Title: Surfing the Web for Crystals and Polyhedra

Brief Overview:

This unit is designed to be an introductory unit for geometry. Through a variety of hands-on activities and the interactive viewing of a video, the students are introduced to polyhedra. The lesson then connects the polyhedra with the crystal structures of minerals. Students will investigate and retrieve information on polyhedra and crystal structures using the Internet. Students will create an Internet Scavenger Hunt and exchange the hunt via e-mail. The use of the Internet embellishes the curriculum allowing students to access information far beyond what is provided by available school resources.

Link to Standards:

- **Problem Solving** Students will classify polyhedra and use them to describe crystalline structures.
- **Communication** Students will express orally and in writing the geometric characteristics that distinguish one mineral's crystal system from another.
- **Reasoning** Students will demonstrate the ability to reason logically as they classify and identify geometric solids in the real world.
- **Connections** Students will use and value the relationship between polyhedra and crystalline structure of minerals thereby connecting geometry and earth science.
- **Algebra** Students will discover and express the algebraic relationship among the edges, faces, and vertices of polyhedra.
- **Geometry** Students will interpret and build models of polyhedra; they also will simulate nature with geometric models.

Grade/Level:

Grades 9-12 Geometry (interdisciplinary connection to earth science)

Duration/Length:

This activity will take 5 or 6 days. The activities may take longer than anticipated depending on class duration and student's prior knowledge.

Prerequisite Knowledge:

Students should be able to recognize and name polygons; they also should be familiar with the following geometric concepts/relationships: point, line segment, line, plane, parallel, vertex (corner), perpendicular, angle, right angle, axes, diagonal, intersection, symmetry, dimensions, and adjacent.

Objectives:

Students will:

- develop cooperative learning skills and techniques through their local group and interschool communication.
- develop global communication skills through search and retrieval via the Internet and/or World Wide Web.
- collect and organize data from resources.
- construct models of polyhedra.
- compare a polyhedron to a crystal specimen.
- describe a crystal specimen in the context of its geometric properties.
- use geometric vocabulary to describe and analyze polyhedra and crystal models.
- develop an appreciation for real-life applications of geometric models in nature.
- express their understanding in verbal and written form.

Materials/Resources/Printed Materials:

Materials for student activities:

- Toothpicks and marshmallows (open package to let them dry)
- Coffee stirrers and twist ties (can be found at the grocery store)
- Polydrons (contact your local elementary school or can be purchased from Dale Seymour or Creative Publications)
- Copy of blackline master for the Great Shapes Contest
- Scissors
- Scotch tape
- Computer with Internet access
- Mineral specimens
  - -can be obtained from Earth Science teacher
  - -also available from Ward's 1-800-962-2660
- Set of geometric models (preferably transparent)
- Blackline master of paper templates for Platonic solids (in The Platonic Solids Activity Book)
- Sets of polyhedra dice (Platonic solids)

Teacher Resources:

- The Platonic Solids Activity Book by Key Curriculum Press
- The Platonic Solids video by Key Curriculum Press
- Earth Science text (recommend latest version of Merrill & D.C. Heath)
- Mineral and Gem Society (search Internet for home page??)
  - Contact for speaker or mineral specimens
- Laser disk, Geology and Meteorology, from The Living Textbook by Optical Data
- Internet for Teachers, IDG Books Worldwide (available in most bookstores)
- On the Shoulders of Giants by Lynn Steen, National Academy Press, 1990

WWW Resources:

- http://mineral.galleries.com (outstanding reference!!)
- http://geology.wisc.edu/~jill/
  -college reference; great tables for axes and categories; movies!
- http://galaxy.einet.net/images/gems/gems-icons.html
- http://bubba.ucc.okstate.edu/jgelder/solstate.html
- http://www.xs4all.nl/"mineral/chem.html
- http://www.science.ubc.ca/~geol202/s/rockcycle.html
  -site under construction
- http://www.oro.net/brucer/sacred_geometry.html
  -geometry (2D/3D) background and connections to nature
- http://www.geom.umn.edu/docs/education/build-icos/
  -teacher's guide for building an icosahedron as a class project
- http:/www.cs.utk.edu/~plank/plank/origami/kaleido_pics/
- http:/www.cs.utk.edu/~plank/plank/orgami/mosely.txt
  -instructions for stellated dodecahedron (origami)
- http://vvv.com/m2/public_html/m2java.html
- http://zeta.cs.adfa.oz.au/Spirit/platonic-solids.html
- http://www.li.net/~george/virtual-polyhedra/platonic-info.html
  -basic information on Platonic solids
- http://galaxy.einet.net/images/gems/gems.html

Development/Procedures:

- Participate in The Great Shapes Contest

- View The Platonic Solids video using the NTTI (National Teacher Training Institute) model

- Build polyhedra choosing from a variety of materials: toothpicks and marshmallows, straws and connectors, paper templates, or polydrons. The polyhedra to be built include the five Platonic solids. Additionally, using straws and connectors, they are to build one rectangular prism (with no square faces) and one hexagonal prism. Complete the worksheet POLY 4 U LAB.

