Scope, Sequence & Coordination

A National Curriculum Development and Evaluation Project for High School Science Education

SS
&C

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Scope, Sequence & Coordination

SS&C Research and Development Center

Bill G. Aldridge, *Principal Investigator and Project Director**
Dorothy L. Gabel, *Co-Principal Investigator*
Erma M. Anderson, *Associate Project Director*
Nancy Erwin, *SS&C Project Editor*
Rick McGolerick, *Project Coordinator*

Evaluation Center

Frances Lawrenz, *Center Director*
Doug Huffman, *Associate Director*
Wayne Welch, *Consultant*
University of Minnesota, 612.625.2046

Houston SS&C Materials Development and Coordination Center

Linda W. Crow, *Center Director*
Godrej H. Sethna, *School Coordinator*
Martha S. Young, *Senior Production Editor*
Yerga Keflemariam, *Administrative Assistant*
Baylor College of Medicine, 713.798.6880

Houston School Sites and Lead Teachers
Jefferson Davis H.S., Lois Range
Lee H.S., Thomas Goldsbury
Jack Yates H.S., Diane Schranck

California Coordination Center

Tom Hinojosa, *Center Coordinator*
Santa Clara, Calif., 408.244.3080

California School Sites and Lead Teachers
Lowell H.S., Marian Gonzales
Sherman Indian H.S., Mary Yarger
Sacramento H.S., Brian Jacobs

Iowa Coordination Center

Robert Yager, *Center Director*
Keith Lippincott, *School Coordinator*
University of Iowa, 319.335.1189

Iowa School Sites and Lead Teachers
Pleasant Valley H.S., William Roberts
North Scott H.S., Mike Brown

North Carolina Coordination Center

Charles Coble, *Center Co-Director*
Jesse Jones, *Center Co-Director*
East Carolina University, 919.328.6172

North Carolina School Sites and Lead Teachers
Tarboro H.S., Ernestine Smith
Northside H.S., Glenda Burrus

Puerto Rico Coordination Center**

Manuel Gomez, *Center Co-Director*
Acenet Bernacet, *Center Co-Director*
University of Puerto Rico, 809.765.5170

Puerto Rico School Site
UPR Lab H.S.

Pilot Sites
Site Coordinator and Lead Teacher
Fox Lane H.S., New York, Arthur Eisenkraft
Georgetown Day School, Washington, D.C., William George
Flathead H.S., Montana, Gary Freebury
Clinton H.S., New York, John Laffan**

* Western NSTA Office, 394 Discovery Court, Henderson, Nevada 89014, 702.436.6685
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National Science Education Standard—Earth and Space
The Origin and Evolution of the Universe

Early in the history of the universe, matter, primarily the light atoms hydrogen and helium, clumped together by gravitational attraction to form countless trillions of stars. Billions of galaxies, each of which is a gravitationally bound cluster of billions of starts, now form most of the visible mass in the universe.

Stars produce energy from nuclear reactions, primarily the fusion of hydrogen to form helium. These and other processes in stars have led to the formation of all the other elements.

Teacher Materials

Learning Sequence Item:

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Starlight

March 1996
Adapted by: Glendena Heiman

Gravitation, Star Processes, and the Formation of the Elements. Students should understand, on a descriptive and empirical level, experiments dealing with the inverse square law of light and emission spectroscopy. For example, they should be able to interpret flame test results to identify common elements. (*Earth and Space Sciences, A Framework for High School Science Education, p. 159.)*

Contents

This micro-unit was adapted by **Glendena Heiman** (North Scott High School, Eldridge, Iowa)

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Learning Sequence

Gravitation, Star Processes, and the Formation of the Elements. Students should understand, on a descriptive and empirical level, experiments dealing with the inverse square law of light and emission spectroscopy. For example, they should be able to interpret flame test results to identify common elements. (*Earth and Space Sciences, A Framework for High School Science Education, p. 159.)*

Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
What is Light? **Activity 1** Light Near and Far **Activity 2** Light from Candles Near and Far **Activity 3** A Model: The Inverse Square Law for Light Intensity **Assessment 1** Flames **Assessment 4**	What Do Light Meters Do? **Activity 4** Light and Bright **Assessment 3**	Creative Story **Assessment 2**	

