5E Cycle Materials

Program: Research Experience for Teachers
CCMR

Mona Steigerwald

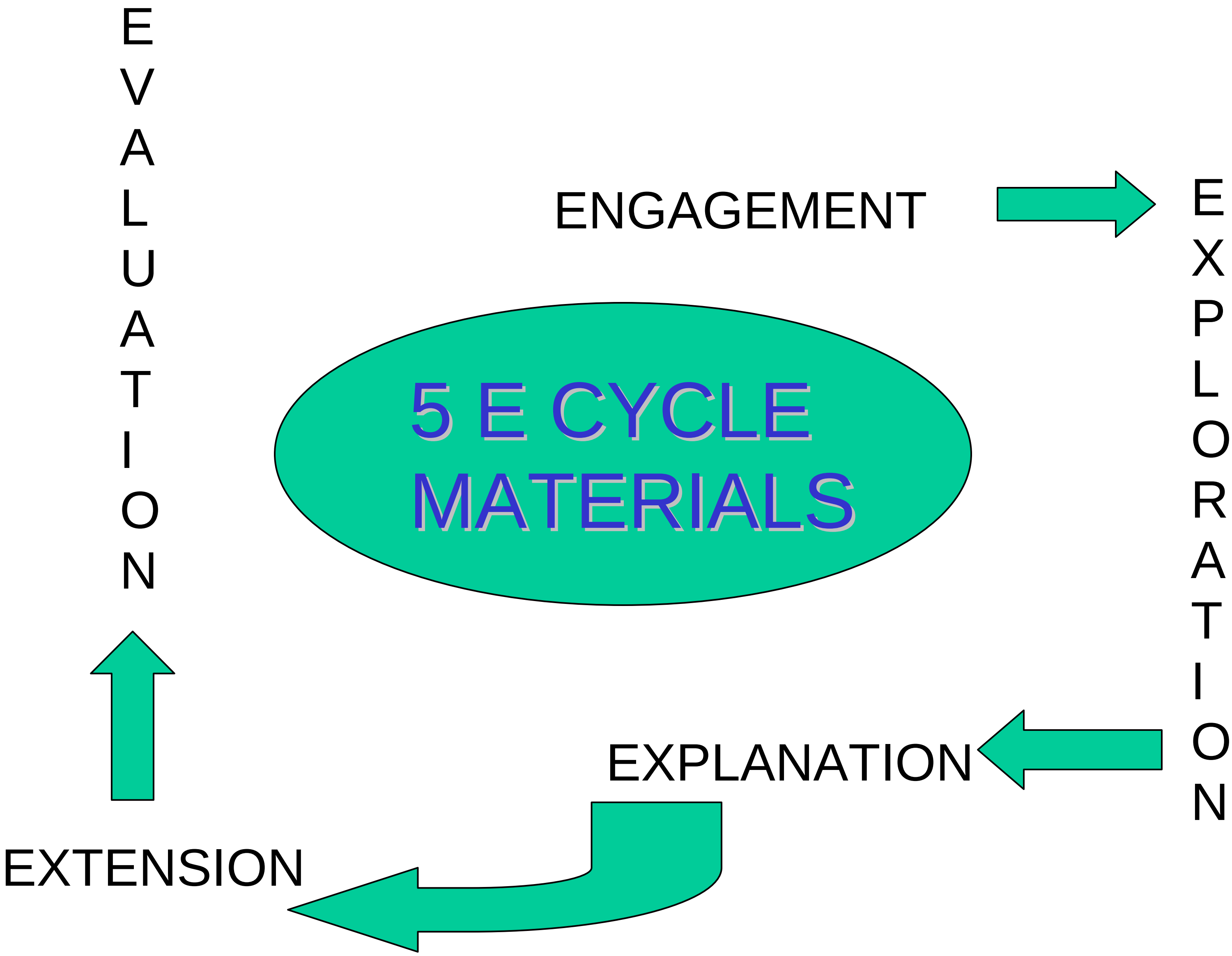
8/16/02

PROLOGUE:

The project that follows presents a small portion of what was gained from my experience as an RET at Cornell. Other attributes include:

- Connections being made between the teachers on the team, and the teachers and college personnel in the Outreach Program.
- Leaving with a much better understanding of the research being conducted.
- The feeling that I am a scientist.
- A need to go beyond the basics. For example, don't just teach that metals are malleable, experiment and see which are more malleable.
- A renewed spirit for teaching.
- A need to let students truly experience the investigative process more often.

The units that follow were made utilizing the 5E Learning Cycle. It is explained in the following pages, and I felt it was a good format to use because it stresses inquiry and real world applications, both an important part of teaching students about material science and how scientists investigate problems. I'm sure my examples are not always the best, and maybe activities would be better placed elsewhere, and the format itself helped me to think about building on what they know and varying the lesson; I'm sure I'll get better at it. In some cases the activities aren't fully written out, just explained on the 5E learning cycle organizer. The last page contains websites I referred to in each unit.


5 E CYCLE MATERIALS
ENGAGEMENT
EXPLORATION
EXPLANATION
EXTENSION
EVALUATION

Designing a Science Lesson Using the 5E's Model

1. Identify the Scientific Concept for the Lesson
   What scientific principle should students learn from this lesson?

2. Identify a real-world or practical application related to the concept.
   This can be:
   * a problem that students can solve   or
   * a decision that students can make   or
   * a question students can answer with information collected from the activities in the lesson.
   This application will be presented during the ENGAGEMENT and will be completed during the EXTENSION.

3. Provide Opportunities to collect information from:
   * the media center and /or
   * the internet and/or
   * lab work
   This will become the EXPLORATION.

4. Develop a series of Questions (using a SR, BCR, and/or ECR format):
   a. FOR INDEPENDENT STUDENT REFLECTION TO:
   * help students analyze the collected information
   * guide student thinking
   b. FOR CLASS DISCUSSION TO:
   * compare data and ideas
   * critique conclusions
   This makes up part 1 of the EXPLANATION.

