Teaching Grade 10 Science Using an Inquiry Approach

Light and Geometric Optics
Inquiry-based Learning Unit

RATIONALE

We have taken the Light and Geometric Optics Unit of the new grade 10 science curriculum and have developed it into an inquiry-based unit. This was done for two main reasons. First, the approach in teaching science is shifting from the traditional (teacher-centred) classroom to a constructivist (student-centred) focus, and secondly, the new Ontario Science curriculum is centred on an inquiry-based approach that needs to be woven into every unit.

Presently, most high school science classrooms take the 'traditional' approach to learning. That is, students are viewed as 'blank slates' onto which teachers etch new information and concepts (Llewellyn, 2005). In science, these classrooms are teacher directed and 'prescription' labs are provided for students to confirm information they have been taught. In this environment, students have minimal opportunity to develop their problem solving skills and use their creativity. However, recent educational studies have shown that inquiry-based learning develops a greater understanding of course material and enhances problem solving skills. Due to this, many science teachers are shifting their approach from 'traditional' to 'constructivist'. A teaching environment that uses a constructivist approach views students as thinkers and provides them with situations in which to use their creativity to solve various problems. In constructivist classrooms, teachers become more of a facilitator and allow students to explore and problem solve a variety of concepts. Studies have shown that when a constructivist approach is used in the classroom, students improve in both in depth of their understanding and in their thinking and problem solving skills (Llewellyn, 2005). In addition, inquiry-based learning also allows for the active exploration which uses critical, logical, and creative thinking skills (Llewellyn, 2005). Furthermore, in constructivist classrooms students have opportunities to complete 'authentic science' by generating questions to be solved, spending time brain storming possible solutions, generating hypotheses, developing procedures, gathering and recording data, and communicating their findings (Llewellyn, 2005).

The new Ontario Science curriculum is designed to have an inquiry-based approach woven throughout all units in science. An inquiry-based unit such as this meets the requirements of the strand entitled, 'Scientific Exploration Skills and Exploration of Careers'. Using an inquiry-based approach will meet the following curricular expectations:

- A1. demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating);
- A2. identify and describe a variety of careers related to the fields of science under study, and identify scientists, including Canadians, who have made contributions to those fields.

In summary, the skills developed through inquiry-based learning are important in the success in secondary and post-secondary endeavours. We live in an information world where information and data is available at our finger tips through the internet. Therefore, obtaining information is not the problem. Students now need to be able use that information correctly to solve problems with which they will be confronted.

MINISTRY EXPECTATIONS COVERED BY THIS UNIT

Overall Expectations

By the end of this course, students will:

- E2. investigate, through inquiry, the properties of light, and predict its behaviour, particularly with respect to reflection in plane and curved mirrors and refraction in converging lenses;
- E3. demonstrate an understanding of various characteristics and properties of light, particularly with respect to reflection in mirrors and reflection and refraction in lenses.

Specific Expectations

By the end of this course, students will:

- E2.1 use appropriate terminology related to light and optics, including, but not limited to: angle of incidence, angle of reflection, angle of refraction, focal point, luminescence, magnification, mirage, and virtual image [C]
- E2.2 use an inquiry process to investigate the laws of reflection, using plane and curved mirrors, and draw ray diagrams to summarize their findings [PR, C]
- E2.3 predict the qualitative characteristics of images formed by plane and curved mirrors (e.g., location, relative distance, orientation, and size in plane mirrors; location, orientation, size, type in curved mirrors), test their predictions through inquiry, and summarize their findings [PR, AI, C]
- E2.4 use an inquiry process to investigate the refraction of light as it passes through media of different refractive indices, compile data on their findings, and analyse the data to determine if there is a trend (e.g., the amount by which the angle of refraction changes as the angle of incidence increases varies for media of different refractive indices) [PR, AI, C]
- E2.5 predict, using ray diagrams and algebraic equations, the position and characteristics of an image produced by a converging lens, and test their predictions through inquiry [PR, AI, C]
- E2.6 calculate, using the indices of refraction, the velocity of light as it passes through a variety of media, and explain the angles of refraction with reference to the variations in velocity [PR, C]cepts
- E3.1 describe and explain various types of light emissions (e.g., chemiluminescence, bioluminescence, incandescence, fluorescence, phosphorescence, triboluminescence; from an electric discharge or light-emitting diode [LED]) E3.2 identify and label the visible and invisible regions of the electromagnetic spectrum
- E3.3 describe, on the basis of observation, the characteristics and positions of images formed by plane and curved mirrors (e.g., location, orientation, size, type), with the aid of ray diagrams and algebraic equations, where appropriate
- E3.4 explain the conditions required for partial reflection/refraction and for total internal reflection in lenses, and describe the reflection/ refraction using labelled ray diagrams
- E3.5 describe the characteristics and positions of images formed by converging lenses (e.g., orientation, size, type), with the aid of ray diagrams
- E3.6 identify ways in which the properties of mirrors and lenses (both converging and diverging) determine their use in optical instruments (e.g.,cameras, telescopes, binoculars, microscopes)
- E3.7 identify the factors, in qualitative and quantitative terms, that affect the refraction of light as it passes from one medium to another
- E3.8 describe properties of light, and use them to explain naturally occurring optical phenomena (e.g., apparent depth, shimmering, a mirage, a rainbow)

GENERAL UNIT OUTLINE

This unit is designed to address the majority of the curricular expectations of the Light and Geometric Optics unit through an inquiry-based approach to learning. The Light and Geometric Optics curricular expectations can be broken down into three main topics: Properties of Light, Mirrors and Lenses. In this unit, students will research specific topics and become experts in a specific area of light.