Suggested Sequence of Events

Event # 1

Lab Activity

1. What is Light (20 minutes)

Event #2

Demonstration

2. Light Near and Far (15–20 minutes)

Event #3

Lab Activity

3. Light from Candles Near and Far (45 minutes)

Event #4

Lab Activity

4. What Do Light Meters Do? (15 minutes)

Event #5

Readings from Inquiry, Science and Technology, Personal and Social Perspectives, and History of Science. Students select two or three from list.

Reading 1
Reading 2
Reading 3

The above readings can be found in the student version of this publication.

Assessment items can be found at the back of this volume.

Assessment Recommendations

This teacher materials packet contains a few items suggested for classroom assessment. Often, three types of items are included. Some have been tested and reviewed, but not all.

1. Multiple choice questions accompanied by short essays, called justification, that allow teachers to find out if students really understand their selections on the multiple choice.

2. Open-ended questions asking for essay responses.

3. Suggestions for performance tasks, usually including laboratory work, questions to be answered, data to be graphed and processed, and inferences to be made. Some tasks include proposals for student design of such tasks. These may sometimes closely resemble a good laboratory task, since the best types of laboratories are assessing student skills and performance at all times. Special assessment tasks will not be needed if measures such as questions, tabulations, graphs, calculations, etc., are incorporated into regular lab activities.

Teachers are encouraged to make changes in these items to suit their own classroom situations and to develop further items of their own, hopefully finding inspiration in the models we have provided. We hope you may consider adding your best items to our pool. We also will be very pleased to hear of proposed revisions to our items when you think they are needed.

Science as Inquiry

What is Light?

Materials:

Station 1. matches or lighters, goggles
Station 2. candles and matches, goggles
Station 3. neon light source
Station 4. light bulb with low wattage (incandescent light)
Station 5. fluorescent light
Station 6. pictures of living things that emit light
Station 7. light sticks

Procedure:

Students will create a table listing the names of the light source used, their observations of the different light sources, as well as find a reference describing light and write this in their report. Darken the room. Have students light matches, candles, light sticks, etc., and observe the emission of light. Allow them to experiment with the various forms of light and then record their observations.

Background:

The main source of light for the earth is the sun. It is essential for life on earth. Without light, living things on the earth would not survive. Light is difficult to understand and scientists have developed various models and theories to explain it. The greek word *photo* means light. Newton is credited with first recording observations about light and for beginning the long search for a definition.

One model describes light in terms of waves which are similar to water waves. The photon model of light was invented by Albert Einstein in 1905. He explained light as tiny particles called *photons.* The modern photon model has been a combination of a particle model and a wave model—and then back to the photon model. It is not a model that has been agreed upon by scientists over history, or even today. Students need to develop their own definition first, then find the definition of the Wave Particle Theory.

It is more accurate to say that photons act like particles in some situations, but like waves in other situations. To gain more information, students need to consider taking an advanced course in physics.

Variations:

Adapted from:

Science as Inquiry

Light Near and Far

Demonstration

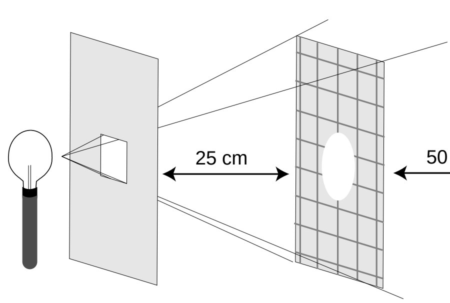
Materials:

100 watt exposed light bulb in fixture (point source)
1 large poster board with 2 cm square cut out of the middle
1 large poster board with 2 cm squares drawn on it (like graph paper)*
washable marking pens
*laminate or cover with clear plastic so that markings can be washed off

Procedure:

Set up this demonstration by taping the “graph-paper” poster in the front of the room. Position the point source of light (the light bulb) behind the other poster and allow the light to shine through the 2-cm-square opening. In order to illustrate the difference between the positions of the source of light and the area covered by the light, experiment with the light source. Keep experimenting, moving the light source until with the last position, the graph-paper poster is completely covered.

