Shapes, Angles and More

An Integrated Unit of Study
Geometry
Grades 3-6

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Unit Introduction

Grade Level: 3 - 6

The purpose of this unit is to provide a variety of information and materials for teachers to use along with their teaching of geometry to students in the primary and middle grades. The activities can be modified to work with any grade level.

A series of PowerPoint presentations are included for use in different ways. Students have created several of the presentations as part of their final project for the geometry unit. They have been included as samples of what your students can do.

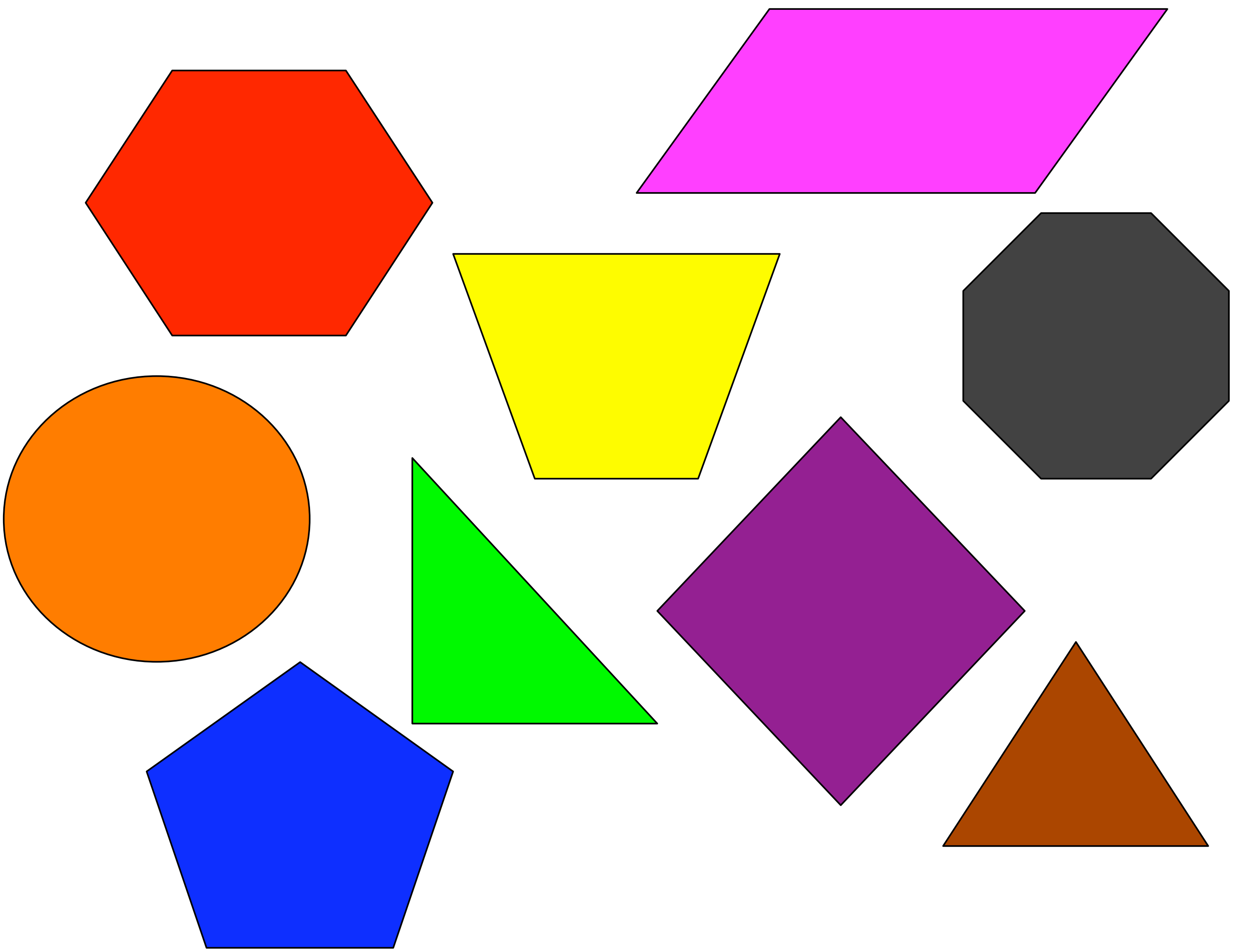


Table of Contents

Standards & Key Learnings

NCTM STANDARD 12. GEOMETRY

1. Identify, describe, compare, and classify geometric figures
2. Visualize and represent geometric figures with special attention to developing spatial sense
3. Explore transformations of geometric figures
4. Represent and solve problems using geometric models
5. Understand and apply geometric properties and relationships
6. Develop an appreciation of geometry as a means of describing the physical world

NORTH AMERICAN DIVISION OF SEVENTH-DAY ADVENTISTS
KEY LEARNINGS – GEOMETRY

5th

- Learn the relationship between radius and diameter
- Classify angles according to the measure
- Identify and select appropriate units to measure angles (degrees)
- Understand and use linear, square and cubic units
- Count faces, vertices and edges
- Create perspective drawings
- Describe ray, segment, interior and exterior of an angle
- Recognize and create patterns with tessellations

6th

- Define and use appropriate geometrical vocabulary
- Use strategies to develop formulas for determining perimeter and area of triangles, rectangles and parallelograms and volume of rectangular prisms
- Find the area of parallelograms and triangles
- Find the circumference and area of circles
- Find the volume and surface area of prisms

Key Learnings – Geometry 6th grade continued

- Classify triangles according to the angles and sides
- Understand parallel, intersecting, and perpendicular lines
- Measure an angle using a protractor
- Draw similar figures that model proportional relations
- Explore fractal patterns
- Do geometric construction, e.g. bisect a segment

Inventory Test

(adapted from http://www.harcourtschool.com/menu/resources.html)

Student Name ______________________________ Date____________________

The Grade 6 Inventory Test assesses Grade 5 content. Lesson numbers and Learning Goals are provided for your reference.

Date Mastered	Item #	Lesson #	Goal #	Learning Goal
	1	1.1	1A	To identify place value, and to read and identify whole numbers to billions
	2	2.3	2C	To compare and order decimals to thousandths
	3	3.4	3D	To add and subtract whole numbers and decimals
	4	3.5	3D	To add and subtract whole numbers and decimals
	5	4.3	4B	To write and solve addition and subtraction equations
	6	5.3	5B	To interpret data using range, mean, median, and mode
	7	6.6	6A	To choose appropriate scales, intervals, and graphs
	8	6.3	6B	To display, read, interpret, and analyze data in tables and graphs
	9	8.3	8A	To write estimates and products for decimal factors, including amounts of money
	10	9.5	9B	To solve problems by using an appropriate problem-solving skill such as *interpret the remainder*
	11	10.2	10B	To write estimates and quotients for division of multidigit whole numbers by 2-digit divisors
	12	10.3	10B	To write estimates and quotients for division of multidigit whole numbers by 2-digit divisors
	13	10.6	10C	To solve problems by using an appropriate problem-solving strategy such as *predict and test*
	14	11.3	11B	To write quotients for decimals divided by 1- and 2-digit whole numbers
	15	11.4	11D	To solve problems by using an appropriate problem solving skill such as *choose the operation*
	16	12.4	12C	To use a table and an equation to represent functions
	17	12.6	12E	To write and solve multiplication equations by using mental math and multiplication properties
	18	13.2	13A	To determine divisibility, and to find the least common multiple and the greatest common factor of a set of whole numbers
	19	14.1	14A	To identify exponents, and to write and evaluate expressions using exponents
	20	15.2	15A	To write equivalent fractions, including fractions in simplest form

Student Name ______________________________

Inventory Test (continued)

Date Mastered	Item #	Lesson #	Goal #	Learning Goal
	21	15.3	15B	To write a value using a mixed number
	22	16.5	16C	To write sums and differences of unlike fractions
	23	18.1	18A	To write products of whole numbers and fractions
	24	18.3	18C	To write products of fractions and mixed numbers and mixed numbers and mixed numbers
	25	19.3	19A	To write quotients of fractions divided by fractions and whole numbers or mixed numbers divided by fractions
	26	20.5	20C	To identify congruent and similar figures and identify lines of symmetry
	27	21.5	21C	To identify and draw solid figures from different views
	28	22.3	22C	To add and subtract with positive and negative integers
	29	23.3	23C	To graph figures on a coordinate plane and to perform transformations on figures
	30	24.4	24C	To change or select appropriate units of capacity and weight, within customary or metric units
	31	25.4	25B	To use the appropriate formula to find the circumference of a circle
	32	26.3	26C	To relate perimeter and area
	33	27.2	27B	To find the surface area of a rectangular prism
	34	27.3	27C	To use the appropriate formula to find the volume of a rectangular prism
	35	28.2	28A	To use a ratio to represent the relationship between two quantities and express it in three ways
	36	28.3	28B	To identify and write equivalent ratios and proportions
	37	29.2	29A	To express percent as part of one hundred, and to write the equivalent decimal and fraction for a percent
	38	29.3	29A	To express percent as part of one hundred, and to write the equivalent decimal and fraction for a percent
	39	30.2	30A	To make predictions of probability experiments and to express probabilities as fractions
	40	30.4	30C	To organize and show possible choices

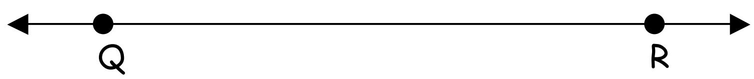
Vocabulary

The world is made of many things. Some can be touched, counted, or seen. There are other things that exist only in the imagination, but these imaginary things can be very powerful tools! You can see geometry everywhere around you, in manmade structures, in nature, in sports, in manufacturing, and in art. In geometry there are only four imaginary items—simple ideas—upon which everything else is built: point, line, plane, and space.