5. Provide explanations that will increase the student's understanding of the concept.
   Formative assessment is appropriate after the completion of this second part to the EXPLANATION.

6. Evaluation occurs throughout the lesson.
   The EVALUATION of all important concepts, skills, and processes concludes the lesson.

Please send questions and comments to:
Michael_J_Szesze@fc.mcps.k12.md.us
This page was created by Michael Szesze, Program Supervisor for Science.

This page was created on July 17, 2001 and last modified on July 21, 2001.
URL: http://www.mcps.k12.md.us/curriculum/science/instr/5Eslessondesign.htm

5E's Strategies for Teaching Science

1. Engage

- Observe surroundings for points of curiosity
- Ask questions about the real world
- Consider possible responses to questions
- Note unexpected phenomena
- Identify situations where student perceptions vary

2. Explore

- Engage in focused play
- Brainstorm possible alternatives
- Experiment with materials
- Observe specific phenomena
- Design a model
- Collect and organize data
- Employ problem-solving strategies
- Select appropriate resources
- Discuss solutions with others
- Design and conduct experiments
- Evaluate choices
- Engage in debate
- Identify risks and consequences
- Define parameters of an investigation

3. Explain

- Communicate information and ideas
- Construct and explain a model
- Construct a new explanation
- Review and critique solutions
- Utilize peer evaluation
- Assemble multiple answers/solutions
- Determine appropriate closure
- Integrate a solution with existing knowledge and experiences
- Analyze data

4. Extend

- Make decisions
- Apply knowledge and skills to other disciplines

- Transfer knowledge and skills
- Share information and ideas orally and in writing
- Ask new questions
- Develop products and promote ideas
- Use models and ideas to illicit discussions and acceptance by others
- Conduct more investigations
- Conduct activities in other disciplines

5. Evaluate

- Journals, Logs, etc.
- Portfolios
- Constructs mental and physical models
- Student data sheets
- Performance assessments
- Produce a Product
- Rubrics and Scoring Tools
- Tests (SR, BCR, ECR)

Please send questions and comments to:
Michael_J_Szesze@fc.mcps.k12.md.us
This page was created by Michael Szesze, Program Supervisor for Science.

This page was created on July 17, 2001 and last modified on July 21, 2001.
URL: http://www.mcps.k12.md.us/curriculum/science/instr/5Estrategies.htm

ELECTROSTATIC CHARGES

The aim is to get students to understand the nature of electrons and visualize how and why they move, concepts they need to know before the study of bonding and intermolecular forces.

5 E's Lesson Components	Activity
ENGAGEMENT: meant to capture the student's attention, help them access prior knowledge. (Must include an indication of where lesson is going.)	Demonstration: moving a 2X4 with a balloon
EXPLORATION: students are given time to think, plan, and organize collected information to develop their ideas about the content.	Students experiment with a balloon and bits of paper, and draw models of what occurs in the balloon and wood.
EXPLANATION: allow students to explain, and follow with the teacher explanation. Their understanding is clarified and modified because of reflective activities.	Lab: Students are given the tribo-electric series and asked to: a) make a demonstration to show and explain to class b) find out where a new substance belongs in the series
EXTENSION: gives the student the opportunity to expand and solidify their understanding of the concept, and/or apply it to a real world situation.	Make a brochure to explain your new product that uses one of the following processes: electrophotography, electrostatic precipitator, and electro-static spray painting
EVALUATION: gathering of evidence that students have understood the new learning.	Lab quiz based on the explanation activity. Students are given 2 objects to rub together, and the triboeclectric series. They must explain what occurs in the atoms of each to induce the charge and draw a model of the inside of each material.

Demonstration: Moving a Board with a Balloon

Procedure:

1. Bring the whole class to a table in the room.

2. Place a watch glass face down on the lab table and use the convex surface as a pivot for the piece of lumber.

3. Put a few drops of lubricating oil on top of the convex surface of the watch glass and then balance the lumber on the pivot. (The oil allows the board to rotate with less friction).

4. Rub the surface of the balloon on the piece of fur to build up a static charge.

5. Hold the charged balloon a few inches from one end of the lumber and the board will move toward the balloon.

6. Divide the class into small groups and have each group tear up a piece of notebook paper into small pieces. Also give each group a balloon.

7. Have each group charge their balloon and bring it close to their pieces of paper or hair.

8. Initiate discussions within each group as to why the balloon moves things.

9. After group discussions, have each student write a short essay about the experience and what properties of science were dealt with.

Suggested Inquiry-Based Questions to Use in Activity:

* What is causing the lumber to move?

* Using the triboelectric series, determine what charge the balloon and the wood acquire. Draw a model of the balloon and wood to show how the charges occurred.

* How do the terms attraction and repulsion relate to our investigation?

Assessment:

Small Group- The teacher will go from group to group and verbally assess whether each member of the group understands the principle of electrical charges and that like charges repel and opposite charges attract, and how the positive is induced in the wood.

Individual- Each student will write a short essay describing the activity and the properties involved. Assessment will come from the child's ability to correctly identify the scientific principles involved in this activity.

Adaptations for Special-Needs Students:

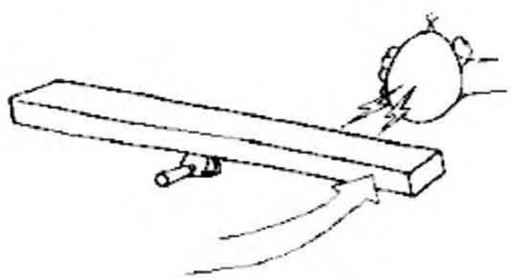
For a child with vision impairment, the teacher should allow the student to physically feel the elements used in the activity. Also the student should be free to feel the lumber move and experience how the hairs on his or her body rises when the charged balloon is placed nearby.