Now, place the light source so that it is exactly 25 cm distance away from the graph-paper poster. Have a student “circle” or mark the area on the graph-paper poster that is covered by the light with a colored marker. Move the light source 50 cm away. Have a student mark this area on the graph-paper poster. Move the source 100 cm (or 1 meter) from the graph-paper poster. Again, have a student mark this area with the marker.



Direct the students attention to the marked areas. Discuss with them the distance (of the light source) vs. area (circles on the graph-paper poster). Have students make a data table comparing the information shown by the demonstration related to area and distance. Have them explain how the current theory might have begun when someone asked “What is light?”

Background:

This demonstration represents the inverse square law for light intensity. It can be illustrated by observing or thinking about the apparent brightness of light bulbs. If a 60-watt bulb and a 25-watt bulb are placed side-by-side, the 60-watt bulb will appear brighter. But if the 60-watt bulb is moved a greater distance away, the 25-watt bulb may be seen as brighter, or, depending on the distance, the two may appear to have the same brightness level. Apparent brightness depends on two factors: the wattage and the distance of the source being observed.

The Inverse Square Law for Light Intensity: As the distance between an observer and a light source increases, the observable brightness decreases with $1/\text{distance}^2$. (The light spreads out over an increasing area of space to decrease apparent brightness.) This law is similar to the inverse square law found for gravitational, electrostatic and magnetic forces. The mathematical formula for this law is:

$$\left(\frac{\text{intensity at distance 1}}{\text{intensity at distance 2}} = \frac{\text{distance 2}}{\text{distance 1}} \right)^2$$

$$(\text{distance 2})^2 = \frac{24\ \text{watts/m}^2}{6\ \text{watts/m}^2} \times 25\ \text{m}^2 \quad (\text{distance 2})^2 = 4 \times 25 \text{ or } 100\ \text{m}^2$$

Variations:

Adapted from:

Culver, Roger B., Facets of Physics: A Conceptual Approach, West Publishing Co., Minneapolis/St. Paul, Minn., 1993.

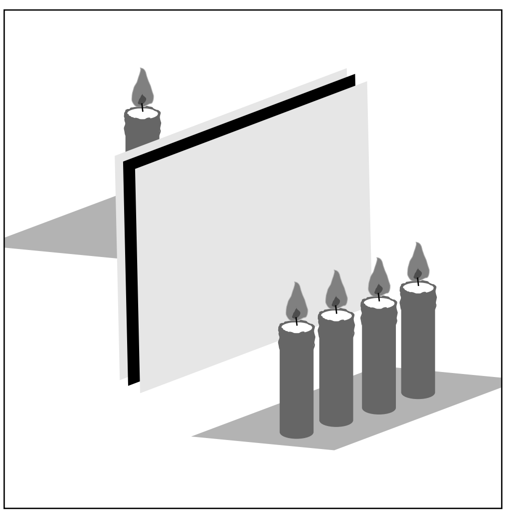
Science as Inquiry

Light from Candles Near and Far

Materials:

Per lab group:

2.5 in. × 5 in. by 0.5 in. block of paraffin (sold in grocery stores—canning section)
aluminum foil
scissors
rubber band
5 candles
box of matches
scratch paper (to catch candle drips)
meter stick



Procedure:

Have students create a paraffin light meter by first cutting the paraffin block in half to form two 2.5-inch squares. They then cut out one 2.5-inch piece of aluminum foil. Students fold the foil (shiny side out) in half to fit the paraffin squares. They "make a sandwich" by placing one paraffin square on the table, then the foil, followed by the remaining paraffin square. Students place a rubberband around the "sandwich" to hold it together. They then stand the newly created paraffin light meter on its side on the table—with the wider-side facing them.

