

**Name:** Jonathan Smartt

**Title:** Thin Lenses Investigation

**Date of Lesson:** Week 2, Day 2

**Technology Lesson:** Yes

**Length:** 75 minutes

**Course:** Physics

**Grade Level:** 11<sup>th</sup> or 12<sup>th</sup>

**Source:** Some information taken from Holt Physics textbook

**TEKS Addressed:**

§112.39. Physics, Beginning with School Year 2010-2011 (One Credit).

(c) Knowledge and skills.

(1) Scientific processes. The student conducts investigations, for at least 40% of instructional time, using safe, environmentally appropriate, and ethical practices. These investigations must involve actively obtaining and analyzing data with physical equipment, but may also involve experimentation in a simulated environment as well as field observations that extend beyond the classroom. The student is expected to:

(A) demonstrate safe practices during laboratory and field investigations;

(2) Scientific processes. The student uses a systematic approach to answer scientific laboratory and field investigative questions. The student is expected to:

(E) design and implement investigative procedures, including making observations, asking well-defined questions, formulating testable hypotheses, identifying variables, selecting appropriate equipment and technology, and evaluating numerical answers for reasonableness;

(F) demonstrate the use of course apparatus, equipment, techniques, and procedures, including...batteries, clamps,...convex lenses,...mini lamps (bulbs) and sockets,...metric rulers,...meter sticks, scientific calculators,...and laser pointers;

(H) make measurements with accuracy and precision and record data using scientific notation and International System (SI) units;

(J) organize and evaluate data and make inferences from data, including the use of tables, charts, and graphs;

(7) Science concepts. The student knows the characteristics and behavior of waves. The student is expected to:

(E) describe and predict image formation as a consequence of...refraction through a thin convex lens;

**Concept Statement:**

When light traveling in air enters a pane of glass, it is bent toward the normal. As the light exits the pane of glass, it is bent again. When the light exits, however, its speed increases as it enters the air, so the light bends away from the normal. Because the amount of refraction is the same regardless of whether light is entering or exiting a medium, the light rays are bent as much on exiting the pane of glass as they were on entering. Thus, the exiting ray of light is parallel to the ray that entered the pane, but it is displaced sideways by an amount that depends on the thickness of the pane, the index of refraction of the glass, and the angle of incidence of the light ray. When the surfaces of a medium are curved, the alignment of the normal line differs for each spot on the surface of the medium. Thus, when light passes through a medium that has one or more curved surfaces, the change in the direction of the light rays varies from point to point. This principle is applied in objects called lenses. Like mirrors, lenses form images, but lenses do so by refraction rather than by reflection. The images formed can be either real or virtual, depending on the type of lens and on the placement of the object. Lenses are commonly used to form images in optical instruments, such as cameras, telescopes, and microscopes. In fact, the front of the human eyeball acts as a type of lens, converging light toward the light-sensitive retina at the back of the eyeball.

**Performance Objectives:**

- Use ray diagrams to find the position of an image produced by a converging or diverging lens, and identify the images as real or virtual.
- Solve problems using the thin-lens equation
- Calculate the magnification of a lens
- Describe the positioning of lenses in compound microscopes

**Resources:**

Compound microscopes, various slides

**Supplementary Materials, Handouts:**

Graphing Calculator Worksheet

<b>ENGAGEMENT</b>		<b>Time: 5 minutes</b>
<b>What the Teacher Will Do</b>	<b>Probing Questions</b>	<b>Student Responses Potential Misconceptions</b>
<p>Warm Up Question</p> <p>Students will discuss at their tables and then discuss as a class.</p>	<p>If there are two converging lenses in a compound microscope, why is the image still inverted?</p>	

<b>EXPLORATION</b>		<b>Time: 30 minutes</b>
<b>What the Teacher Will Do</b>	<b>Probing Questions</b>	<b>Student Responses Potential Misconceptions</b>
<p>Students will work in groups of 4 and identify the optical components (lenses, mirror, object, and light source) and knobs of a compound microscope. Find out how they function at different magnifications and what adjustments must be made to obtain a clear image. Sketch a ray diagram for the microscope's image formation. Estimate the size of the images you see given a slide, and calculate the approximate size of the actual cells or microorganisms you observe. How closely do your estimates match the magnification indicated on the microscope?</p>		

<b>EXPLANATION</b>		<b>Time: 15 minutes</b>
<b>What the Teacher Will Do</b>	<b>Probing Questions</b>	<b>Student Responses Potential Misconceptions</b>
<p>Each group of 4 will present their findings, walking the class through the steps they took, how they organized their data and measurements, how they analyzed the data and calculated the magnification of the microscope, and the error between their calculated magnification and the true magnification.</p>		

<b>ELABORATION</b>		<b>Time: 20 minutes</b>
<b>What the Teacher Will Do</b>	<b>Probing Questions</b>	<b>Student Responses Potential Misconceptions</b>
<p>This is an extension from week 1 and is meant to help students understand how weeks 1 and 2 tie together.</p> <p>See Graphing Calculator Worksheet</p> <p>I have the program code, but it will take too long to type and format the keystrokes right now.</p>		

<b>EVALUATION</b>		<b>Time: 0 minutes</b>
<b>What the Teacher Will Do</b>	<b>Probing Questions</b>	<b>Student Responses Potential Misconceptions</b>
<p>Students will be evaluated through their answers on the graphing calculator investigation and their presentation of their work on the microscope investigation.</p>		

## Graphing Calculator: Snells Law

The relationship between the angle of refraction and the index of refraction, as you learned last week, is described by Snell's law:

$$n_i(\sin \theta_i) = n_r(\sin \theta_r)$$

You will program your graphing calculator to make use of Snell's law. Once the program is executed, your calculator will ask for the angle of incidence. The graphing calculator will use the following equation to create a graph of the index of refraction of the substance (Y1) versus the angle of refraction (X). The relationships in this equation are the same as those in Snell's law shown above.

$$Y_1 = \frac{\sin(I)}{\sin(X)}$$

- There is no mention of the index of refraction of the first medium in the equation used by your graphing calculator. Why has this factor been neglected?

Program your graphing calculator to create a graph of the angle of incidence versus the angle of refraction to determine the index of refraction. Use this program to find the index of refraction for the following situations:

- a light ray moving from air into a substance with an angle of incidence of  $40^\circ$  and an angle of refraction of  $30^\circ$
- a light ray moving from air into a substance with an angle of incidence of  $40^\circ$  and an angle of refraction of  $25^\circ$
- a light ray moving from air into a substance with an angle of incidence of  $60^\circ$  and an angle of refraction of  $45^\circ$
- a light ray moving from air into a substance with an angle of incidence of  $60^\circ$  and an angle of refraction of  $30^\circ$
- In items b–e, is the light bent toward or away from the normal?

Before writing the program, press **MODE** **↓** **↓** **→** **ENTER** to set the calculator in degree mode. Open a new program by pressing **PRGM** **→** **→** **ENTER**. Name the program REFRACT and press **ENTER**. Then enter the program in the table below. To exit the program editor, press **2<sup>nd</sup>** **QUIT**. To run the program, press **PRGM**, select REFRACT, and press **ENTER** **ENTER**. Enter the value for the angle of incidence and press **ENTER**. The calculator will provide a graph of the index of refraction versus the angle of refraction. Press **TRACE** and use the arrow keys to trace along the curve. The  $x$  value corresponds to the angle of refraction in degrees, and the  $y$  value corresponds to the index of refraction. After you have finished using the graph for one angle of incidence, press **2<sup>nd</sup>** **QUIT** to run the program for the next angle of incidence.