Extensions:

+ Study of atoms, including the parts of atoms (electrons, protons and neutrons) and their properties.

+ How electricity is used by humans in everyday life.

+ Where electricity is present in nature.



www.eecs.umich.edu/mathscience/funexperiments/agesubject/lessons/whelmer/static.html

TRIBOELECTRIC SERIES

Air (*?)
Human Hands <---- Most Positive
Asbestos
Rabbit Fur
Glass
Mica
Human Hair
Nylon
Wool
Fur
Lead
Silk
Aluminum
Paper
Cotton ZERO
Steel
Wood
Amber
Sealing Wax
Hard Rubber
Nickel, Copper
Brass, Silver
Gold, Platinum
Sulfur
Acetate, Rayon
Polyester
Styrene (Styrofoam)
Orlon
Saran
Polyurethane
Polyethylene
Polypropylene
Vinyl (PVC)
Silicon
Teflon <----- Most Negative

The above list is from NATURE'S ELECTRICITY, p63
by Charles K Adams (c)1987 Tab Books, #2769

* I don't know if I believe that "air" really is in this position.
Electrification via airflow usually involves collisions with dust,
snow, or condensed water suspended in the air. - Bill B.

WARNING: the order of the above list is different in different books. Polarities are dependant upon atomically-thin surface layers, so don't be suprised if your particular examples of a material are not in the right place should you make your own list. It is best to choose two materials which are far apart on the list, then you can be fairly sure that their polarity will not be backwards from what you expect.

Note: the term "frictional electrification" is misleading. Separation of charges is not accomplished by friction. Surface charge imbalance comes from the same source that friction does: adhesion on the molecular level. Surfaces stick together because chemical bonds form. When surfaces in contact are separated, the bonds rupture, and any asymmetrical bonds (such as ionic bonds) will tend to leave imbalanced charges behind. Other effects are important too, and this subject is not very well studied in science. Go search for info about surface charge, contact electrification, and Atomic Force Microscopes.

Since most materials are not flat enough or flexible enough to attain large-area contact, most materials don't become very strongly electrified when simply touched together. For example, when fur is used on plastic it helps greatly if you drag the filaments of hair across the plastic surface. Among other things, this acts to increase the total contact area. Some surfaces, such as adhesive tape or plastic sheets, CAN attain intimate contact over a large area, and DO exhibit strong charging when they are simply touched to another surface and pulled away.

This phenomenon is called "contact charging" or "electrification by contact." Use these terms and avoid giving the idea that the mechanism for the electrification is CAUSED by friction. I also like to tell people that "surface charging is caused by peeling," since the scotchtape demo works so well, and since "peeling" always implies a preexisting intimate contact between surfaces.

Caveat: contact electrification is not well understood. Friction DOES play a part. For example, the ordering of the triboelectric series is different when surfaces are rubbed together rather than simply touched. The order of the series also changes when surfaces of differing roughness are rubbed together. Even IDENTICAL substances can generate a charge-imbalance if one surface is rough and the other one smooth. This is probably a major reason why different references give different ordering of the series: the experiment must guarantee that no rubbing occurs, otherwise results will vary from trial to trial.

http://www.amasci.com/emotor/tribo.txt

ELECTROSTATICS NEWSLETTER

July/August No.145

PRESIDENT'S MESSAGE

It's a great honor to be writing this message as your new ESA President. I hope to continue the legacy of the great ESA presidents of the past Al Seaver, Joe Crowley, Glenn Schmieg, Charlie Kalt, Bob Gundlach, Emery Miller, and Peter Castle, to name a few who have helped foster the vision set out by A.D. Moore and the founders of ESA. I'd like to extend a special thanks to Al Seaver as outgoing President for his dedicated service over the past four years. Through his vision, encouragement, and leadership, coupled with his unique prowess at email communication, ESA has entered the computer age, extended outreach to new members, brought many new leaders and committee chairs into the fold, and continued an exchange and dialog with our counterparts in the Institute of Electrostatics Japan. I am sure I speak for the entire membership when I extend a round of applause to Al: "Many thanks from all of us." Thanks are also due to our outgoing Vice President, Mark Zaretsky, whose ever present involvement and advice has helped Al Seaver immensely in his job of running the ESA. Mark also serves the distinction of being the only Vice President in ESA history to have actually stepped in, even if only for a short time, as acting President. (For those of you who could not attend the Annual ESA meeting in Boston, Al was slightly under the weather on the night of the banquet and was unable to preside over the banquet.) Finally, I'd like to echo Al's note of appreciation to the faithful members of the outgoing ESA council Tom Lee and Ed Escalon for their continued presence and help in guiding the ESA, as well as to all the committee chairs who help keep ESA running.

What's in store for the next two years? I believe that the biggest challenge facing the ESA today is the identification of new areas of electrostatics that should call ESA home. Electrostatics is becoming increasingly more important in biomedical engineering, molecular genetics, and drug delivery. It also serves as a core discipline for microelectromechanical systems (MEMS), and shows immense promise in the continued control of industrial pollution. A perusal of the literature, both technical and trade, will show numerous researchers who use electrostatics every day but perhaps are unaware of the existence of the ESA. I believe that we should identify these individuals, let them know about the ESA and its activities. and hopefully bring them in as new contributing members and as speakers at future ESA meetings. Indeed, several new people were invited to speak at the 1999 ESA meeting and expressed interest in joining. I hope that this trend continues.

What's the challenge for you: Identify one individual who works with or uses electrostatics but is unaware of the existence of the ESA. Perhaps you've read an article related to electrostatics in a journal or magazine? Maybe you've heard a speaker who works in a field related to electrostatics? Send that person's name either to me or to Bill

Smart, our newsletter editor, and we'll put them on the mailing list for a year. In that way, perhaps we can continue the heritage of the ESA as being a premier world forum for issues related to electrostatics.