There are four main expectations for the students.

1. Students will research a specific expectation of the Light and Geometric Optics unit through addressing a specific question (see *Exploring Light - Experimental Set-up for specific topic suggestions)*
2. Create a handout that provides all relevant information and diagrams. This is to be verified by the teacher prior to given it to the class.
3. TEACH the class their topic along with an effective demonstration
4. Devise a lab or activity that illustrates their findings. This lab will be conducted during class and provide the other students with opportunity to verify their findings.

TEACHING DIRECTED MOMENTS

Periodically, there will be times where students will need specific direction or instruction, so they can convey concepts more clearly. Below is a list of the areas of the curriculum that may need to be addressed to ensure students can clarify their concepts. These times of specific instruction can be done to either the entire class or to specific groups that may need assistance. Every class is going to be different, so by no means is this list exhaustive.

- Ray Diagram Construction
  - Plane mirrors
  - Concave and Convex mirrors
  - Concave and Convex lenses
  - Universal Symbols for Optics
- Apparatus Set-up for Optics Bench
- Algebraic Equations...relationships/mathematics/application
- Clarification of Optic Terms...correct use
- How to set-up an effective lab/activity...items you should include...how to present your lab clearly.
- How to set-up handouts...to make them clear and organized.

DAY 1: INTRODUCTION/GENERATING INTEREST

To introduce this unit, students need to be provided with topics to generate discussion or interest. Providing students with possible topics or uses of light will provide them with opportunities to explore a topic of interest, which motivates students to complete the research. To generate this interest, we have suggested three slightly different approaches. The approaches below are to be used to generate interest and questions to explore. You want students to leave your classroom with questions, not answers. Avoid providing students with answers or too much background information. This unit is designed to have them 'discover' the answers.

- Brainstorming and demonstrations. Have students engage in an open discussion about different aspects of light. Possibly provide computer lab time for some preliminary research. This will provide them with background information to generate possible topics (Enriched…high academic)
- Demonstrations of properties of light to engage students and generate interest. Topics are more teacher directed to provide students with a better understanding of the direction you would like them to take (Academic).
- Demonstration of specific topics and providing students with direct questions to study (Applied).

Possible Demonstrations

- Beaker Optics
  - Why does it look like the pencil (any long object) bends as it is placed in a beaker of water?
  - show using different objects
- Images in Concave Mirrors
  - observe the images...why do you think they take that form?
- Images in Convex Mirrors
  - observe the images...why do you think they take that form?
- Light through a Prism
  - Why do they break into different colours?
- What happens to the image through a concave lens?
- What happens to the image through a convex lens?
- Inverted Images in Mirrors...why?

Additional Demo Ideas

- http://buphy.bu.edu/~duffy/optics.html
- http://faraday.physics.uiowa.edu/optics/6A10.60.htm
- http://fog.ccsf.cc.ca.us/~tbardin/html/optics.html
- http://www.hands-on-optics.org/resources/
- McDermott, L. Physics By Inquiry. New England: John Wiley & Sons. 1996.
- Dick, D., Geddis, A., James, E., McCaul, T., McGuire, B., Poole, R., Holzer, B. Physics 11. Toronto: McGraw-Hill Ryerson. 2000.

DAY 2

Research Day

Complete Checkpoint #1 (refer to Experimental Set-up)

DAYS 3 & 4

Research and Testing Days

Complete Checkpoint #2

DAYS 5-7

Conducting the Investigation

Creation of Student Handout

DAY 8

Student Presentations (3)

Handout provided for each student (teacher edited/approved)

DAYS 9 & 10

Student Lead Labs for Day 8 Presentations

DAY 11

Review/Quiz on topics covered on Days 8 - 10

Student Presentations (3)

Handout provided for each student (teacher edited/approved)

DAYS 12 & 13

Student Lead Labs for Presentations on Day 11

DAY 14

Review/Quiz on topics covered on Days 9 - 11

Student Presentations (3)

Handout provided for each student (teacher edited/approved)

DAYS 15 & 16

Student Lead Labs for Presentations on Day 14

DAYS 17-20

Review/Quiz

Buffer Days

Review any Misconceptions

Cover any topics that were not covered during the presentations

DAY 21

Unit Test