The most important thing to remember about a point is that it has absolutely no dimensions—no length, no width, no depth. It is simply a location. We use a dot, like point S shown here, to symbolize a point, but a dot is not a true point because any written or printed dot, no matter how small, has dimensions.

.S

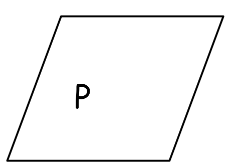
A line is a set of points that has only one dimension, length. Think of multitudes of points lying on a single path. Points on the same line are called "collinear points." Two points are needed to define a line.



Notice how to write the symbol for this line. The arrowheads on line QR show us that the line extends endlessly in both directions—it has no endpoints. When two lines meet at a point, they are called "intersecting lines."

$$\overleftrightarrow{QR}$$

The set of points called a plane lies all on one surface. In algebra, you've already used the coordinate plane for plotting points, so you're familiar with at least one example of a plane. The surface of a table is another example of a plane—but a plane actually extends endlessly.



Also, remember that the surface of a plane has no thickness. At least three points not on the same line are needed to define a plane.

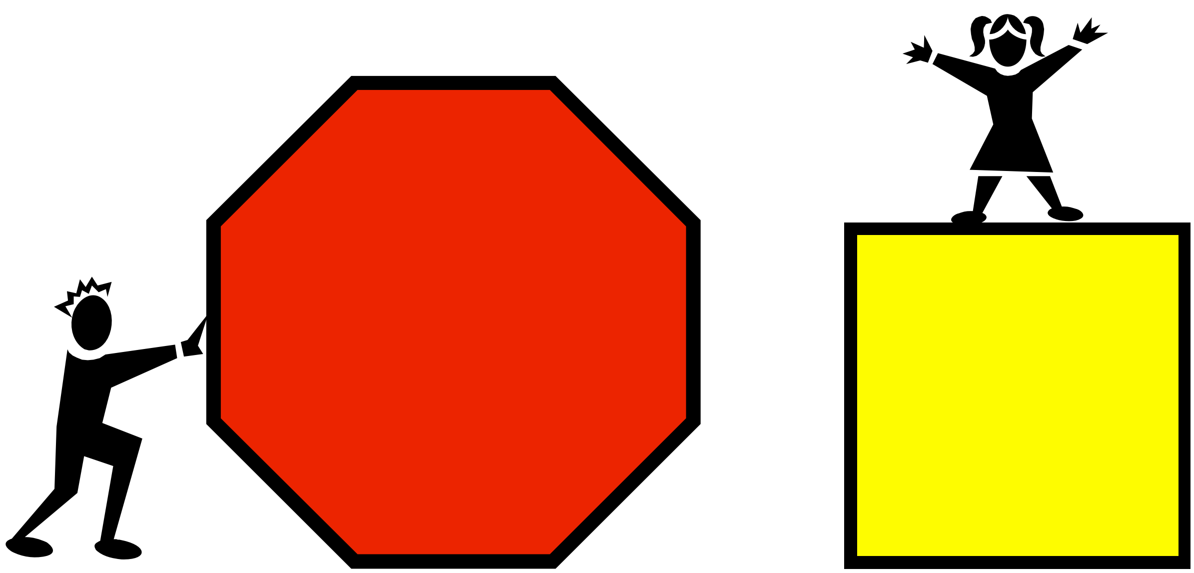
Finally, there is space, the set of all points. It's difficult to illustrate the idea of space, since it's everywhere! You can think of it as an open, empty room, or the inside of an empty box. Space has no boundaries and extends endlessly in all directions.

Of course, these four terms are just the beginning. You'll encounter many more words and their meanings as you work through this geometry course. Before you move on, here are more basic terms to become familiar with. You'll be seeing them often.

- **Acute angle** -- an angle measuring between zero and 90 degrees
- **Acute triangle** -- a triangle with three acute angles
- **Alternate exterior angles** -- congruent angles formed by two parallel lines cut by a transversal; located on opposite sides of the transversal outside the parallel lines
- **Alternate interior angles** -- congruent angles formed by two parallel lines cut by a transversal; located on opposite sides of the transversal between the parallel lines
- **Altitude** -- the height of a 2-D or 3-D geometric figure measured perpendicularly from the center of the top face or point to the center of the base
- **Base** -- the top and bottom parallel polygonal faces
- **Center** -- the point in the middle of the circle or sphere
- **Circle** -- a 2-D figure; the set of all points at a given distance from the center
- **Circular** -- a cone or cylinder with circles for base(s)
- **Circumference** -- the perimeter of a circle
- **Closed curve** -- a curve that can be traced without lifting the pencil, has the same starting/stopping points and may cross itself (creates an inside and outside of the curve)
- **Complementary angles** -- two or more angles that sum to 90 degrees
- **Concave** -- a line segment connecting two points of the interior can go outside the polygon; at least one of the interior angles is greater than 180 degrees
- **Cone** -- a 3-D figure with a circular or non-circular base and rounding sides rising to a point
- **Congruent** -- of the same size and shape
- **Convex polygon** -- a line segment connecting any two points of the interior does not go outside the polygon; none of the interior angles is greater than 180 degrees
- **Corresponding angles** -- congruent angles formed by two parallel lines cut by a transversal; positioned on matching "corners" of intersections

- **Cylinder** -- a 3-D figure with circular or non-circular parallel congruent bases and curving sides
- **Diagonal** -- a line segment connecting two non-adjacent vertices of a polygon
- **Equiangular triangle** -- a triangle with three congruent angles
- **Equilateral triangle** -- a triangle with three congruent sides
- **Isosceles trapezoid** -- a trapezoid with two congruent legs
- **Isosceles triangle** -- a triangle with two congruent legs
- **Kite** -- a quadrilateral with two pair of adjacent congruent sides
- **Lateral faces** -- the polygon shapes making up the sides of a polyhedron
- **Non-circular** -- a cone or cylinder with base(s) that are not circles but ovals or other curvy shapes
- **Oblique** -- a 3-D geometric figure with an altitude not perpendicular to the base
- **Obtuse angle** -- an angle measuring between 90 and 180 degrees
- **Obtuse triangle** -- a triangle with one obtuse angle
- **Parallel lines** -- lines that never intersect in a plane
- **Parallelogram** -- a quadrilateral with two pair of parallel sides
- **Perimeter** -- the distance around a 2-D figure
- **Perpendicular** -- meeting at a 90 degree angle
- **Polygon** -- a simple closed two-dimensional shape made of line segments
- **Polyhedron** -- a 3-D figure with faces made of polygons
- **Prism** -- a 3-D figure with parallel congruent polygon bases and sides made of parallelograms
- **Pyramid** -- a 3-D figure with a polygon for a base and triangular faces meeting at a point at the top
- **Pythagorean Theorem** -- the sum of the squares of the legs of a right triangle equals the square of the hypotenuse; $a^2 + b^2 = c^2$ where c is always the hypotenuse side
- **Radius** -- the distance from the center to the circle
- **Rectangle** -- a parallelogram with a right angle
- **Regular** -- 2-D or 3-D figure having all congruent sides and all congruent angles
- **Rhombus** -- a quadrilateral with four congruent sides
- **Right angle** -- an angle measuring exactly 90 degrees
- **Right triangle** -- a triangle with one right angle

- **Right** -- a 3-D geometric figure with an altitude perpendicular to the base(s)
- **Scalene triangle** -- a triangle with three sides of different lengths
- **Skew lines** -- lines that are not parallel and do not intersect in space
- **Simple curve** -- a closed curve that does not cross itself
- **Sphere** -- a 3-D figure; the set of all points at a given distance from the center
- **Square** -- a quadrilateral with all congruent sides and all congruent angles
- **Straight angle** -- measuring exactly 180 degrees; makes a straight line
- **Supplementary angles** -- two or more angles that sum to 180 degrees
- **Surface** -- a 3-D geometric figure with polygons or curves for the sides and bases
- **Transversal** -- a line that crosses a pair of parallel lines
- **Trapezoid** -- a quadrilateral with one pair of parallel sides
- **Vertical angles** -- congruent opposite angles formed by two intersecting lines



History of Geometry

Egyptians
c. 2000 - 500 B.C.

