# Diffraction Inquiry Activity

Author: Lisa Tarman
Date Created: August 2008
Subject: Physics
Level: High School - Algebra based
Standards: Standard 1: Analysis, Inquiry, and Design
Standard 2: Information Systems
Standard 3: Mathematics
Standard 4: Science
**Schedule: 1 65 minute period**
(plus homework to complete write-up & follow-up discussion)

## Objectives:

Use sound scientific method to learn how variables affect diffraction through a grating.

## Students will:

- Identify dependent and independent variables
- Design an investigation to explore the relationships among x, L, λ, and d for a laser beam through a diffraction grating
- Communicate the results of their investigations

## Vocabulary:

**Wavelength**
**Diffraction**

## Materials: (prices Aug 08)

**For Each Group :**
Ring stand w/ clamp to hold grating
3 different known diffraction gratings
*Basic Science Supplies*
*Code: 320331 $26.95*
Projection Screen
*White paper somehow supported vertically*
Ruler
Red laser pointer
*Arbor Scientific – Economy laser pointer*
*Product ID: P2-7300 $19.00*
Laser holder
*Arbor Scientific - Laser Tripod*
*Product ID: P2-7670 $15.00*
(Or wood block with binder clip to hold in button)
**To share – circulate to all groups:**
Green laser pointer
*Arbor Scientific - Economy laser pointer*
*Product ID: P2-7677 $49.00*
**For teacher:**
"Diffraction Lesson" PowerPoint
*Available at CCMR Educational Resources*
Plain slide
Single diffraction grating that looks like slide

## Safety:

Use caution when operating laser pointers.

## Science Content for the Teacher:

It is assumed that the class is familiar with the parts of a wave and can list wave phenomena (reflection, refraction, diffraction, interference), but have NOT seen diffraction from a diffraction grating.

A diffraction grating looks like a gray filter (or blank slide), but it has many closely spaced grooves. It is often labeled with how many lines per cm or mm. In the investigation, students will need to know the **space between lines in meters**. You may need to demonstrate that, especially if students are not trained to always use mks units.

Example: 300 lines per mm Lines would be 1/300 mm apart

$d = 1 / 300 / 1000 = 3.33 \times 10^{-6}$ m

Students should follow sound scientific method by isolating dependent and independent variables and holding others constant for each part.

Anticipated results:

X increases as λ increases
Wavelengths of laser pointers should be labeled. Only 2 trials are possible for this part unless more laser pointers with different wavelengths are available. The spots should be closer together (x) for the green laser.

X increases as L increases
Many trials are possible for this part. The distance from grating to screen should be varied and measured in meters. The spots should be closer together (x) when screen is closer.

X decreases as d increases
Diffraction grating spacings should be labeled (d or how many lines per length). Only 3 trials are possible unless more gratings with different spacings are available. The spots should be closer (x) when the spacing is larger (d).

# Preparation:

*** Determine the wavelength of your lasers and label them.**
The ones from Arbor are 670 nm (red) and 532 nm (green).
If you don't know yours, carefully do the experiment and use $x = \lambda L/d$ to solve for $\lambda$

*** Establish your Expectations for reporting results**
One size never fits all. You determine what is right for your students.
This is ideal for differentiated instruction.

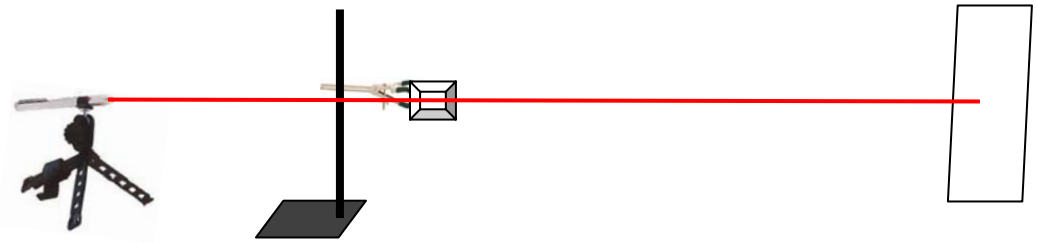
Possibilities:
Open Ended - Students determine how to communicate their findings (Multiple Intelligences)
Paperless - Teacher website lists guidelines & students submit electronically
(example on "Diffraction Lab" page at http://TarmanPhysics.wikispaces.com)
Handout - A paper gives guidelines or options for reporting results
Lab Paper - Less inquiry more cook-book….but sometimes necessary
A version for needy students (and teachers?) is included as part of this lesson