- Identify, classify, and compare the crystal structure of several crystal systems using the Crystals worksheet.

- Using the Internet with a partner or in a small group, complete the activity "I Surf Therefore I Know--An Introduction to the Internet"

- Develop an Internet scavenger hunt as group using the Internet, write a solution key for the hunt, and challenge another group to solve their hunt.

Evaluation:

1. At the end of the unit give each pair of students two crystals with the following instructions: "You have ten minutes to discuss orally with your partner the geometric properties present in these crystals. Focus on the identifiable characteristics that distinguish one polyhedron from another."

2. After ten minutes have passed have the students return to their individual seats with the following instructions: " Individually write a paragraph that discusses geometric solids found in each structure. Use appropriate terms including faces, edges, vertices, axes, angles of axes, as well as the correct names of solids. Demonstrate mathematical understanding."

Extension/Follow Up:

- Origami (unit origami for a cube, octahedron, stellated polyhedra)
- D.I.M.E. Books 1,2,3(drawing 2D to 3D and vice versa) and isometric dot paper (available from Creative Publications)
- "Geometer's Sketchpad" (software for PC and Mac by Key Curriculum)
- "Cabri" by Texas Instruments (available for computers and also on the TI-92)
- <u>Stella Octangula Activity Book</u> and video
- Chemistry connections
- Art connections
- Architecture connections
- Geometry connections (many other concepts in geometry can be taught using polyhedra as the basis)
- Research project (write a paper that relates prims and pyramids to minerals, crystals, or molecules).

Authors:

Joyce Curry
Thomas Dale High School
Chester, VA

Sandra P. Flora
Northside High School
Roanoke, VA

Adele Neuberg
George Mason High School
Falls Church, VA

PERSONAL NOTE from the developers: Our intention is to begin the year with this unit and then continually refer to polyhedra throughout the year using them as the basis for teaching many other concepts in geometry.

THE GREAT SHAPES CONTEST RULES

SUPPLIES:
Scotch tape
Scissors
Great Shapes Contest Grid Sheets

RULES:

1. Each team will be allowed 15 to 20 minutes to make as many different polyhedra as time allows. When time is called, all creation stops. Only completed polyhedra count.

2. Each team shall decide how to best assemble the polyhedra, working as a team.

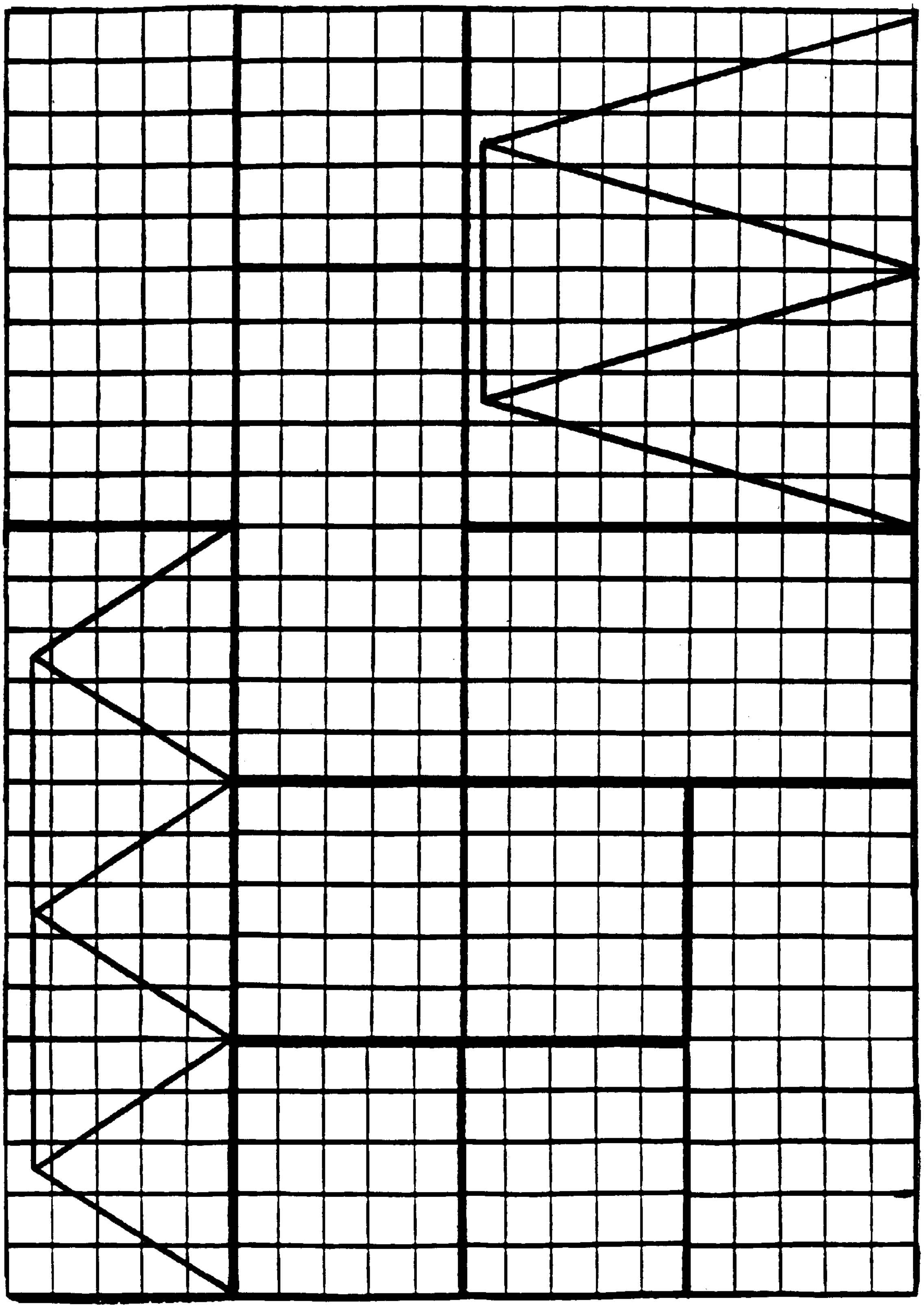
3. Each team will be given as many grid sheets as needed.