Ancient Egyptians demonstrated a practical knowledge of geometry through surveying and construction projects. The Nile River overflowed its banks every year, and the river banks would have to be re-surveyed.

Babylonians
c. 2000 - 500 B.C.

Ancient clay tablets reveal that the Babylonians knew the Pythagorean relationships. One clay tablet reads

"4 is the length and 5 the diagonal. What is the breadth? Its size is not known. 4 times 4 is 16. 5 times 5 is 25. You take 16 from 25 and there remains 9. What times what shall I take in order to get 9? 3 times 3 is 9. 3 is the breadth"

Greeks
c. 750-250 B.C.

Ancient Greeks practiced centuries of experimental geometry as Egypt and Babylonia had, and they absorbed the experimental geometry of both of those cultures. Then they created the first formal mathematics of any kind by organizing geometry with rules of logic. Euclid's (400 B.C.) important geometry book *The Elements* formed the basis for most of the geometry studied in schools ever since.

The Fifth Postulate Controversy
c. 400 B.C. – 1800 A. D.

There are two main types of mathematical (including geometric) rules: *postulates* (also called axioms), and *theorems*. *Postulates* are basic assumptions - rules that seem to be obvious and are therefore accepted without proof. *Theorems* are rules that must be proved.

Euclid gave five postulates. The fifth postulate reads: Given a line and a point not on the line, it is possible to draw exactly one line through the given point parallel to the line.

Euclid was not satisfied with accepting the fifth postulate (also known as the parallel postulate) without proof. Many mathematicians throughout the next centuries unsuccessfully attempted to prove Euclid's Fifth.

The Search for pi
??? B.C. - present

It seems to have been known from the most ancient of times that the ratio of the circumference and diameter of a circle is a constant, but what is that constant? A search for a better answer to that question has intrigued mathematicians throughout history.

Coordinate Geometry
c. 1600 A.D.

Descartes made one of the greatest advances in geometry by connecting algebra and geometry. A myth is that he was watching a fly on the ceiling when he conceived of locating points on a plane with a pair of numbers. (Maybe this has something to do with the fact that he stayed in bed every day until 11:00 A.M.) Fermat also discovered coordinate geometry, but it's Descartes' version that we use today.

Non-Euclidean Geometries
c. early 1800's

Since mathematicians couldn't prove the 5th postulate, they devised new geometries with "strange" notions of parallelism. (A geometry with no parallel lines?!?) Bolyai and Lobachevsky are credited with devising the first non-euclidean geometries.

Differential Geometry
c. late 1800's-1900's

Differential geometry combines geometry with the techniques of calculus to provide a method for studying geometry on curved surfaces. Gauss and Riemann (his student) laid the foundation of this field. Einstein credits Gauss with formulating the mathematical fundamentals of the theory of relativity.

Fractal Geometry
c. late 1800's-1900's

Fractals are geometric figures that model many natural structures like ferns or clouds. The invention of computers has greatly aided the study of fractals since many calculations are required. Mandlebrot is one of the researchers of fractal geometry.

Points, Lines, and Planes

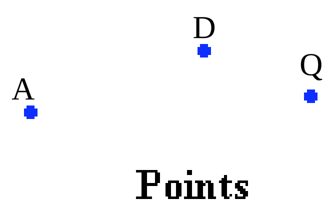
The most basic geometric form is a point. It is represented as a dot with a capital letter from the alphabet - which is its name.

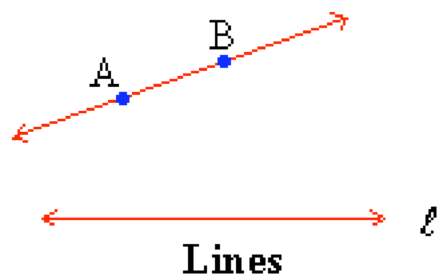
A line is a set of points extending in opposite directions up to infinity. It is represented by two points on the line and a double- headed arrow or a by a single letter in the lower case.

A plane is a two dimensional (flat) surface that extends in all directions up to infinity.

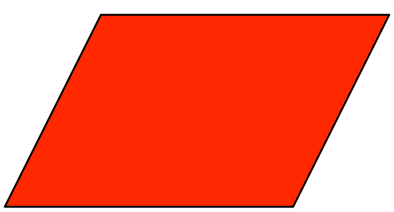
A plane has obviously no size and definitely no shape. However it is represented as a quadrangle and by a single capital letter

Look at the diagram below. It shows points A, D & Q, line AB, line l and plane P.





P

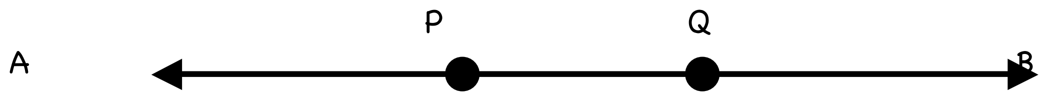


Some facts about points, lines and planes.

1. An infinite number of lines can be drawn through any given point.
2. One and only one line can be drawn through two distinct points.
3. When two lines intersect they do so at only one point.

Line Segments

A line segment is a part of a line. It has a fixed length and two end points. They are used to name the line segment.



Segment PQ is a segment of line AB. A line contains infinite segments, and if two segments on a line have a common end point, they can be added. Every segment has one and only one midpoint.

Segment PQ and segment QR are two segments on line l and they have a common end point Q. Therefore segment PQ + segment QR = segment PR.

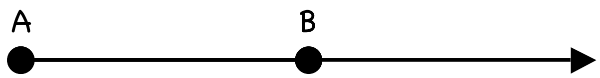
Are the following statements true or false?

1. Any number of lines can pass through a single given point.
2. If two points lie in a plane the line joining them also lies in the same plane.
3. Any number of lines can pass through two given points.
4. Two lines can intersect in more than one point.
5. Two planes intersect to give two lines.
6. If two lines intersect, only one plane contains both the lines.
7. A line segment has two end points and therefore a fixed length.

Answers
1. True
2. True
3. False (One and only one line passes through two given points.)
4. False (Two lines can intersect in only one point.)
5. False (Two planes intersect to give one line.)
6. True
7. True

Rays and Angles

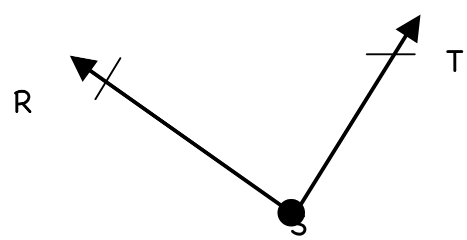
A *ray* has one end point and extends in the other direction "forever." It is represented by naming the end point and any other point on the ray with the symbol:



$\overrightarrow{AB}$

A is the end point of a ray and B is a point on it. This ray is represented as $\overrightarrow{AB}$. A ray can extend only in one direction.

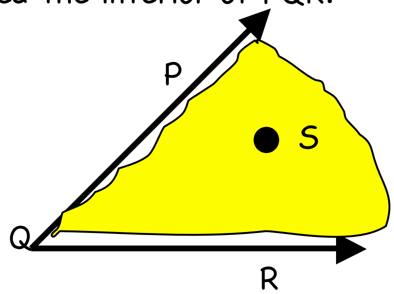
Two rays going in different directions but having a common end point form an *angle*. The common end point is called the *vertex* of the angle, and the rays are called its *sides* or *arms*. An angle is represented by the symbol ∠ and named S, using either both the rays or just the vertex.