*** Practice Opening Demo & the experiment**

*** Preview "Diffraction Activity" Powerpoint**
View with NOTES visible to see what to say
View as Slideshow to be familiar with annimations

# Classroom Procedure:

***Engage (Time: 5 min )***



Demonstrate laser pointer going straight through a plain slide.
Swap the slide for a diffraction grating (that looks the same) with a large d so there are several dots on screen.

See if students have an explanation

Show 20 second YouTube clip of diffraction in ripple tank
(IF they are familiar with a ripple tank)
http://www.youtube.com/watch?v=4EDr2YY9lyA&feature=related

Students will probably say the "other slide" has a slit in it.
Probe further – because they probably think it is the 2 sides of the bent waves where the screen cuts the diffracted waves!
"Why aren't they moving?" "Are the dots a wavelength apart?"

***Explore (Time 55 min: )***

Show PowerPoint "Diffraction Activity" to show origin of dots on screen and the purpose of the inquiry activity

** IF you're going to provide the "Diffraction Inquiry Activity Lab Paper", distribute it on the next to last slide of PowerPoint

Divide students into groups of 3 ideally.

Students vary L, λ, and d to see effects on x.

Complete analysis for Homework

***Explain (Time: depends)***

Students report their findings -- turning in "Lab Paper", electronic submission, whiteboarding, orally, song, dance, etc. !

***Expand (Time: depends )***

1. Relate activity to the equations on the AP Equation Sheet:

$$x_m \approx \frac{m\lambda L}{d} \qquad d\sin\Theta = m\lambda$$

The distance **x** is from the central maximum, so if you don't use the distance to the first dot you must include **m**, an integer specifying which order maximum was used.

Using the small angle approximation, $\sin\Theta \approx \tan\Theta$, simple trig shows that the two equations are equivalent.


$$\tan\Theta = \frac{opp}{adj} = \frac{x}{L} \approx \sin\Theta$$

2. Explore diffraction from 3 dimensional lattice – Bragg diffraction

   Create Venn Diagram for diffraction from diffraction grating and crystal

3. Research additional displays of diffraction to show in classroom with laser pointer (CD, DVD, hair, wire mesh)
   Resource – "Diffraction" Lesson from CCMR Education Lending Library

4. Research additional observable effects and applications of diffraction.

## Assessment:

The following rubric can be used to assess students during each part of the activity. The term "expectations" here refers to the content, process and attitudinal goals for this activity. Evidence for understanding may be in the form of oral as well as written communication, both with the teacher as well as observed communication with other students. Specifics are listed in the table below.

1= exceeds expectations
2= meets expectations consistently
3= meets expectations occasionally
4= not meeting expectations

| | Engage | Explore | Explain | Expand/Synthesis |
|---|---|---|---|---|
| 1 | Contributes to class discussion of demonstration with excitement and wonder | Completes well-designed investigation with no teacher involvement | Clearly communicates findings of investigation in unique or super-detailed way | Completed multiple extension activities with insight and brilliance |
| 2 | Engaged in discussion of demonstration | Completes investigation efficiently with minor assistance | Clearly communicates findings of investigation | Furthers knowledge of diffraction with an extension activity |
| 3 | Appears to notice & consider demonstration | Completes investigation with some design flaws or excessive teacher attention | Reports findings with ambiguity or flaws | Attempts extension but fails to construct new knowledge. |
| 4 | No participation or interest in demo | Does not engage / leech on lab partners | Incomplete or nonexistent | No interest in extension |

## Acknowledgments:

Cornell Center for Materials Research
National Science Foundation
York City School District
Nev Singhota, Kevin Dilley , & Jane Earle
CCMR Facility Managers – Particularly Maura Weathers for clear explanations of X-ray diffraction