4. CONTEST: The team with the greatest number of different polyhedra earns extra credit points.

5. CONTEST: The class will vote for the most impressive polyhedron. The team that created this polyhedron will earn extra credit points.

Adapted from the NCTM Geometry and Patterns Seminar, August 8-9, 1994

THE GREAT SHAPES CONTEST



INSTRUCTIONS FOR INTERACTIVE VIEWING OF VIDEO <u>THE PLATONIC SOLIDS</u>
USING THE NTTI MODEL

Before viewing the video with the class review the following concepts: faces, angles, corners, edges, polygons. Tell the class that they are going to view <u>The Platonic Solids</u> in an interactive format. After viewing the video they will build seven polyhedra. *(Teacher's note: Polyhedra dice models available during the video will enhance understanding for students)*

(Teacher's note: The bold writing consists of commands to the teacher.)

1) **Say,** "Listen for the definition of regular polygon." **Start** the video <u>The Platonic Solids</u> at the beginning. **Pause** when the square, the pentagon and the triangle come on the screen. **Ask**, " What is a regular polygon?" (a polygon with all sides equal and all angles equal).

2) **Say,** "Listen for the characteristics of polyhedra". **Resume. Pause** when the speaker says "The cube is an example of---." **Ask,** "What are the characteristics of regular polyhedra?" (All faces are regular polygons; all faces are the same; same number of faces meet at each vertex.)

3)**Turn the volume to zero**. *(Teacher's note: three examples of solid figures that are not Platonic solids will follow. By turning the sound off the students will focus solely on the visual characteristics of each of the solids.)* **Say** "Watch the figure which follows. Why is it not a Platonic solid?". **Resume. Pause** when the first figure disappears. **Ask,** "Why is this figure not a Platonic solid?". (Some vertices are the intersection of three polygons and some are the intersection of four polygons.). *(Teacher's note: If no one gets the correct answer **replay** the segment. **Pause** when the corner with three polygons meeting appears - **pause** again when the corner with four polygons meeting appears. Repeat the question.)*

4) Say, "Watch the figure which follows. Why is it not a Platonic solid?". **Resume. Pause** when one of the faces of the polyhedron is entirely on the screen. Ask, "Why is the figure not a Platonic solid?". (The faces are not equilateral polygons). **Replay** if necessary.

5) **Say,** "Watch the figure which follows. Why is it not a Platonic solid?". **Resume. Pause** when multiple faces of the third polyhedron are on the screen. **Ask**, "Why is the figure not a Platonic solid?". (The faces are not congruent or equal.) **Replay** if necessary**.**

6) Resume. Pause when, "How many Platonic solids?" comes on the screen. Allow the students to predict.

7) Turn the volume up. **Say, "** Listen to hear if your predictions were correct." **Resume. Pause** when "Platonic Solids from Triangles?" comes on the screen. **Ask**, " How was your prediction?" Allow students to respond informally.

8) Say, "Listen for how the tetrahedron, the octahedron and icosahedron are formed and what do they have in common?". **Resume. Pause** when the video shows the six regular triangles lying flat. **Ask**, "How is the tetrahedron formed?" (Three regular triangles form a corner - a fourth regular triangle to close the figure). **Ask**, "How is the octahedron formed?" (Four regular triangles form a corner shaped like a pyramid - fit two such pyramids together). **Ask**, "How is the icosahedron formed?" (Five triangles form a corner; fit two such figures together with a band of ten triangles in between.) **Ask**, "What do the tetrahedron, the octahedron and the icosahedron have in common? (They are all constructed from regular triangles.)