For the Friendly Society,

Mark Horenstein

http://www.electrostatics.org/Newletters/NL-145.htm

MORE ON ELECTRONS

This unit focuses on the excitation of electrons, and an introduction to diffraction is included so students better understand the spectroscope.

5 E's Lesson Components	Activity
ENGAGEMENT: meant to capture the student's attention, help them access prior knowledge. (Must include an indication of where lesson is going.)	Flame test demonstration Project the spectrum with the overhead projector
EXPLORATION: students are given time to think, plan, and organize collected information to develop their ideas about the content.	Make a "log" (made from twisted newspaper) soaked with different solutions, view everyone's as they burn and identify the ions present using the data from the engagement section. Diffraction lab (included as part of a packet created by Dr. Aaron Couture at Cornell)
EXPLANATION: allow students to explain, and follow with the teacher explanation. Their understanding is clarified and modified because of reflective activities.	Describe how the colored flame is produced and define diffraction
EXTENSION: gives the student the opportunity to expand and solidify their understanding of the concept, and/or apply it to a real world situation.	Overview of the electron microscope (and other objects using a cathode ray tube) Observe electromicrographs on the internet*
EVALUATION: gathering of evidence that students have understood the new learning.	In the computer lab create a word document including a brief description of how the electron beam is created in the electron microscope and insert 3 related electromicrographs with the scale included.*

*List of websites at the end

Calculation Investigation

Days needed 1
Grade Level 11 - 12

Objective

In this activity, students will learn how white light, such as that from an overhead projector, is broken up into its component colors by a diffraction grating. They will then learn the relationships between light's wavelength, frequency, and energy and how to convert between any of these characterizations of a particular color of light. Background information includes general information on the electromagnetic spectrum and the nature of light.

Science and Math Standards

NCTM	NSES
Content Standard 1: - Mathematics as problem Solving	Content Standard B: - Structure of Atoms - Light, heat, energy and magnetism
Content Standard 2: - Mathematics as Communication	
Content Standard 4: - Mathematical Connections	
Content Standard 6: - Functions	

Pre-requisites

Science Students should read the background material on the Electromagnetic Spectrum
Math Students should have a basic understanding of algebra and should have read the background material on the Electromagnetic Spectrum

Introduction

Light can be described in many ways, by its energy, its wavelength, or its frequency. All three terms are equally important, and all are interrelated. Each color in the spectrum, for example red, has a distinct energy, but also has a specific wavelength and frequency. The convention is that infrared light and visible light (the rainbow of colors our eyes can see) are usually described by wavelength, radio waves in terms of frequency, and high-energy X-rays and gamma-rays in terms of energy. This scientific convention allows the use of the units that are the most convenient for that energy of light. For example, it would be inconvenient to describe both low-energy radio waves and high-energy gamma-rays with the same units because the difference between their energies is so great. A radio wave can have an energy on the order of 4×10^{-10} eV, as opposed to 4×10^{9} eV for gamma-rays. That's an energy difference of 10^{19}, or ten million trillion, eV!

Engagement

Using the overhead projector, prism, diffraction grating, and two sheets of cardboard, the students will set up the apparatus as illustrated below to project the spectrum of white light on a screen. Students will then pose questions about what they are observing, and what they are going to do to answer these questions.

Using an Overhead Projector to Project a Spectrum

We (and two of our teacher interns) have tried this recently. We had very good success with the overhead projector method of generating a good, large spectrum. This idea was originally published by Dr. Philip M. Sadler in the article "Projecting Spectra for Classroom Investigations," *The Physics Teacher*, 29(7), 1991, pp. 423-427.

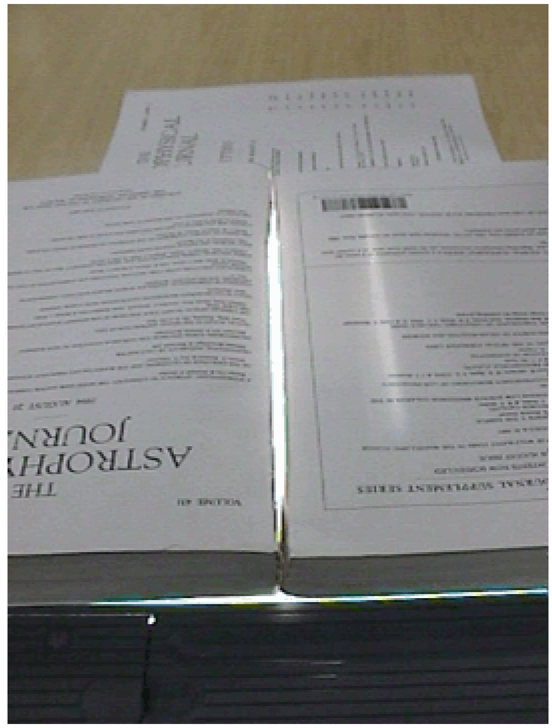
You will need:

- an overhead projector and a source of power
- two or three books or pieces of 8x10 dark construction paper
- diffraction grating - (a film with thousands of microscopic grooves per inch that break up white light) - this is available from Edmund Scientific. Use one about the size of a 35mm slide.
- white wall or screen

1) To make a visible light spectrum, plug in the projector, and turn on the lamp. Set up the projector so it is projecting at a white screen or wall.

2) Use books on the base plate of the projector to completely block all but a single slit of light no larger than an 1" wide from being projected on the screen. Focus the projector.

