# Least Time Principle Lab

#### Teacher's Guide

## Topic:

Refraction and Lenses

### The following information is provided to the student:

#### **Question:**

How do the ratios of light speed compare to the ratio of angles for light passing from one medium to another?

### **Purpose:**

To use the least time principle and an analogy to a life guard's most efficient path in order to relate the ratio of light speeds to the ratio of angles of incidence and refraction.

A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion. The Data section should include the provided tables and an additional table which summarizes the results of the three trials. The Conclusion section should respond to the question raised in the purpose and state an equation relating the two ratios.

URL: http://www.physicsclassroom.com/shwave/leasttime.cfm

### **Materials Required:**

A page from The Shockwave Physics Studios: http://www.physicsclassroom.com/shwave/leasttime.cfm

#### **Description of Procedure:**

Students navigate to the above page, read the directions and conduct the activity. Using a trial and error method, students determine the optimal entry point of a life guard into the water in order to save a drowning swimmer in the least amount of time. Two to three combinations of running speed on sand and swimming speed in water are used. Data is entered into the provided tables. Once students determine the optimal entry location into the water for a path of least time, the angle of approach and departure from the boundary are provided. Using the speeds and angles, students can answer the question posed in the Purpose of the lab.

#### **Alternative Materials and Procedure:**

A more thorough approach to this lab is provided at The Shockwave Physics Studios:

http://www.physicsclassroom.com/shwave/leatimedirns.cfm

The alternative exercise is a guided exercise with an extensive procedure.

### **Safety Concern:**

There is always a higher than usual level of risk associated with working in a science lab. Teachers should be aware of this and take the necessary precautions to insure that the working environment is as safe as possible. Student *horseplay* and off-task behaviors should not be tolerated.

#### The Laboratory

## **Suggestions, Precautions, Notes:**

- 1. This lab uses an analogy of a life guard traveling between two points in the least amount of time. It is based upon <u>Pierre de Fermat's principle of least time</u>. The principle states that path taken by a ray of light in traveling between two points is the path which requires the lest amount of time.
- As a post-lab discussion, use the relationship between the speed ratios and the ratio of the sines of the angles to derive Snell's law. Make use of the fact that  $v_{\text{material}} = c/n_{\text{material}}$ .

## **Auxiliary Materials:**

The following page is provided to the student for completion and inclusion in their lab notebook.

Data Set #		Data Set #		Data Set #	
Sand Speed = m/s		Sand Speed = m/s		Sand Speed = m/s	
H <sub>2</sub> O Speed = m/s		H <sub>2</sub> O Speed = m/s		H <sub>2</sub> O Speed = m/s	
Angle in Sand =°		Angle in Sand =°		Angle in Sand =°	
Angle in Water =°		Angle in Water =°		Angle in Water =°	
Entry Pt.	Time (s)	Entry Pt.	Time (s)	Entry Pt.	Time (s)

## **Scoring Rubric:**

RL3.	Least Time Principle Lab	Score
	Included, labeled and organized all parts of the lab report.	
	Data section includes the provided data table; table is complete. Another	
	table with calculated ratios is included; column headings are indicated. The	/
	calculated data lead to the development of an appropriate conclusion.	
	Conclusion states the relationship between the ratio of speeds and the	
	ratio of the angles. An equation is reported. The statement and equation are	
	correct.	

## **Connections to The Physics Classroom Tutorial:**

The following readings are a suitable accompaniment to this lab:

http://www.physicsclassroom.com/Class/refrn/u14l2a.cfm http://www.physicsclassroom.com/Class/refrn/u14l2b.cfm

# The Laboratory

## **Connections to Minds on Physics Internet Modules:**

Sublevels 3 and 4 of the Refraction and Lenses module are suitable accompaniments to this lab: <a href="http://www.physicsclassroom.com/mop/module.cfm">http://www.physicsclassroom.com/mop/module.cfm</a>