9) Say, "Listen for how the cube is formed?" **Resume. Pause** when the cube goes off the screen. **Ask**, " How is the cube formed? (Three squares form a corner - join two such figures to form a cube.)

10) Say, "Listen for how the dodecahedron is formed?" **Resume. Pause** when the word dodecahedron comes on the screen. **Ask**, "How is the dodecahedron formed?" (Three pentagons meet at one vertex - four such structures come together to form the dodecahedron.)

11) Say, "Listen for applications of the Platonic solids. **Resume** when "Platonic Solids from the Real World" comes on the screen. **Stop** when duality comes on the screen. **Ask**, " Name some applications of Platonic solids." (Molecular structure, dice, architecture, art, model for the universe, microscopic organisms, crystal structure.)

(Teacher's note: Allowing students to replay portions of <u>*Platonic Solids*</u> *during construction activities may be helpful to some students.)*

POLY 4 U LAB

DEFINITIONS:

1. A polyhedron is a three-dimensional figure formed by regions shaped like polygons that share a common side.
2. A face of a polyhedron is a flat surface formed by a polygon.
3. An edge of a polyhedron is the line segment where two faces intersect.
4. A vertex of a polyhedron is the point at which three or more edges intersect
5. A polyhedron is regular if all faces are congruent regular polygons and all faces meet at each vertex in exactly the same way.

EXPECTATIONS:

1. Recall the properties of regular polyhedra discussed in the Platonic Solids Video. Using this information and the definitions above, each team will use the resources provided (toothpicks, marshmallows, coffee stirrers, twist ties, polydrons, nets) to build the 5 Platonic solids. These are the tetrahedron, the hexahedron, the octahedron, the icosahedron and the dodecahedron.
2. Each team will also build models of a rectangular prism(with no square faces), a rectangular prism (with 1 pair of square faces) and a hexagonal prism, using straws and connectors.

COMPLETE THE CHART BELOW:

Polyhedron	Polygon Name(s) of Faces	Number of Faces (f)	Number of Vertices (v)	Number of Edges (e)	Number of Faces at Each Vertex
tetrahedron					
hexahedron					
octahedron					
dodecahedron					
icosahedron					
rectangular prism (with no square faces)					
hexagonal prism					

EVALUATION:

1. What relationship exists between the polyhedron name and its number of faces?

2. Could you have 4 squares at a vertex of a polyhedron? Explain your answer.

3. Explain why the rectangular prism is not a regular polyhedron.

4. Why are there just five regular polyhedra?

5. Explain your method of determining the number of vertices for each polyhedron.

6. Do the following steps to see if you get the same number of edges for the tetrahedron.
   a. Record the number of faces (f) from above. _____
   b. Count the number of edges (e) on each face. _____
   c. Count the number of faces (F_e) that share an edge. _____
   d. Determine the number of edges using the formula, $(f)(e)/F_e$, where f, e, and F_e are determined above.
   e. Does your calculation agree with your chart data? If not, check your calculation and your chart data.

7. Now using the shortcut from above, determine the number of edges for an octahedron.

8. Do the following steps to see if you get the same number of vertices for the tetrahedron.
   a. Count the number of faces (f). ______
   b. Count the number of vertices (v) each face has. ______
   c. Count the number of faces (F_v) that meet at each vertex. ______
   d. Determine the number of vertices using the formula, $(f)(v)/F_v$, where f, e and F_v are determined above.
   e. Does your calculation agree with your chart data? If not, check your calculation and your chart data.

9. Now using the shortcut from above, determine the number of vertices for an octahedron.

10. For each of the Platonic solids, add the number of faces (f) and the number of vertices (v). Complete the chart below. Compare this sum to the number of edges (e).

Polyhedron	Sum of Faces (f) and Vertices (v)	No. of Edges (e)
tetrahedron		
hexahedron		
octahedron		
dodecahedron		
icosahedron		
rectangular prism		
hexagonal prism		

11. Describe the algebraic relationship that exists between this sum (f + v) and the number of edges (e)?

12. This relationship was discovered by one of the most famous mathematicians. He lived in the 1700's. Who was he? HINT: use textbook only if needed

13. Does this algebraic relationship exist between this sum (f + v) and the number of edges (e) for polyhedra that are not regular? Justify your answer.

14. For which of the Platonic solids is 2e exactly equal to 3v? ($2e=3v$)

15. For whom were these solid figures named? HINT: A famous Greek philosopher.

16. How many of these polyhedra are space filling? (HINT: How many "tessellate" in three dimensions?)

THE ULTIMATE CHALLENGE!
17. If each face were to be colored differently from its adjacent faces, what would be the minimum number of colors needed to color all faces of each Platonic solid?