Set-up for the experiment, including the overhead, books to create a slit of light, and the diffraction grating (at top of overhead)

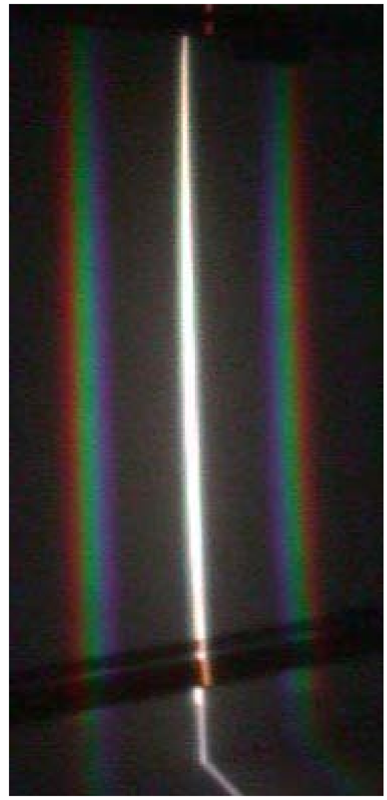


Close-up of creating the slit of light from the overhead.

3) Place a diffraction grating over the lens at the top of the "projection stack". Rotate the grating (if necessary) until the spectrum appears on both sides of the projected slit on the wall or screen.

4) Turn off the lights, lower blinds, whatever you can do to make the room dark. You should now have a nice spectrum projected onto the screen/wall.

Close-up showing the placement of the diffraction grating on the overhead lens.



The image on the screen shows the central white band of light coming from the projector, plus a spectrum on both sides.

Exploration

Print out the Student Worksheet for the class. Have the students complete it.

- Student Worksheet
- Solution for Student Worksheet

Evaluation

Formative assessment and observation should be evident throughout the lesson. The worksheet, final questions during closure or a future quiz may serve as summative assessment.

Closure

If students have been keeping a lab journal, direct students to write for ten minutes in their journals summarizing the lab and all procedures in this lesson. Encourage students to then share their findings and what they might have written in their journals. Otherwise, have students create a lab report for this lesson, summarizing their findings. The format of the lab report would then be up to the teacher.

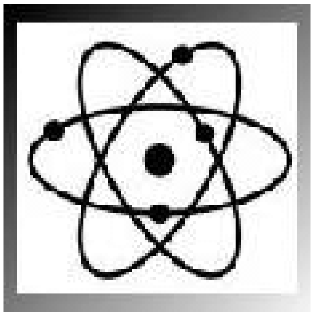
Extension

Using a supply of diffraction gratings, students can make their own spectroscope (either making "spectroscope glasses" using two gratings or a "spectroscope telescope" using one grating and a hollow tube). Students can then look at different light sources. (Caution students that they should not look a the sun !)

Back to the Main Spectra Unit Menu

URL of this page: http://imagine.gsfc.nasa.gov/docs/teachers/lessons/xray_spectra/activity-emspectrum.html

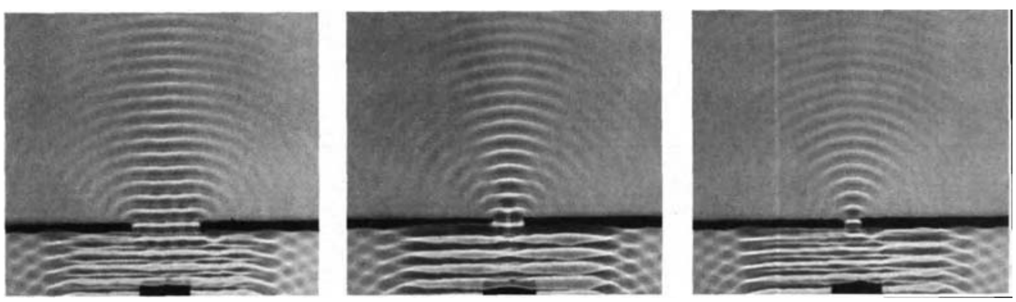
---



Atoms are **small**- really small! So we need special tools in order to see how they are arranged. One of the most popular tools is diffraction (just ask any physicist!). What is diffraction and how does it work? Hold on- you're about to find out!

What is Diffraction?

What happens to a water wave if it passes through a wall with a gap in it? Water waves in a tank with just such a gap are pictured below[1]. If the gap is big, nothing-special happens- the waves pass right through. But as the hole gets smaller something surprising begins to happen!



The hole begins to look as if someone had thrown a stone in the water just at that point. The ripples spread out from the hole in circular rings. The effect of waves spreading out as they pass through a small opening is called diffraction.

The same effect allows sound waves to easily bend around corners, allowing you to hear someone you can't see.

Experiment

Lets investigate another kind of wave that you are familiar with- light! Believe it or not, light is a wave! But its wavelength is much smaller than sound or water. Here, we'll pass laser light through a fine wire mesh- watch carefully to see if anything strange happens!

1) Set up the laser about 5 ft from the screen. Point the laser so that it is pointing at the screen.

2) Place the wire meshes in front of the laser. Record the patterns that you see below. What is different about each mesh? Record a descriptive word below the box.

Mesh #1	Mesh #2
________	________

3) Try tipping and rotating the wire mesh while it is in the laser beam. What happens to the pattern?

Questions

- ➢ Was the light hitting the screen a shadow?

Yes No

- ➢ What happened to the spacing of the pattern, as the mesh got smaller?

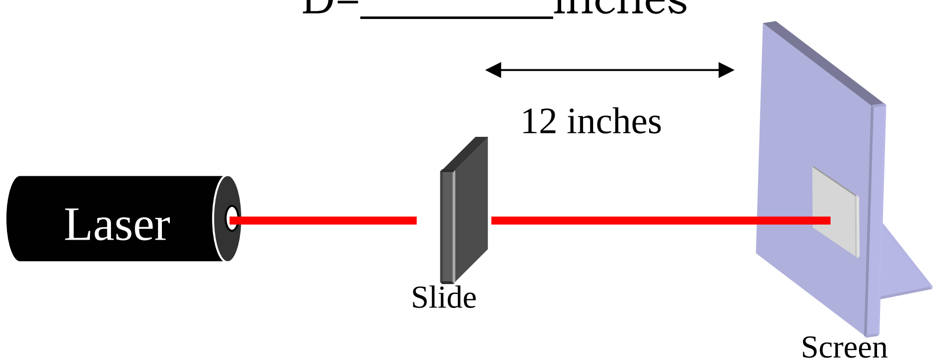
Mesh spacing ↓
Pattern spacing ____

Experiment 2

Time to put our observations to work! We know that light is diffracting from the wire mesh- now let's try making a measurement. We'd like to measure the size of something so small that we can't see it by eye. In the next experiment, we'll use diffraction of light just like a ruler. We'll measure a mesh so tiny that it isn't visible by eye.