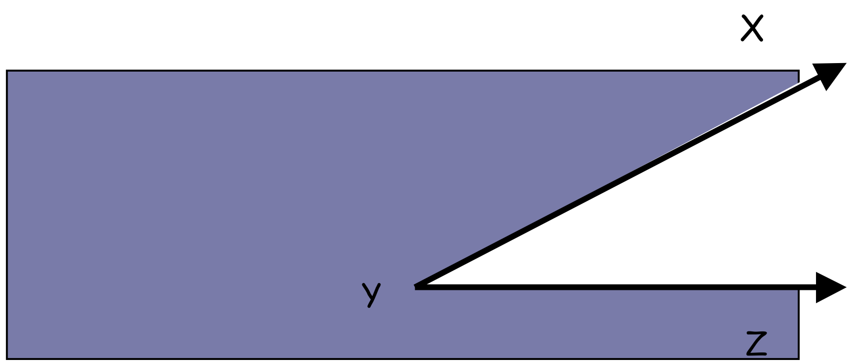
∠RST or ∠S

Interior and Exterior of an Angle

The interior of ∠PQR is the shaded region in the example below. S is a point in the interior of ∠Q because it lies on the R- side of ray PQ and the P - side of ray QR. The set of all such points is called the interior of PQR.



The shaded region below shows the exterior of ∠XYZ. The exterior of an angle is defined as the set of points in the plane of a given angle which are neither on the sides of the angle nor in its interior.



Measuring Circles

Materials:

- Sir Cumference and the First Round Table by Cindy Neushwander
- Various round objects (cup, plate, tin, bowl, roll of tape, small
- tire, lamp shade, film container, CD) – placed in stations around the room. Place 2-3 items at each station.
- Bag for each group containing: string, ruler, scissors
- Recording sheet (needs to be created by the teacher, or students can create in their notebooks)
- Pencils

Vocabulary:

- *Circumference* - The length around a circle.
- *Diameter* - A straight-line segment passing through the center of a circle.
- *Radius* - A line segment that joins the center of a circle with any point on its circumference.

Procedure:

Before: Ask students what they know about finding the area and perimeter of squares. Let students know that today they will be learning about measurements associated with circles. Read Sir Cumference and the First Round Table .

Summary of Story: This story is about King Arthur and his knights. The knights gather around a table to discuss the fact that the neighbors are threatening to make war, but there is a problem with the table. Sir Cumference and Geo the carpenter build tables of different shapes, but each table causes a different problem with the knights. Eventually Sir Cumference, with his wife Lady Di of Ameter and his son Radius, find the perfect table -- a round table.

After reading the story, ask the class for definitions of radius, circumference, and diameter. Write the definitions on the board. Explain how to find the circumference, diameter, and radius of a circle (show how a piece of string can be used to find circumference).

Inform the class that they will have a chance to measure some circular objects in terms of circumference, diameter, and radius. Students will be working in small groups. Remind students that when they are working in groups, each person should receive a job, and everyone should cooperate. When working in small groups, students will be able to talk quietly and still hear each other. For the activity, students will need a recorder, someone to get the supplies, and someone to measure. Each supply bag will contain a piece of string, a ruler, scissors, and a list of stations (each bag has a different order of stations). Remind students that the scissors are only for cutting the string; if they are used in any other way the group will lose the use of them.

During: Each station has 2-3 different circular objects that can be found around the house (examples: lampshade, plate, clock, film container, small tire, and a CD). The students will be moving around the room to the various stations, measuring and recording diameter, circumference, and radius. The students will take turns recording and measuring. Students will have 5 minutes at each station. Circulate around the room to make sure that all students are participating. Note if students are working together or if any of the students seem to be having trouble.

Note: The recording sheet could contain the names of different objects and/or the stations. It also could contain columns to record the measurements of the circumference, radius and diameter of the objects. The recording sheet can either be teacher-created, or the students can create it in their notebooks.

After: After the groups have been to all of the stations, have them return to their seats. Ask students to share their results for each object. Have the groups explain any problems they encountered. Ask if anyone used a different method than what was shown on the board for finding the circumference, diameter, and radius. Ask if anyone can think of any reason we may need to know the circumference, diameter, and/or the radius of a circle. Explain that we may need to know the diameter of a clock to see if it will fit in a spot on the wall. We may need to know the circumference of a candle to see if it can fit in a candleholder. We also may need to know the size of a round table to be able to find a tablecloth that will fit the table.

Assignment: When students go home, they should look around their house and find an object in the shape of a circle. They should find the radius, diameter, and circumference of that object. Students can share their results during the next class.

Assessment: Collect students' recording sheets to see if students understand the difference between circumference, diameter, and radius. Optional: Have students write an entry in their journals, sharing what they learned today.

Adapted from *Educator's Reference Desk Lesson Plans*

Planning a School Garden

Description: In this activity, students will use their understanding of perimeter and area to plan a school garden. Students must follow the requirements provided by the school principal.

Objectives:

- Students will be able to calculate the perimeter and area of a rectangular space.
- Students will be able to research flowers and plants suitable for the given environment.
- Students will be able to write a letter to the principal explaining their plans for the school garden.

Materials:

- encyclopedias or Internet availability for researching flowers and plants
- paper
- pencils
- *Sample Principal Letter*
- *Garden Worksheet*

Vocabulary:

- *Perimeter* - The distance around a figure (P=L+L+W+W).
- *Area* - The number of square units needed to cover the surface of a figure (A=L*W).

Procedure:

Near the end of a unit about perimeter and area, present a poster-size letter written by the school principal. (This can be word processed and made into a poster by a poster machine - or the letter can be made into an overhead transparency.) In the letter, the principal asks students to plan a flower garden for the school. The letter lists the requirements for the garden. Students are to use these requirements to develop a plan for the garden (measurements and a diagram).

The flower garden activity has three main parts. First, students need to determine the measurements of the garden (focusing on perimeter and area). Second, students need to research the types of plants that would be suitable for the garden. Lastly, students need to write a letter to the principal explaining their mathematical measurements and reasoning, along with the names of the flowers and plants to be used in the garden.

Encourage students to develop their plans on scrap paper, so the teacher can assess their work before the final copy is recorded on a worksheet (see **Materials**). Students may use books, encyclopedias, and/or the Internet to research plants that would be suitable for the garden. When students' plans have met with the teacher's approval, then students can complete the Garden Worksheet. Students will show their mathematical understanding of area and perimeter, and they will construct a drawing showing where the flowers and plants will be located. Once students have completed the Garden Worksheet, they can begin writing a letter to the principal explaining their plan for the garden.

Note: Once all papers have been graded and assessed, the class can vote on the best garden and letter. As an extension, students could be given a similar problem to solve, such as determining the dimensions of a basketball court. Similar problems could be set up as a learning center in the classroom.

Assessment: Review the worksheets and letters to the principal to assess students' understanding of the concepts of area and perimeter. Did students select appropriate flowers and plants for the garden? Did students provide a clear explanation of their mathematical reasoning in their letters to the principal?

SAMPLE LETTER FROM THE PRINCIPAL

Your School Name
Your School Address

Date

Dear 4th graders,
I am assigning the 4th grade a special project. I would like you to design a flower garden in the front of the school. There are some requirements that I would like you to follow. I would like the garden to be a rectangular shape with a perimeter of 48 feet. I want it to be 8 feet long. A fence must be put around it to protect it from being walked on. The fence posts should be placed every 4 feet. Finally, a tarp needs to be purchased to protect it in the winter. In this garden you may plant the flowers and plants of your choice.

Before you begin working outside you must submit a plan that includes a diagram of the garden with all the measurements stated above.

Happy planning!

Principal's Signature
Principal's Name

______________________ Garden

By: ________________________

Perimeter=

Area=

Number of posts=

Explanation:

Drawing

Adapted from Educator's Reference Desk Lesson Plans

Polygons

Objectives: Students will be able to:

- 1) identify a polygon, perpendicular lines, and parallel lines
- 2) become familiar with geoboards

Materials:

- geoboards
- rubber bands
- dot paper (http://mathforum.org/trscavo/geoboards/contents.html)
- teacher-made worksheet

Procedure:

1. Ask the students if they know what geometry is. Take answers from all students. Ask why it is important for us to learn about shapes. Then ask if students know what a *geoboard* is. Introduce the geoboard to the class and demonstrate how to use one.

2. Take five minutes for students to make shapes with their geoboards. This is important, because it gives students a chance to play with the geoboard (not during your instruction.

3. Hand out dot paper to the students.

4. Inform them that they are going to go outside and discover geometry. Ask the students to use their dot paper to draw geometric shapes they see outside. Take about 5 to 10 minutes outside for everybody to draw two shapes that they see outside.

5. Back in the classroom, have students transfer their shapes from their dot paper to their geoboards. This is really good to help younger children with hand-eye-coordination.

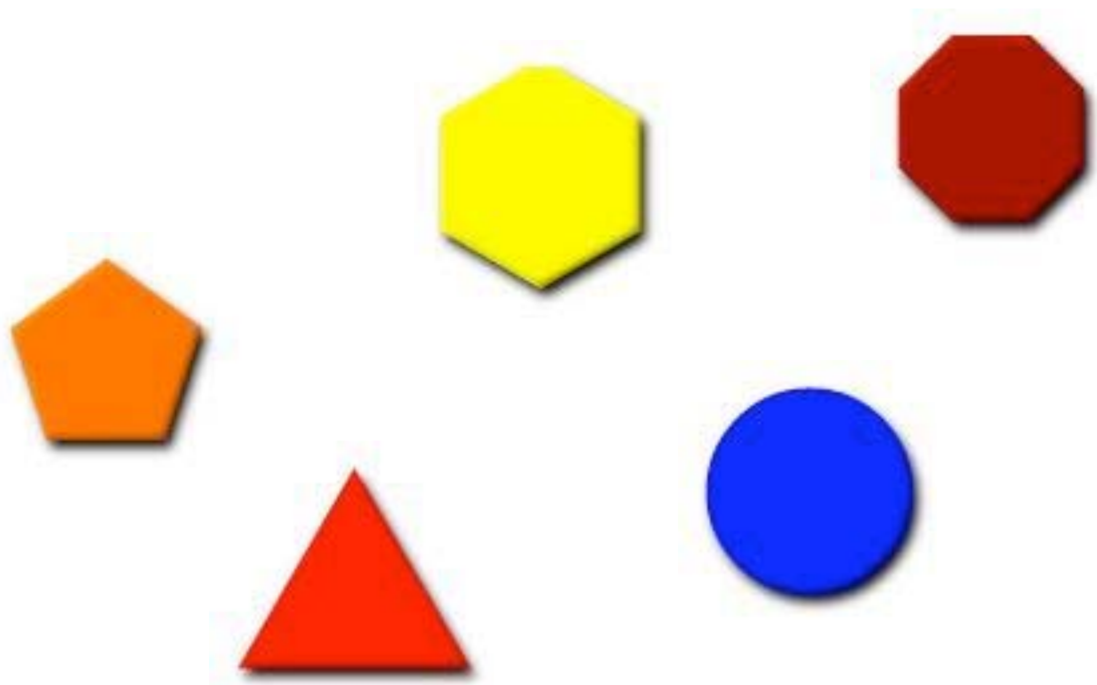
6. Circulate around the classroom. Without making it obvious, have students with a geoboard with a polygon on it put their geoboard up front on the left and have all students with shapes that are irregular polygons put their geoboards on the right. See if the students can figure out why some are on the left and some are on the right. This may take them several minutes. Once you get the right answer, discuss what a polygon is and go over its properties *(a figure with usually more than five sides.)*

7. Divide the geoboards up again, this time have parallel lines on the right and no parallel lines on the left. Have students try to figure out how they are divided. Do this same procedure for perpendicular lines.

8. Once the students understand polygons, parallel and perpendicular, clear off the geoboards. As you read a list of polygon rules, have them make the described polygon. *(Example: Make a sided polygon with one pair of parallel lines, Make a sided polygon with two sets of perpendicular lines.)*

9. Hand out worksheet with several of these different principles to make different polygons. This can be used in the classroom with geoboards, or given for homework with dot paper.

10. *For any Spanish-speaking students it is a great idea to write polygon, perpendicular and parallel in both English and Spanish on the board.* (http://www.math.com/tables/spanish/eng-spa.htm)



Building a Dream Home

Description: In this activity, students will identify shapes that architects use to build houses. Students will then explore these shapes by building a model of their "dream" home.

Objectives: The students will:

1. Identify how architects use shapes.
2. Work cooperatively to create and execute a plan to build a model of a home.
3. Create a cone, cube, rectangular prism, and cylinder.
4. Use at least three 3-dimensional shapes in their dream home.

Materials:

- patterns for 3-dimensional shapes
- construction paper
- tag board
- scissors
- glue

Procedure:

Introduction: - Questions to ask students . . .

1. "How many of you know what an architect does?
2. "What is the difference between architecture and an architect?"
3. "What shapes do architects use to build things?
4. "Are those 3-dimensional or 2-dimensional?"
5. "Today, each of you is going to join a team of other architects. Together, you will design a model of your dream home."

Lesson Focus:

1. Before you begin this lesson, facilitate an activity that creates cooperative groups of 2-4. One piece of paper will be given to each cooperative group. Students will be instructed that they will have only two minutes to write down as many geometric shapes as they can. Each student will write the name of only one geometric shape and then pass the paper to the next student. The game ends when the time expires.

2. Demonstrate how to make cones, rectangular prisms, cylinders, and cubes from the photocopied patterns. Have students practice making their own.

3. Discuss with the class that they will be acting as architects and that it is very important for architects to have a plan.

4. Give students enough time to come up with a plan for their model dream homes. They must incorporate at least three 3-dimensional shapes.

5. Encourage the class to do their personal best when "erecting" their structure. Creativity is a positive thing. If students decide to make something else instead of what you asked, be flexible!

6. Mount their creations on tag board, and display them for all to enjoy.

Assessment: Examples of some questions that could be asked:

1. "What did you learn from this activity?"

2. "What did you like best about it?"

3. "Who can tell me what subject we are studying?"

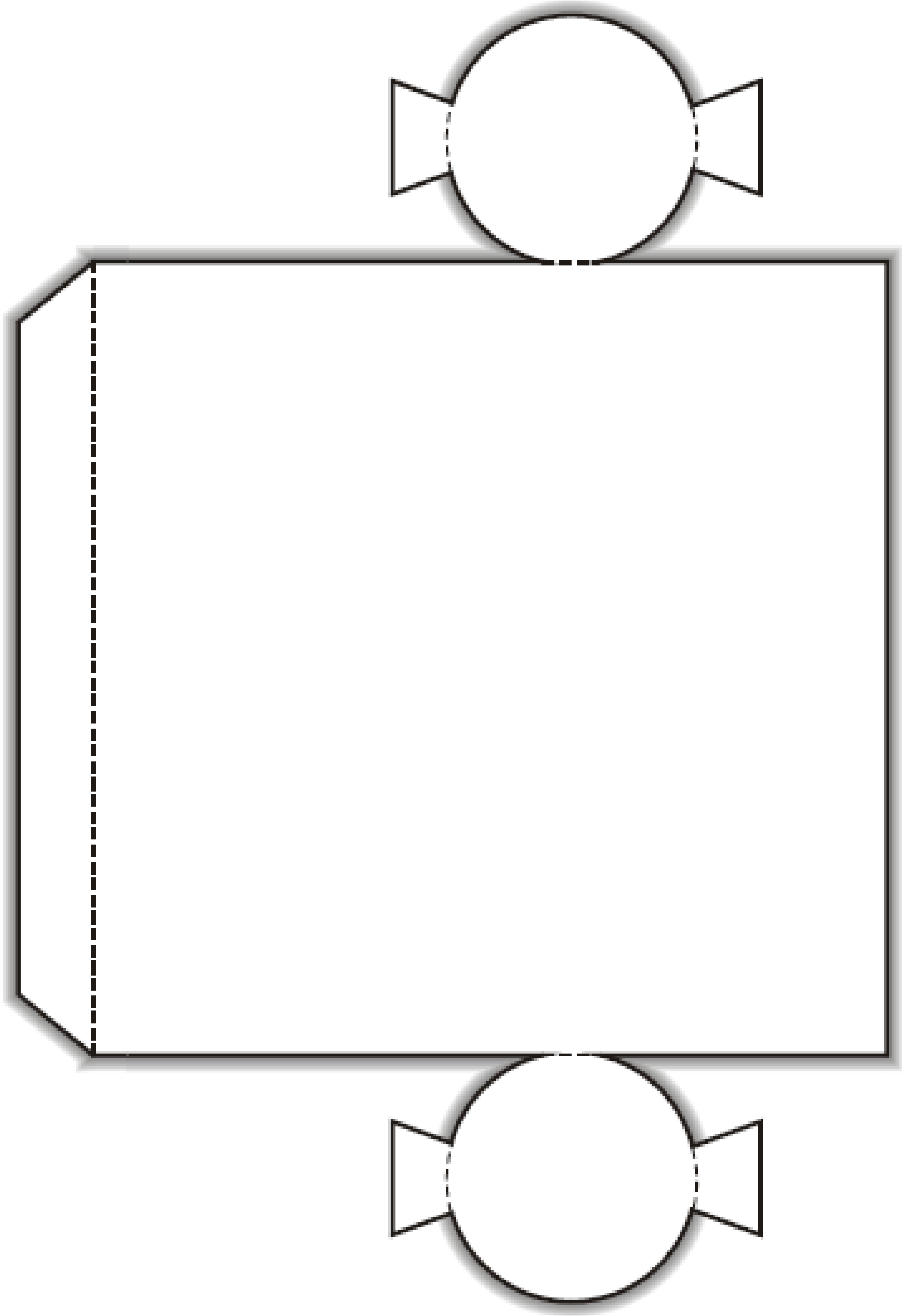
4. "What do architects do?"