Regular tetrahedron

Regular hexahedron

Regular Octahedron

Regular Dodecahedron

Regular Icosahedron

The algebraic relationship between r, v and e is called Euler's formula. Leonard Euler, an eighteenth century Swiss mathematician, stated that the number of faces, f, the number of vertices, v, and the number of edges, e, of a polyhedron had the relationship $f + v - e = 2$.

Adapted from Key Curriculum Press - The Platonic Solids Activity Book

POLY 4 U LAB TEACHER'S KEY

DEFINITIONS:

1. A <u>polyhedron</u> is a three-dimensional figure formed by regions shaped like polygons that share a common side.
2. A <u>face</u> of a polyhedron is a flat surface formed by a polygon.
3. An <u>edge</u> of a polyhedron is the line segment where two faces intersect.
4. A <u>vertex</u> of a polyhedron is the point at which three or more edges intersect
5. A <u>polyhedron</u> is <u>regular</u> if all faces are congruent regular polygons and all faces meet at each vertex in exactly the same way.

EXPECTATIONS:

1. Recall the properties of regular polyhedra discussed in the Platonic Solids Video. Using this information and the definitions above, each team will use the resources provided (toothpicks, marshmallows, coffee stirrers, twist ties, polydrons, nets) to build the 5 Platonic solids. These are the tetrahedron, the hexahedron, the octahedron, the icosahedron and the dodecahedron.
2. Each team will also build models of a rectangular prism(with no square faces), a rectangular prism (with 1 pair of square faces) and a hexagonal prism, using straws and connectors.

COMPLETE THE CHART BELOW:

Polyhedron	Polygon Name(s) of Faces	Number of Faces (f)	Number of Vertices (v)	Number of Edges (e)	Number of Faces at Each Vertex
tetrahedron	triangles	4	4	6	3
hexahedron	squares	6	8	12	3
octahedron	triangles	8	6	12	4
dodecahedron	pentagon	12	20	30	3
icosahedron	triangles	20	12	30	5
rectangular prism (with no square faces)	rectangle	6	8	12	3
hexagonal prism	rectangle 2 hexagons	8	12	18	3

EVALUATION:

1. What relationship exists between the polyhedron name and its number of faces?

   The *prefix describes the number of faces.*

2. Could you have 4 squares at a vertex of a polyhedron? Explain your answer.

   No*, it would be flat (2 dimensional).*

3. Explain why the rectangular prism is not a regular polyhedron.

   The *faces are not congruent.*

4. Why are there just five regular polyhedra?

   (6)(60)=360, (4)(90) = 360, (3)(120) = 360 so all are plane figures, (4)(108) = 432

5. Explain your method of determining the number of vertices for each polyhedron.

   I counted.

6. Do the following steps to see if you get the same number of edges for the tetrahedron.
   a. Record the number of faces (f) from above. __*4*___
   b. Count the number of edges (e) on each face.__*3*___
   c. Count the number of faces (F_e) that share an edge. __*2*___
   d. Determine the number of edges using the formula, $(f)(e)/F_e$, where f, e and F_e are determined above. (*4)(3)/2 = 6*
   e. Does your calculation agree with your chart data? If not, check your calculation and your chart data. *Yes*

7. Now using the shortcut from above, determine the number of edges for an octahedron. (*8)(3)/2 = 12*

8. Do the following steps to see if you get the same number of vertices for the tetrahedron.
   a. Count the number of faces (f). __*4*__
   b. Count the number of vertices (v) each face has. __*3*__
   c. Count the number of faces (F_v) that meet at each vertex. __*3*__
   d. Determine the number of vertices using the formula, $(f)(v)/F_v$, where f, e and F_v are determined above. (4)(3)/3 = 4

e. Does your calculation agree with your chart data? If not, check your calculation and your chart data. *Yes*

9. Now using the shortcut from above, determine the number of vertices for an octahedron. *(8)(3)/4 = 6*

10. For each of the Platonic solids, add the number of faces (f) and the number of vertices (v). Complete the chart below. Compare this sum to the number of edges (e).

Polyhedron	Sum of Faces (f) and Vertices (v)	No. of Edges (e)
tetrahedron	8	6
hexahedron	14	12
octahedron	14	12
dodecahedron	32	30
icosahedron	32	30
rectangular prism	14	12
hexagonal prism	20	18

11. Describe the algebraic relationship that exists between this sum (f + v) and the number of edges (e)?

    f + v - e = 2

12. This relationship was discovered by one of the most famous mathematicians. He lived in the 1700's. Who was he? HINT: use textbook only if needed. *Leonard Euler*

13. Does this algebraic relationship exist between this sum (f + v) and the number of edges (e) for polyhedra that are not regular? Justify your answer.