1) Put the slide with the clear plastic into the beam, and look at the resulting pattern. Is it different than the wire mesh? What do you think is causing the diffraction?
2) Now point the laser so that the diffraction hits the measurement grid, as pictured below. The grid has lines every 1/5-inch. What is the distance from the center of the beam to the first diffraction spot?

D=_________inches



4. Now for some numbers. We would like to find out what the spacing of the pattern is, even though we can't see it by eye. From diffraction theory we know:

$$\text{Spacing} = \frac{\text{Wavelength of light} \times \text{Slide to screen distance}}{\text{Beam displacement (D)}}$$

$$\text{Spacing} = \frac{.67\ \mu\text{m} \times \text{Slide to screen distance}}{\text{Beam displacement (D)}}$$

$$\text{Spacing} = \frac{.67\ \mu\text{m} \times (\qquad\qquad \text{inches})}{(\qquad\qquad \text{inches})}$$

Multiply the three numbers to find out what the spacing of the pattern on the slide is:

Spacing = __________µm

What is an µm?

An µm or micron is just like any other unit of metric measurement. One kilometer is equal to one thousand meters; one millimeter is equal to one-thousandth meters, and so on. One micron is equal to one-millionth meters. That is:

$$1\ \mu\text{m} = \frac{1}{1{,}000{,}000}\ \text{meters}$$

Just for comparison, your hair is about 25µm in size. Pretty small, don't you think? Well, if you think that microns are small, **atoms are 10,000 times smaller**!

How small is small?

X-ray Diffraction

By inserting fine wire mesh into the laser light, you have observed the light diffracting. Even when the spacing between the slits was too small to see by eye, you could still tell they were there by observing diffraction. In this way, you have used diffraction of light as a tool to investigate a material (your grating) at small size scales.

Will light diffract from atoms? You bet! But to investigate atomic size objects light that is about the same 'size' as the atoms is required. And you guessed it- this kind of light is *x-ray* radiation. When *x-rays* strike atoms, they diffract and form a pattern similar to the ones you drew above. By studying the pattern of diffraction, the atomic structure of the material can be discovered.

Cornell has a special kind of high-energy accelerator called a **synchrotron** on campus. The accelerator is an intense source of *x-rays*, which can be used for diffraction studies of new materials. We'll finish our workshop by touring the **C**ornell **H**igh **E**nergy **S**ynchrotron **S**ource (**CHESS**) to find out what some of these experiments are.

Bibliography

1. Conceptual Physics, pg. 472, Hewitt, Addison-Wesley Pub. Co., 1992

What's going on inside this building?

The ALS is a research facility used by scientists to:

- Explore the properties of materials
- Analyze samples for trace elements
- Probe the structure of atoms and molecules
- Study biological specimens
- Investigate chemical reactions
- Manufacture microscopic machines.

The ALS produces light--principally x rays--with special qualities. Scientists use these x rays as a tool to do their work, just as dentists use x rays as a tool.

Many scientists working on different projects can use the ALS at the same time. For example, one scientist might be checking samples of mud for tiny amounts of a toxic contaminant, while another might be investigating a polymer to find out how its molecules are arranged.

Fact: X rays have shorter wavelengths than visible light. But both are light, also called electromagnetic radiation.

Why is the ALS so large?

To produce light of the wavelengths and brightness that scientists want, the ALS designers had to create a large machine. Its largest component, the storage ring, has a diameter two-thirds the length of a football field.

The storage ring is a tubular vacuum chamber made to:

- Hold an electron beam travelling through it at nearly the speed of light.
- Maintain the high energy of the electron beam.