5. "What are three-dimensional shapes?"

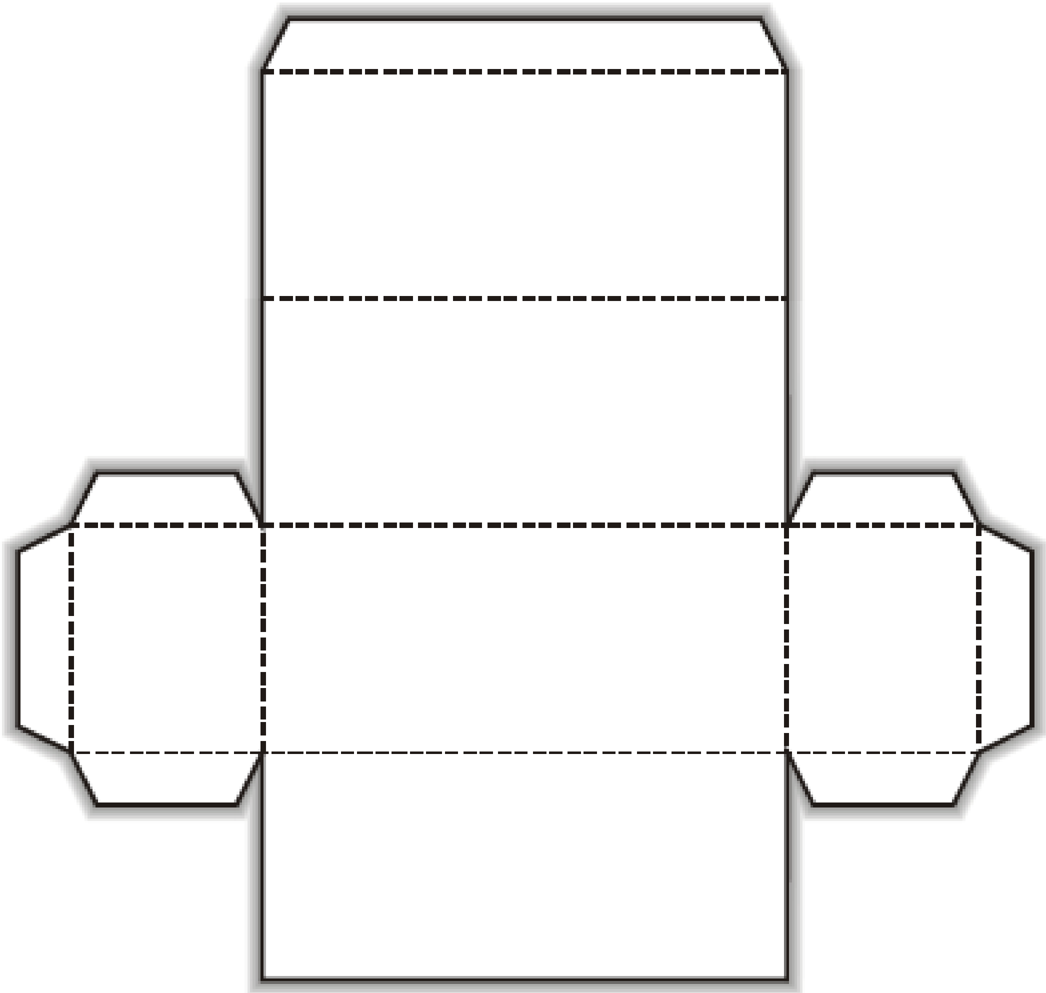
Useful Internet Resources:

- Polyhedra Nets - Paper http://mathforum.org/alejandre/workshops/net.html
- Structured Curriculum Lesson Plan - Geometry This PDF file has patterns for making a rectangular prism, triangular prism, cone, cube, and cylinder. (You will need Adobe Acrobat Reader to view them.) http://intranet.cps.k12.il.us/Lessons/StructuredCurriculumTOC/SCMathematics/HS_Geometry_Daily_Lessons_/SCMAGE2/MAGE155174.PDF