    Yes. This relationship will hold true for any polyhedron, even if its faces are not regular polygons.

14. For which of the Platonic solids is 2e exactly equal to 3v? (2e=3v)

It works for the tetrahedron, the hexahedron and the dodecahedron. This holds true when exactly three faces meet at each vertex. It works because three is the minimum number of faces that can meet at a vertex.

15. Who were these solid figures named after?
HINT: He was a famous Greek philosopher.

Plato

16. How many of these regular polyhedra are space filling? (HINT: How many "tessellate" in three dimensions?)

CHALLENGE FOR TEACHERS!

THE ULTIMATE CHALLENGE!

17. If each face were to be colored differently from its adjacent faces, what would be the minimum number of colors needed to color all faces of each Platonic solid?

Regular tetrahedron (4)

Regular hexahedron (3)

Regular Octahedron (2)

Regular Dodecahedron (4)

Regular Icosahedron (3)

The algebraic relationship between r, v and e is called Euler's formula. Leonard Euler, an eighteenth century Swiss mathematician, stated that the number of faces, f, the number of vertices, v, and the number of edges, e, of a polyhedron had the relationship $f + v - e = 2$.

Adapted from Key Curriculum Press - The Platonic Solids Activity Book

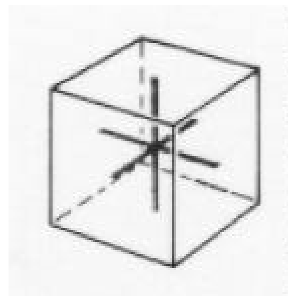
Crystals and Crystal Systems*

Background Information:
NOTE: Excellent INTERNET site reference is http://mineral.galleries.com/

A crystal is a regular solid with smooth surfaces. Crystals form in nature in almost every imaginable shape, but all crystals belong to one of six crystal systems. The crystal systems are defined by the dimensions (length, width, and height) of imaginary axes inside the crystal and the angles at which these axes meet.

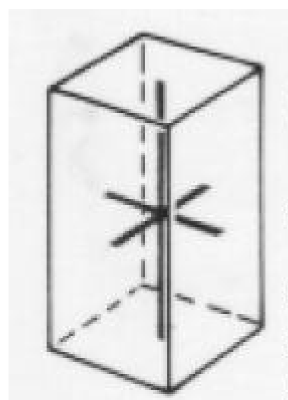
In the **CUBIC** system, the three axes are of equal length and cross each other at right angles.

Examples: Halite, Sylvite



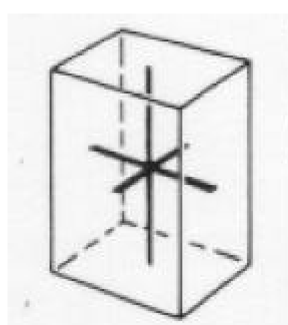
In the **TETRAGONAL** system, the length and width are equal but the height is different; it can be either longer or shorter.

Examples: Wulfenite, Chalcopyrite

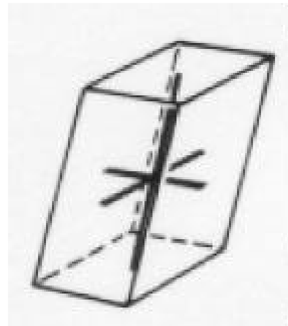


In the **ORTHORHOMBIC** system, all the axes are different in length but all cross at right angles.

Examples: Sulfur, Topaz

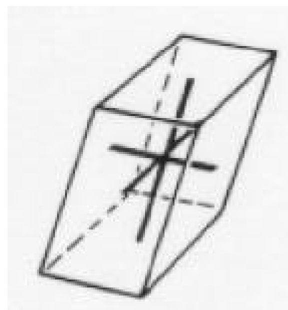


In the **MONOCLINIC** system, all three axes have different lengths. Only two are perpendicular to each other.



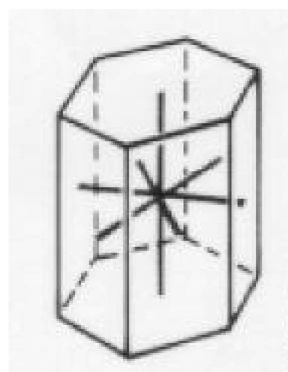
Examples: Gypsum, Borax

In the **TRICLINIC** system, all three axes are different in length with no angles equaling 90 degrees.



Examples: Turquoise, Kyanite

The **HEXAGONAL** system has four axes. Three of the axes are evenly spaced in the same horizontal plane and are the same length. The fourth axis is a different length and crosses the other three at a right angle.



Examples: Quartz, Graphite

Objectives

- identify and classify the polyhedra as crystal structures
- identify and classify some actual mineral crystals with respect to their geometric characteristics

Procedure

- As a group, discuss answers to the following worksheet.
- Each student is to complete his/her own copy.
- Refer to the polyhedra your group constructed in the previous activity.

