eat begged for bread after as little as two days.
- 8) Bread has been proven to absorb water. Since the human body is more than 90 percent water, it follows that consumption of bread can dangerously alter the body's water balance.
- 9) Newborn babies can choke on bread.
- 10) Bread is baked at temperatures as high as 400 degrees Fahrenheit! That kind of heat can kill an adult in less than one minute.

Have these facts convinced you? If not, why not?