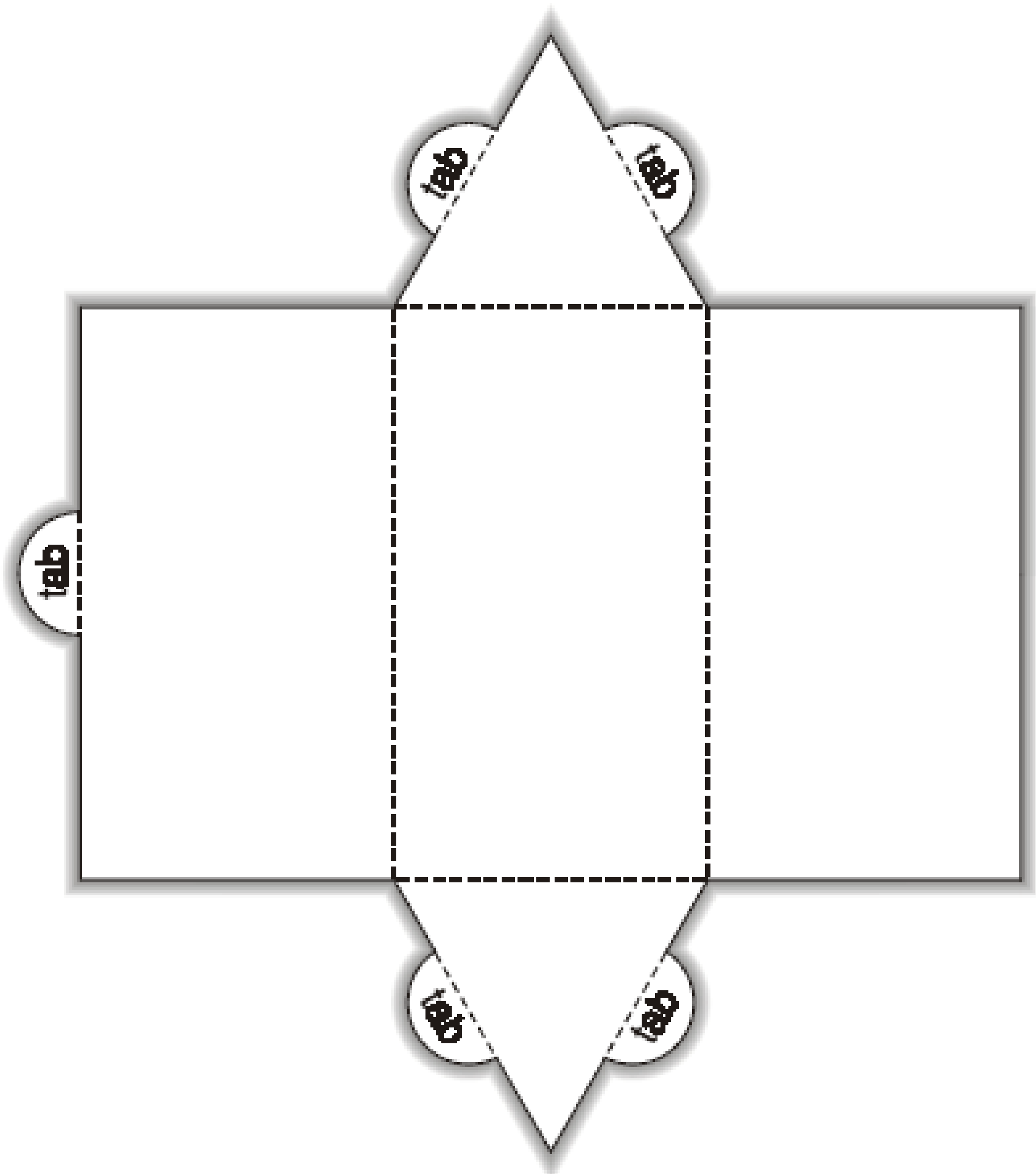
Cylinder Pattern



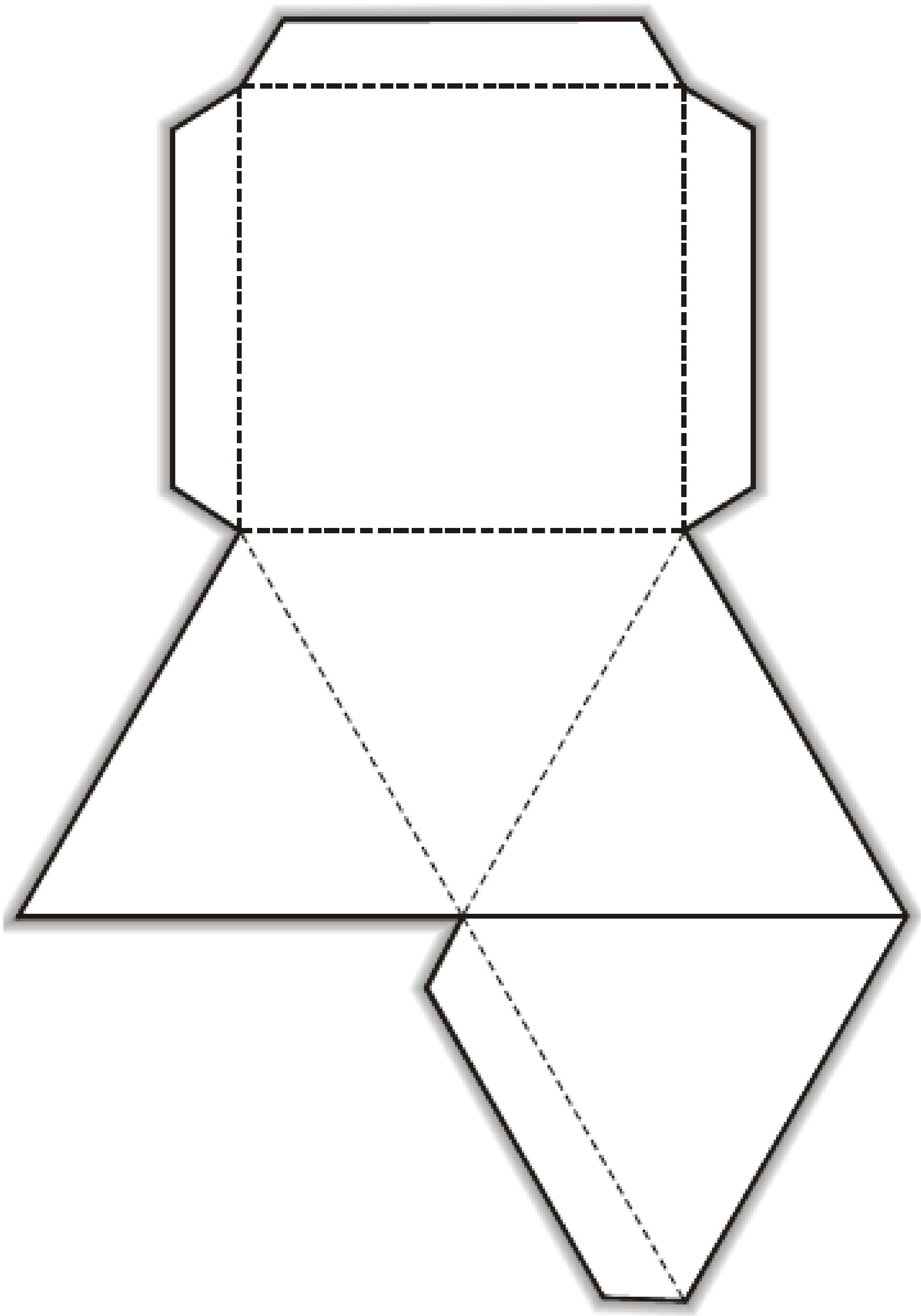
Rectangular Prism Pattern



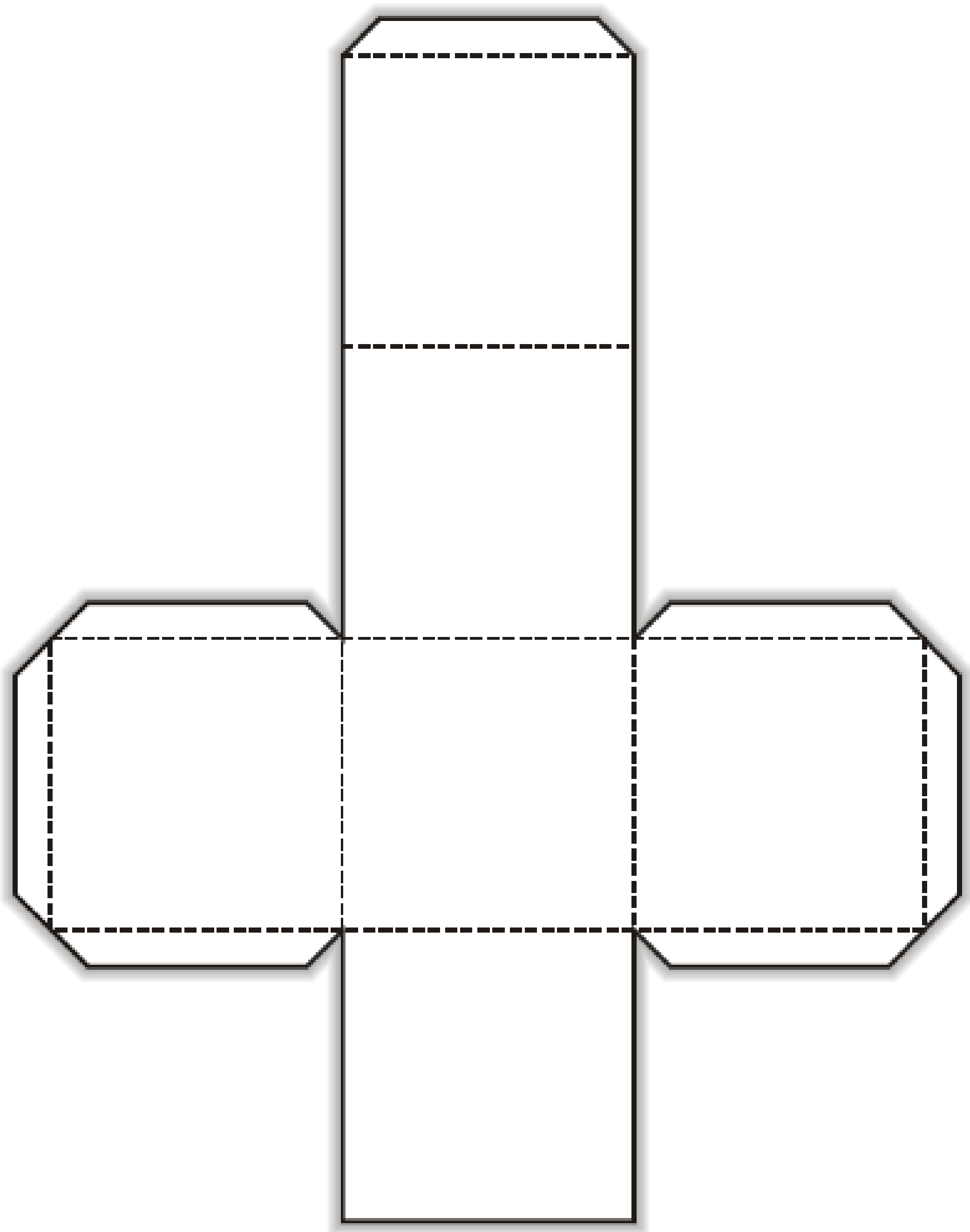
Triangular Prism Model



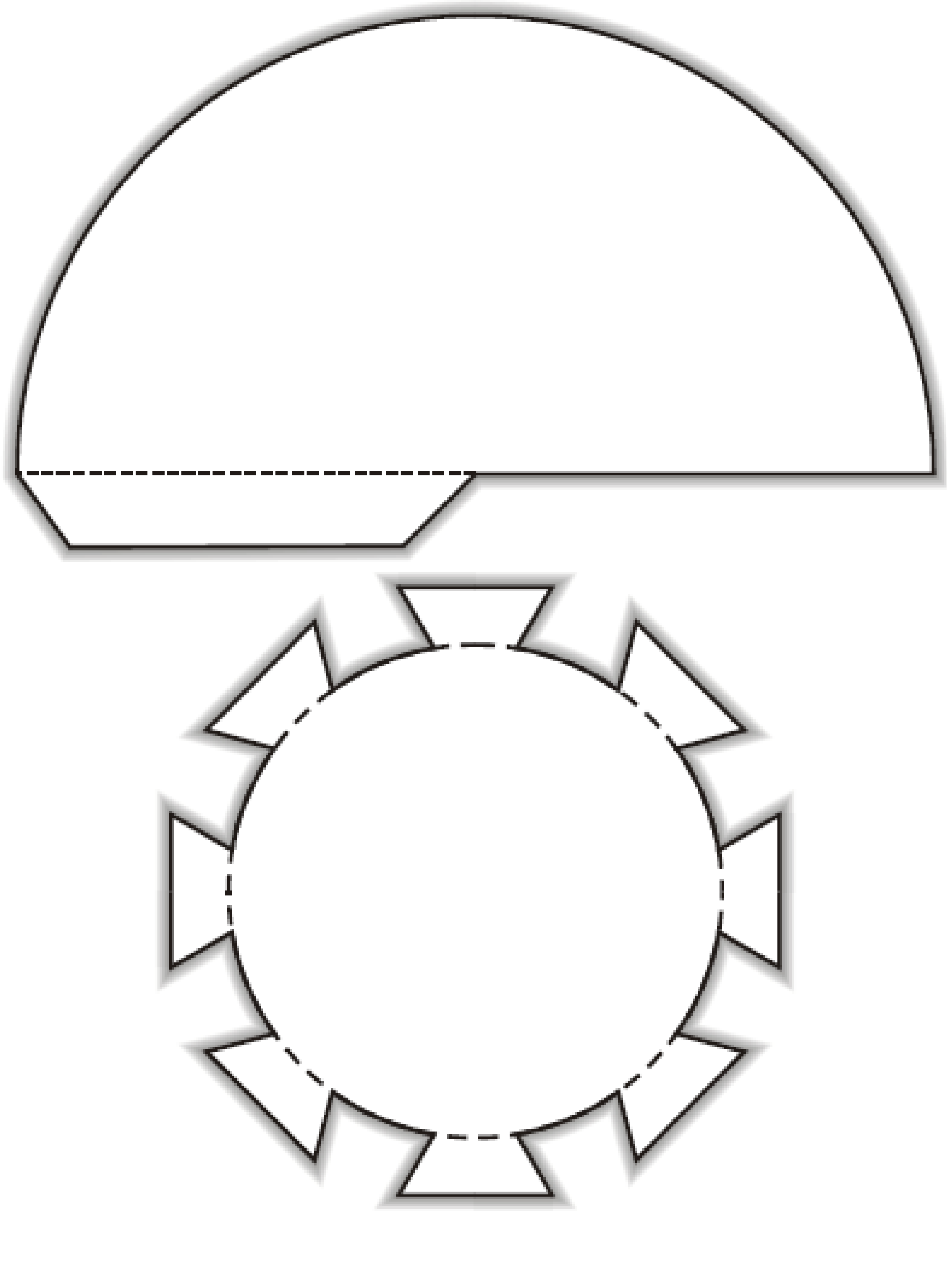
Pyramid Pattern



Cube Pattern



Cone Pattern



Web of Lines

This lesson describes a hands-on way for students to learn about lines, rays, segments, and points. Students use yarn to create a "web" of parallel and perpendicular lines.

Students will realize that lines, segments, rays, and points exist not only on paper but also in the world around us.

Objectives:

- Students will be able to identify, describe, and compare line segments, lines, rays, and angles and use appropriate symbols.
- Students will communicate mathematical understanding in journals using words and/or pictures, numbers, and symbols.
- Students will construct meaning through physical materials.
- Students will express ideas using mathematical vocabulary.

Materials:

- yarn
- mini-boards/dry erase makers for students
- letters of the alphabet cut out of construction paper; attach black dots to the letters to represent points (laminating works well)

Vocabulary:

- Ray - A line starting at a single point and going on forever in one direction.
- Point - A fixed spot on a plane.
- Line - A straight line going on forever in both directions.
- Segment - A line with two endpoints.
- Parallel - Two lines, line segments, or rays that are constantly equidistant apart from one another so that they never intersect.
- Perpendicular - A line, line segment, or ray that touches or intersects another line, line segment, or ray at a 90-degree angle.
- Intersecting - Two lines, line segments, or rays that touch or pass through one another at any angle.

Procedure:

1. Review how to name lines, rays, segments, points, parallel lines, perpendicular lines, and intersecting lines. Clear out the center of the room and have students stand in a circle. Pass yarn around the circle. Students hold onto a small piece of the yarn and then pass it either across the circle or next to them to form a web design. (The teacher must make sure that there are some parallel and perpendicular lines by guiding the passing of the ball of yarn.) The web is then carefully laid down on the floor so that every student has a clear view of it. The laminated alphabet points are placed at intersecting points on the web. These points will allow the children to name rays, line segments, lines, etc. using mathematical terminology.
2. Each student sits near the web with a mini-board. Ask students to find (one at a time) rays, points, lines, segments, intersecting lines, parallel lines, and perpendicular lines. Students must re-draw each figure on their board, label it correctly, and write the symbolic form. Students use the alphabet points that were placed at intersecting points on the web to label the lines, rays, etc. that they find. Then students write out the figures that they find using the correct form of mathematical labeling. Below is information on how students should label rays, lines, etc.