Now, have students place four candles in a row on one side of the light meter, and one candle on the other side. Put scratch paper under all to catch wax drips. Students light the candles. Have them experiment by moving the candles closer and/or further away until the light meter glows the same on both sides. This will indicate the same brightness of the one candle compared to the group of four candles. Students measure the distance from the light meter to the one candle. They then measure the distance from the group of four candles to the meter. Have them experiment with two more trials.

Background:

This activity allows students to experiment with the ideas presented in the demonstration from Activity 2, "Light Near and Far." This is another way to illustrate the Inverse Square Law for Light Intensity. If the distance is doubled, the light is spread out four times the area. Students should be able to show this with the ratio of one and four candles. The difficulty will be their judgment of equal intensity on the left and right side of their light meter. A darkened room will give better results.

Variations:

Adapted from:

Science and Technology

Where Do Light Meters Do?

Materials:

light meter purchased at electronics store
tape measure of meter stick
light sources (used at school or home)

Procedure:

Students need to work as a group. Have them measure the distance that the light meter is away from a light source (i.e., from a student desk, table, etc.) and record their findings. Have them place the light meter half the distance from the light source and take a second reading. They then compare the readings on the light meter and make a data table showing how this relates to distance.

They then measure the distance and find the readings on the light meter for at least two other sources. Students again take a second reading on each of these by doubling the distance from the source, then record these findings.

Background:

If possible, find a chart that suggests the amount of light necessary to do various activities with the least amount of eye strain. Usually electric companies have these charts or probably a library source has this available.

A light meter may be assembled as an activity during the school year. If this is not done, a light meter is often used by photographers and may be available from another department in your school if you do not have one.

The students need to see that as the distance is doubled, the intensity of light will decrease by four. This is another way to see the Inverse Square Law of Light used.

Adapted from:

Science as Inquiry

The Inverse Square for Light Intensity

Item:

Using spray can of vegetable shortening (a substitute for light) and paper towels, make a model to illustrate what happens when a light source is a greater or lesser distance away from an object. Write an explanation about the behavior of light intensity and distance.

Answer:

If the shortening is sprayed at a short distance from the paper towel, a small area will be produced. When the distance is increased a larger area will be produced.

Measure the diameter of the circle, determine the area, and compare the distance the spray was released from to the area it covered. Point out the density of the spray on the towels and relate it to light's apparent intensity.

Science in Personal and Social Perspectives

Creative Story

Item:

Write a story which uses some things that might have been observed about light by the characters in a story (for example, “Twinkle, Twinkle Little Star”). Think of an idea and mix imagination with some principles of science.

Answers:

This is completely open ended. Students might discuss distance compared to brightness. This could be related to space travel or light observed on a camping trip or any number of ideas. The story could be a children’s story, science fiction, etc. The length of the story is up to the teacher. The reason for this assessment is to combine science with writing skills and creativity.

Science and Technology

Light and Bright

Item:

If a light bulb was moved twice the distance away from you what will happen to the apparent brightness of the bulb?

A. The light bulb will be half as bright.
B. The light bulb will be one-third as bright.
C. The light bulb will be one-fourth as bright.
D. There will be no difference in the apparent brightness of the light bulb.

Justification:

The apparent brightness or intensity of a source of electromagnetic wave energy obeys an inverse square law which can be stated: As the distance is doubled, the light is spread out four times the area and will be one-fourth the apparent brightness.

Answer:

C. The distance is doubled so the light intensity is reduced to one-fourth

Science as Inquiry

Flames

Item:

You will need: pliers, wire (e.g., coat hanger 35-cm long), one cork, various powders (i.e., cream of tartar, boric acid powder, sodium chloride), a flame source (bunsen burner, alcohol burner, candle, etc.), goggles, and a fire extinguisher.

Using pliers, make a small loop at the end of the wire—no more than 3 mm across. Insert the other end in the cork to act as a handle. Hold the loop in the flame to clean it. Moisten the loop with distilled water and dip the loop in the powder to be tested. (The water will help the powder stick.) Hold the loop steady in the flame and watch the substance burn. Repeat with all the powders.

Question:

Describe the different flames. How might these be used to test the identity of an unknown substance? Would your results always enable you to tell the identity of a substance? Explain why or why not.

Answer: