NASA All-Stars Multiwavelength Astronomy Lesson Plan **Barge, Nikolaus**

July 2013

Lesson Name: Optical Tools

URL: http://ecuip.lib.uchicago.edu/multiwavelength-astronomy/optical/tools/index.html

Primary Subject: Physics

Secondary Subject: Astronomy

Grade Level(s): High School

Duration: 2-3 45 min. class periods

Objectives Statements:

Students will become familiar with an astronomer's path from childhood to adult as regards his interest in astronomy.

Students will be able to describe one of three specific optical telescopes.

Students will be able to diagram the path of light through a lens.

Students will be able to predict the nature of an image formed using a convex lens.

Materials: Computer lab or cart with internet access, Individual copies of Student handout

Pre-requisites: Cursory understanding of the Electromagnetic Spectrum, some knowledge of optics, initial exposure to lens types and their interactions with light

Procedures: Part I – reading guide, Part II – lens activity (see) handouts below

Introduction

How do we know at all about anything in space? Light combined with our knowledge of science (specifically chemistry and physics). We can learn about the science through study on earth. Light from space must be meticulously collected and analyzed. We are going to be reading about a man who has spent his entire career devoted to collecting light from distant objects in the best ways he could devise.

Reading Guide and Discussion Questions: see handout below

Evaluation Plan: Answers to questions on reading guide and ray diagram handout

Extensions: Students can explore the HST COSTAR instrument

Web Links: See links listed below in handout

Vocabulary: concave lens, object, image, focal length, magnification, far-sighted

Standards Addressed:

NSES

INTERACTIONS OF ENERGY AND MATTER: Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength.

Core Standards

RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Next Gen Standards

HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy

Name: ___________________________ **Date:____________ Pd: ___**

Part I – Reading: "Optical Tools, Nick Woolf"

Go to http://ecuip.lib.uchicago.edu/multiwavelength-astronomy/optical/tools/index.html and answer the reading guide questions below as you read through each page.

Rockets to the Moon

- Nick found inspiration in articles about rockets ships to the moon. What new technology captures your interest? How does it inspire you? What new things do you think we will be able to do by the time you are an adult?

Vacuum tubes and electronics

- Nick was interested early on in electronics, which led him into a career in physics. What careers interest you? What factors have led your interests here?

An odd education

- Briefly describe Nick's "odd education". What do you think are the pros and cons of learning this way? What is a way that you have found helpful for your own learning?

Spectral Interferometry at Lick Observatory

- In old star clusters, why were older stars found at the edge of the clusters?

Stratoscope II

- The following brief clip is from the launch of the Stratoscope II. What might be one reason to send a telescope up in a balloon? http://www.youtube.com/watch?v=B_Tg8nsmnjM
- Read more about the mission here (Article from the "Daily Princetonian"): http://libserv23.princeton.edu/princetonperiodicals/cgi-bin/princetonperiodicals?a=d&d=Princetonian19680520-01.2.8&e=-------en-20--1--txt-IN-----#

Into the Infrared

- Consider what Nick says at the end of this page: "The moral of that story is that just because you are ignorant does not mean you should be quiet." What may have happened if Nick continued with his questions?

- Watch this short video clip from History Channel's "The Universe" to get some more information on the discovery of microwave background radiation. (Start watching at 1:05:15 and continue until 1:13:00) http://www.history.com/shows/the-universe/videos/playlists/full-episodes#the-universe-beyond-the-big-bang

Multiple Mirror Telescope - The Mirror Lab - Vatican Observatory - The Large Binocular Telescope

- Nick worked on a number of significant projects during his career including the "Multiple Mirror Telescope", "The Mirror Lab", "Vatican Observatory", and the "Large Binocular Telescope". Have each member of your group read up on one of these projects, then share out what you learned.

  Multiple Mirror Telescope - http://www.mmto.org/
  The Mirror Lab - http://mirrorlab.as.arizona.edu/
  Vatican Observatory - http://www.vaticanobservatory.org/
  Large Binocular Telescope - http://www.lbto.org/index.htm

Search for Earth-like planets - Astrobiology

- What do you think Nick means when he says “chemistry is probably the necessary way to start a life system, but it isn’t an exclusive way of continuing, especially for intelligent life”?

Name: ___________________________ **Date:____________ Pd: ___**

Part II - Lens Investigation

Older optical telescopes used lenses to focus and magnify light from distant celestial objects. Here you begin to explore how one particular type of lenses work.

1. Go to http://phet.colorado.edu/sims/geometric-optics/geometric-optics_en.html
2. Take some time to play with the simulation to get familiar with how it works.
3. The simulation will allow you to analyze how images are formed as the object is moved around.
4. Using the digital ruler, measure the distance from x to the center line of lens. Record in Table 1 as f. Double this value and record as 2f.
5. Move the pencil to various distances away from the lens.
6. In Table 2, record do, di, hi and your observations of the image.

Table 1	
Focal length, f	
2f	

Table 2					
Position of Object	**Beyond 2f (cm)**	**At 2f (cm)**	**Between 2f and f (cm)**	**At f (cm)**	**Between f and lens (cm)**
do *(distance of the object from the lens)*					
di *(distance of the image from the lens)*					
hi *(height of the image)* *Use qualitative descriptors – very short, tall, etc*					
Direction of image: *inverted or upright*					

Based on your work in the simulation predict what the image will look like for each of the following situations:

The focal length of the lens will be 75 cm for each problem, and the height of each object will be 20 cm.

1. The object is 170 cm from the lens

2. The object is 150 cm from the lens

3. The object is 110 cm from the lens

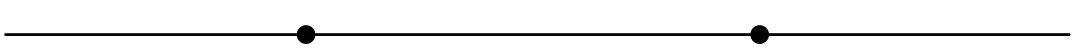
4. The object is 75 cm from the lens

Check your predictions by completing a ray diagram for each situation with the correct path of the light. Find the distance to the image and the magnification in each of the following situations. Using the equations below

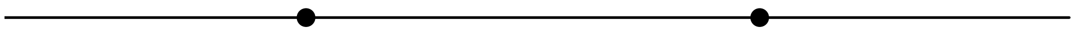
$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \qquad M = \frac{h_i}{h_o} = \frac{d_i}{d_o}$$

The focal length of the lens will be 75 cm for each problem, and the height of each object will be 20 cm.

1. The object is 170 cm from the lens

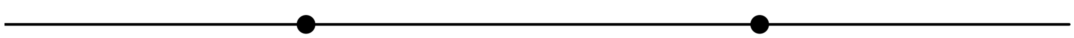


2. The object is 150 cm from the lens



3. The object is 110 cm from the lens

4. The object is 75 cm from the lens



Questions and Conclusions:

1. What is the image like when the object is :

    a. Beyond 2f

    b. At 2f

    c. Between 2f and f

    d. At f

    e. Between f and lens

2. Where should the object be placed to get the largest possible image?

   … the smallest image?

3. Briefly summarize how a lens can used to control the size and location of an image.

4. Research a common vision problem; farsightedness, and describe the lens prescription to correct it. Use diagrams of the eye to show the light paths before and after lens correction.

Extension Opportunity:

The "Hubble Space Telescope" suffered from a vision problem as well. Watch how they fixed it here:
http://www.youtube.com/watch?v=Z6wopUxTZnM

Read more here:
http://hubblesite.org/the_telescope/nuts_.and._bolts/optics/costar/