*Adapted from worksheets by Nancy E. Spaulding, Elmira, NY & MaryBeth Maiello, Falls Church, VA

Crystals and Crystal Systems

Conclusions:

1. Look at the rectangular prism with only two square faces and note that all corners of the model meet at right angles. Position the prism so that its longest axis is vertical. How do the other two axes compare in size with each other?

2. Read the description for the tetragonal system in the introductory material on the previous page. Does the rectangular prism represent a tetragonal crystal? Explain how you know.

3. On the tetrahedron, the corners are the ends of the axes. Compare the dimensions of the axes of the tetrahedron.

4. Describe the axes for the rectangular prism with NO square faces. To what crystal system does this prism belong?

5. If the longest dimension of the hexagonal prism is vertical, how many horizontal axes does the hexagonal prism have? To what crystal system does this prism belong?

6. Using the rectangular prism with NO square faces, shift one base so that the lateral faces are no longer perpendicular to the bases. Describe the axes of this prism. To what crystal system does this prism belong?

7. Look carefully at each of the numbered mineral specimens. For each specimen, try to compare its length, width, and height as well as the angle at which these axes meet. Determine the crystal system to which each belongs. Use the table provided to summarize your observations.

MINERAL	DESCRIPTION of DIMENSIONS	AXIAL ANGLES	CRYSTAL SYSTEM
mineral #1			
mineral #2			
mineral #3			
mineral #4			

Crystals and Crystal Systems (Answer key)

Conclusions:

1. Look at the rectangular prism with only two square faces and note that all corners of the model meet at right angles. Position the prism so that its longest axis is vertical. How do the other two axes compare in size with each other? *Same length*

2. Read the description for the tetragonal system in the introductory material on the previous page. Does the rectangular prism represent a tetragonal crystal? Explain how you know.
Yes, because the length and width are the same.

3. On the tetrahedron, the corners are the ends of the axes. Compare the dimensions of the axes of the tetrahedron. *They are equal.*

4. Describe the axes for the rectangular prism with NO square faces. To what crystal system does this prism belong? *All axes are different in length. It is orthorhombic*.

5. If the longest dimension of the hexagonal prism is vertical, how many horizontal axes does the hexagonal prism have? To what crystal system does this prism belong?
3 horizontal axes, hexagonal

6. Using the rectangular prism with NO square faces, shift one base so that the lateral faces are no longer perpendicular to the bases. Describe the axes of this prism. To what crystal system does this prism belong? *Length of axes are all different and none meet at right angles.*
It is triclinic.

7. Look carefully at each of the numbered mineral specimens. For each specimen, try to compare its length, width, and height as well as the angle at which these axes meet. Determine the crystal system to which each belongs. Use the table provided to summarize your observations.

MINERAL	DESCRIPTION of DIMENSIONS	AXIAL ANGLES	CRYSTAL SYSTEM
mineral #1			
mineral #2			
mineral #3			
mineral #4			

I SURF THEREFORE I KNOW

AN INTRODUCTION TO THE INTERNET

1. Go to http://mineral.galleries.com.
2. Select physical characteristics. Select Crystal System. List the 7 crystallographic systems.

3. Select by Class. Select Halides Class. Select Fluorite.

4. Determine its Crystal System and Crystal Habit.

5. Scroll to octahedron and select it. Compare the octahedron shape to a pyramid.

   How are opposite faces of the octahedron related?

6. Select By Name and then select G and locate Galena. Determine its Crystal System and Crystal Habit.

   The structure of galena is identical to the structure of what other mineral?

   Using your present understanding of the cube, compare its faces.

   What angle is formed by any two adjacent edges?

7. Select H and locate Halite. Describe its Crystal System and Crystal Habits.

Obtain a crystal specimen of Calcite. Compare the angles formed by the two crystals.

Guess the crystal system to which Calcite belongs. Check your conclusion on the Internet.

8. Select C and locate Chalcopyrite. Describe its Crystal System and Crystal Habits.

9. Select Q and locate Quartz. Describe its Crystal System and Crystal Habits.

10. Select T and locate Topaz. Describe its Crystal System and Crystal Habits.

11. Select K and locate Kyanite. Describe its Crystal System and Crystal Habits.

    What is the unique characteristic of Kyanite?

12. Locate Gypsum. Describe its Crystal System and Crystal Habits.
    Sketch the specimen of gypsum shown on the Internet. Write a paragraph comparing your specimen to the picture on the Internet.

13. Access the Smithsonian Gem & Mineral Collection using http://galaxy.einet.net/images/gems/gems.html. Then locate a mineral of your choice and draw a colored sketch of the mineral. Write a brief description of the mineral.