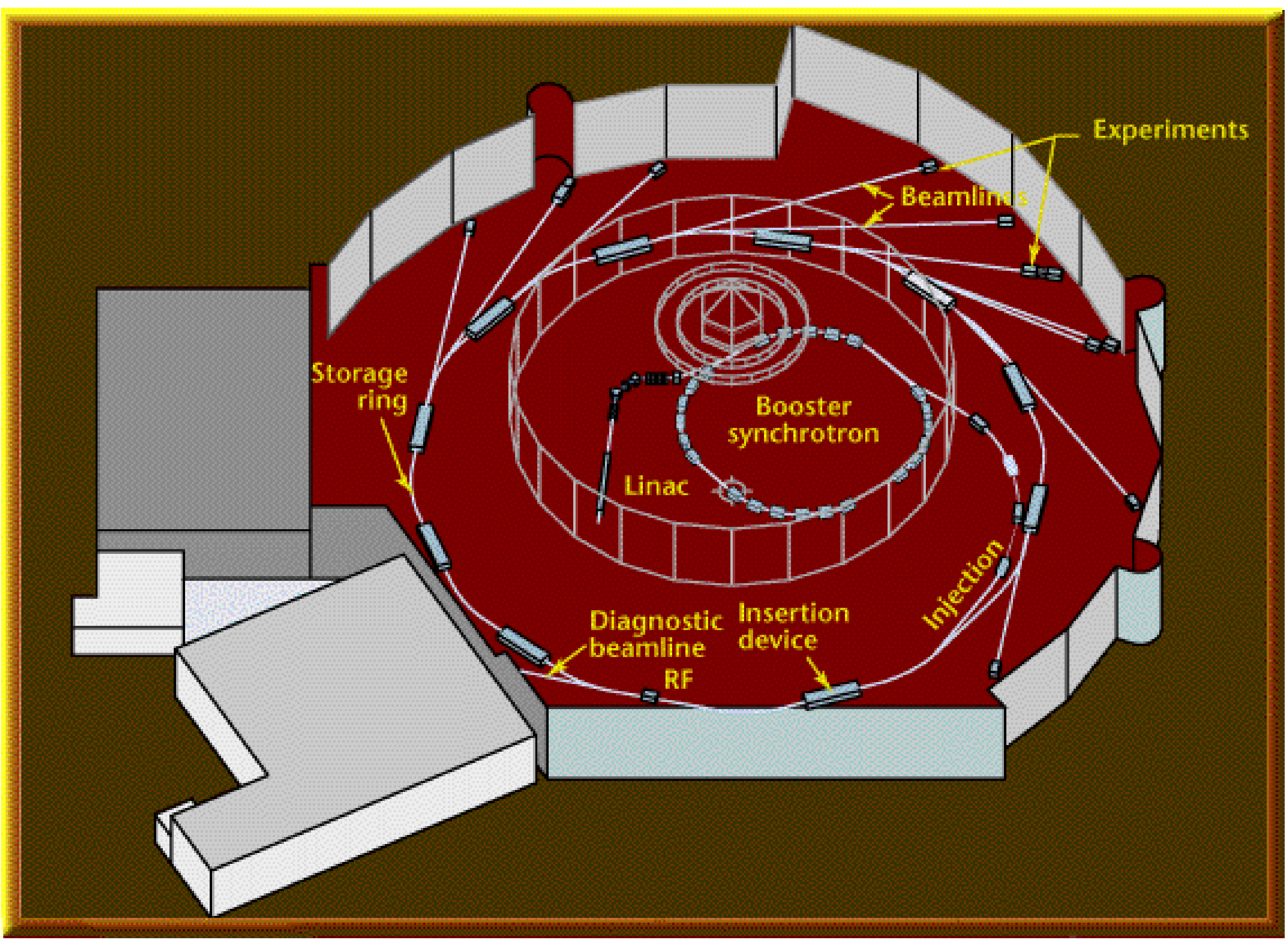
As the electrons circle the ring, they give off light. The ring must be as big as it is to maintain the electron beam at 1.5-1.9 billion electron volts, the energy required to produce light of the desired wavelengths and brightness.

For more information, see ALS Components.

Fact: Light produced by machines that operate like the ALS is called "synchrotron radiation."

http://www.allianceforlifelonglearning.org/cgi-bin/er/reframe.cgi?q=Q7HqS3elBtTtToviOcmkPszsBqrfOt9lLszoR6HpBm00&r=OsnXD30vD3akQ7HjR000

This site also explains the difference between ALS generated x-rays and those produced by an x-ray tube, and diagrams are included to explain the excitement of electrons to higher energy levels.



CRYSTALLINE STUCTURE

The aim is to go beyond the basic introduction of a solid crystal lattice. After building models of crystals, students may better understand that in ionic substances the chemical formula is the ratio of the ions, and that crystalline structure determines the strength of these materials.

5 E's Lesson Components	Activity
ENGAGEMENT: meant to capture the student's attention, help them access prior knowledge. (Must include an indication of where lesson is going.)	Lab: create a structure that can support their textbook 5 cm off the table using 6 pieces of fettuccini and 1 meter of masking tape
EXPLORATION: students are given time to think, plan, and organize collected information to develop their ideas about the content.	Draw pictures of crystals made (some were ½ crystals) and put in order of strength. Use websites to find examples of crystalline structures similar to those made.
EXPLANATION: allow students to explain, and follow with the teacher explanation. Their understanding is clarified and modified because of reflective activities.	Make a model of a crystal and write a report on the properties of the substance.
EXTENSION: gives the student the opportunity to expand and solidify their understanding of the concept, and/or apply it to a real world situation.	Introduce students to x-ray diffraction* (also include history of the x-ray, it makes for great discussions on the scientific method) Compare graphite to diamond crystal structure*
EVALUATION: gathering of evidence that students have understood the new learning.	Students could keep a log of their experiments and activities.

*See websites on the last page

LABORATORY ACTIVITY: STUDENT VERSION

Activity: Metal and Ionic Crystals

Introduction

In this investigation, plastic spheres are used to study the regular geometric shapes of metal and ionic crystals. The regular geometric shapes of crystals reflect the orderly arrangement of the atoms, ions, or molecules that make up the crystal lattice.
Three types of packing in crystals will be investigated-hexagonal close packing, face-centered close packing, and body-centered packing-using equivalent spheres. From the models it will be possible to determine the coordination number of the particles of each structure.

The relative sizes of cations and anions that make up ionic crystals are a determining factor for the coordination number. The effect of size as indicated by ionic radius on coordination number will be examined by building models of rock salt (NaCl) and Wurtzite lattices (ZnS).

Purpose

To gain familiarity with the geometry of metallic and ionic crystal structures.

Safety

Wear protective goggles and apron throughout the laboratory activity.

Procedure

Secure the following per group of two students: 36 two-inch, 13 one-inch, and 13 three-quarter-inch expanded polystyrene spheres. Toothpicks or short lengths of pipestem cleaners can be used as connectors for the spheres.

Part I

1. Use connectors to build these three structures

2. Place one three-sphere layer on the table or desk so that one apex of the triangle faces you. Then place the seven-sphere layer on top of the three-sphere layer so that the center sphere fits into the depression at the center of the first layer. Now place the second three-sphere layer over the center sphere so the top layer is directly above the bottom layer. This resulting structure represents hexagonal close packing (hcp).

3. Count the number of spheres closest the central sphere in the structure. This is called the number of nearest neighbors or the coordination number. Zinc, magnesium, and many other metals pack in this manner. Retain this model for Step 3. Answer Implications and Applications question 1 now.

Part II

4. Build these layers:

Place one five-sphere layer on the table or desk. Then place the four-sphere layer over the first so that the four spheres rest in the spaces between the corner spheres in the bottom layer. Now place the last five-sphere layer on top so that it is situated directly over the bottom layer. Study the structure carefully and decide why it is called face-centered cubic (fcc). Copper, silver, aluminum, and many other metals pack in this manner in crystals. Determine the coordination number. Answer Implications and Applications question 2 now.

http://intro.chem.okstate.edu/ChemSource/Bond/bondpage14.html

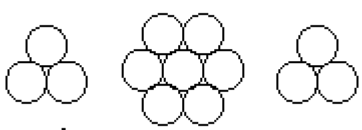


Figure 1.

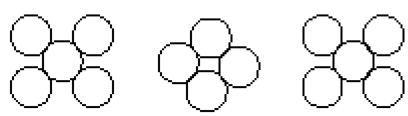


Figure 2

Concept/Skills Development

Activity 2: Metal and Ionic Crystals

Major Chemical Concept

This laboratory activity gives students an opportunity to view the basic structural forms of most metals. Students learn the meaning of coordination number, crystal lattice, and packing. Later, students will be able to correlate properties with structure.
Two common ionic crystal lattices,-rock salt and wurtzite-and their coordination numbers, give students some insight into why ionic solids are brittle with relatively high melting points, and why different-sized ions form different types of crystal lattices. Each ion is surrounded by oppositely-charged ions, producing strong attractions, holding the ions in place.

Level

This activity is appropriate for all levels of students. Basic students probably should not complete the extensions.

Expected Student Background

Students with no previous knowledge of crystals can perform the activity. There are no prerequisite concepts other than those listed for this topic. The activity could also be used to support the topic of condensed states of matter.

Time

Students should be able to complete the activity in one 50-min. period.

Safety

No special precautions are necessary. If students work in the chemistry laboratory, they should wear protective goggles since there may be hazardous materials nearby. Advise students to follow regular laboratory safety procedures.

Materials

The following materials are needed for 24 students working in pairs.

- 432 polystyrene spheres, 2-inch
- 156 polystyrene spheres, 1-inch
- 156 polystyrene spheres, 3/4-inch
- pipestem cleaner lengths, 2 cm, or toothpicks

Advance Preparation

Have sufficient spheres available and placed either in boxes for each two-student group or readily obtainable by students. Consider preparing a set of layers for the models glued together to show students what the layers should look like.

Pre-Lab Discussion

Minimal pre-lab discussion is required. If glued-together layers are available, they could be shown to students. Directions for connecting spheres should be given and also demonstrated.

METALLIC STRUCTURE

The aim is to go beyond the idea that metals are malleable and ductile and to explore the different internal structures of various metals and relate this to their elasticity.

5 E's Lesson Components	Activity
ENGAGEMENT: meant to capture the student's attention, help them access prior knowledge. (Must include an indication of where lesson is going.)	Group lab: Compare the elasticity of different metals using 4 30 inch bars, supported at 2 ends, with ever increasing masses placed in the middle (ends must be free to move, meter stick is placed vertically behind the set up, cm the bar bends with each mass is measured)
EXPLORATION: students are given time to think, plan, and organize collected information to develop their ideas about the content.	**Design an experiment to** -see if elasticity is related to thermal or electrical conductivity -see if the "elasticity ranking" is the same when using rods of a smaller size
EXPLANATION: allow students to explain, and follow with the teacher explanation. Their understanding is clarified and modified because of reflective activities.	Graph information from the previous labs (mass vs. amount of stretch in the metal) Relate properties of metals investigated with metallic bonding Draw models of metallic bonds and explain how they are responsible for the properties
EXTENSION: gives the student the opportunity to expand and solidify their understanding of the concept, and/or apply it to a real world situation.	Use a website to compare "normal" low carbon steel to that with ductile fracture* Lab that models the fracturing process
EVALUATION: gathering of evidence that students have understood the new learning.	Students heat bobby pin, cool quickly, observe and write an explanation of outcome using the model of metallic bonding

*Use the website for the Manchester Materials Center

Extension Activity for 5E Cycle Lab on Metallic Structure

1. Utilize the following website to view low carbon steel in its “normal” state and after ductile fracturing.
http://www.umist.ac.uk/material/microscope/zefold/zeus1e.htm
Note differences in its appearance below.

2.For this activity we will take a suggestion right from the website above. “You can reproduce the ductile fracture mechanism by adding sand to clay or plasticine. Vary the amount of sand and observe how increasing the number of particles decreases the toughness and ductility. The same behaviour is seen in metals.”

Procedure: Obtain clay and sand from the side table. Notice the ductility of the clay before adding the sand. Take the mass of the clay you are using, slowly add a known mass of sand until the clay is no longer ductile. Show the teacher your product at its “endpoint,” give her the masses you used of each sample. Go around the room to see if other lab groups product looks and acts like yours.

Data & Conclusion:

1. Get the data on masses from the board. Determine the percent composition of each component for each lab group and compare these numbers.

2. Explain what this lab was good for and what may have been problematic with this lab.

Websites:

http://mse.iastate.edu/microscopy/path.html
This website gives a nice explanation of how the electron microscope works and provides a great diagram of the components of the microscope.

http://www.umist.ac.uk/material/microscope/zefold/zeus1e.htm
Manchester Materials Science Center -
Contains the "Internet Electron Microscope" –this site has great collection of micrographs. Also shows information obtained through x-ray diffraction.

http://www.ill.fr/dif/3D-crystals/index.html
Gives crystal shapes of various substances

http://members.nuri.net/joo/physics/curri-sub/crystal/lattice.html
Shows the crystal shapes for the different crystal (i.e. face centered cubic). I'd use in conjunction with website below.

http://www.chemicalelements.com/show/crystalstructure.html
Click on the element in the periodic table and the type of its crystal structure is given.

http://www.phschool.com/atschool/sci_exp_lep/physical_science/Student_Area/PS_SC7_ACT.html
Compares graphite to diamond