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TEACHER'S NOTE:
Sometimes minerals are found divided into seven crystal systems, rather than six. If seven crystal systems are used, their names are isometric(cubic), tetragonal, hexagonal, trigonal, orthorhombic, monoclinic, and triclinics. If six crystal systems are used, their names are cubic, tetragonal, orthorhombic, monoclinic, triclinic and hexagonal. In this case, the trigonal system is considered a division of the hexagonal.

THE TEACHER SHOULD VERIFY THE EXISTENCE OF THE SITE(S) PRIOR TO HAVING STUDENTS ACCESS THEM.

1. Go to http://mineral.galleries.com.

2. Select physical characteristics. Select Crystal System. List the 7 crystallographic systems. (isometric, tetragonal, hexagonal, trigonal, orthorhombic, monoclinic, triclinic)

3. Select by Class. Select Halides Class. Select Fluorite.

4. Determine its Crystal System and Crystal Habit. (Isometric, cube, octahedron) (relates to the octahedron, a Platonic solid name)

5. Scroll to octahedron and select it. Compare the octahedron shape to a pyramid. (2 four sided pyramids with bases attached)

   How are opposite faces of the octahedron related? (they are parallel)

6. Select By Name and then select G and locate Galena. Determine its Crystal System and Crystal Habit. (Isometric, often forms cubes)

   The structure of galena is identical to the structure of what other mineral? (Halite)

   Using your present understanding of the cube, compare its faces. (all faces are squares)

   What angle is formed by any two adjacent edges? (all are right angles)

7. Select H and locate Halite. Describe its Crystal System and Crystal Habits. (Isometric, cubes)

   Obtain a crystal specimen of Calcite. Compare the angles formed by the two crystals. (a Calcite crystal does not form right angles like a Halite crystal) Guess the crystal system to which Calcite belongs. (trigonal) Check your conclusion on the Internet.

8. Select C and locate Chalcopyrite. Describe its Crystal System and Crystal Habits. (Tetragonal, tetrahedron) (a good crystal may be hard to find)

9. Select Q and locate Quartz. Describe its Crystal System and Crystal Habits. (Trigonal, hexagonal prisms terminated with a six sided pyramid)

10. Select T and locate Topaz. Describe its Crystal System and Crystal Habits. (Orthorhombic, prismatic crystal with 2 different prisms that produce a rounded or sharp diamond-shaped cross-section) (may be difficult to locate as a crystal)

11. Select K and locate Kyanite. Describe its Crystal System and Crystal Habits. (Triclinic, flat, pinacoid dominated, prismatic crystals) (may be difficult to locate a crystal)

    What is the unique characteristic of Kyanite? (a wide variation in hardness, within the same crystal)

12. Locate Gypsum. Describe its Crystal System and Crystal Habits. (Monoclinic, tabular, bladed or blocky crystals with a slanted parallelogram outline) (may be difficult to locate as a crystal so use a specimen that is not a crystal)
    *** This would be a good mineral to show students in a non-crystalline form to stress that minerals do not always form crystals.

    Sketch the specimen of gypsum shown on the Internet. Write a paragraph comparing your specimen to the picture on the Internet.

13. Access the Smithsonian Gem & Mineral Collection using http://galaxy.einet.net/images/gems/gems.html. Then locate a mineral of your choice and draw a colored sketch of the mineral. Write a brief description of the mineral.

VIRTUAL SCAVENGER HUNT

Suggested Guidelines for Developing a Virtual Scavenger Hunt:

- Students work with a partner.
- Students need to visit a minimum of five (5) sites.
- Students need to visit several levels within a site.
- Students will develop at least ten (10) questions
  - Six of the questions may be short answer/completion
  - Four of the questions must be application/analysis (e.g.,questions utilizing higher-order thinking skills)
- Students are to submit questions on one page with questions and answers on separate page. Answers must include the http address.
- Students will exchange questions either within their class or with another class and attempt to answer all questions.
- Students will e-mail questions to another class. The response is to be e-mailed in return. (NOTE: Teachers are advised that students should have their own e-mail to accomplish this task.)
- Assessment will be done with a rubric designed by the teacher.

RESEARCH PROJECT*

Write a paper that relates prisms and pyramids to minerals, crystals, or molecules.

Some suggested topics:

Minerals are formed by the grouping of atoms. The way in which the atoms are arranged can broken down into a unit cell. In 1850, M.A. Bravais theoretically outlined the rules for the arrangement of the atoms into a crystalline solid. Fourteen types of unit cells form space lattices, or Bracais lattices. These lattices have geometric names.

Although the molecular structure of a mineral has only one geometric shape when found in nature, the mineral may appear in other forms. For example, Boleite, which has a tetragonal molecular structure, may appear physically as a cube or an octahedron. Several other minerals exhibit this characteristic.

*Adapted from Geometry, An Integrated Approach by Larson et al. (D.C. Heath & Co)