After each item, students share and check their answers with each other. Walk around and be available for questions. When students are finished, conclude by discussing how these figures are found in everyday life. As an extension, have students respond to the following questions in their math journals: As a lead-in--"Today we have made a web of lines in our classroom. There are examples of lines, rays, line segments, and points everywhere in our everyday life. Brainstorm two or three examples of these figures around you. Did you notice them as being a point, line, segment, or ray before learning about them in geometry? Why or why not?"

Assessment: Observe students' participation in the activity along with their responses on the mini-boards. Teachers can create a checklist to more formally assess students' abilities to draw, name, and symbolize the figures correctly.

Adapted from: Educator's Reference Desk Lesson Plan

The Greedy Triangle

Description: Students will listen to The Greedy Triangle and use geoboards to create various polygons. Students will also make shapes out of construction paper to form a "shape garden" bulletin board.

Goals:

- Students will be able to recognize and identify various polygons.
- Students will make the connection that a polygon's name refers to the number of sides that it has.

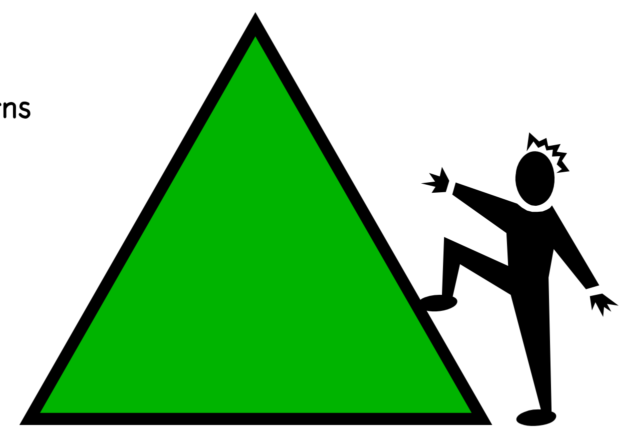
Objectives:

Students will be able to:

- Recognize the following geometric shapes: triangle, quadrilateral, pentagon, hexagon, nonagon, and decagon.
- Relate each shape's name to its number of sides.
- Construct the six geometric shapes on a geoboard.
- Construct one of the six geometric shapes out of construction paper.

Materials:

- overhead projector
- clear geoboard for the overhead
- geoboards for students
- rubber bands
- pictures of shapes
- The Greedy Triangle by Marilyn Burns
- graph paper
- construction paper
- scissors
- markers



Vocabulary:

- triangle -- 3-sided polygon
- quadrilateral -- 4-sided polygon
- pentagon -- 5-sided polygon
- hexagon -- 6-sided polygon
- nonagon -- 9-sided polygon
- decagon -- 10-sided polygon

Procedure:

Review what the side of a shape is (the outside edges of a shape). Hold up pictures of a triangle, quadrilateral, pentagon, hexagon, nonagon, and decagon and ask if anyone can identify the shapes. Ask where students may have seen these shapes in their environment (at school, at home, at the store, on the road or sidewalk, etc.) Share the story The Greedy Triangle. Be sure to have the students listen for the names of the different shapes mentioned in the story.

Summary of Story:

A triangle is bored with having only three sides, so he goes to the shape doctor. He is changed into a quadrilateral, pentagon, hexagon, nonagon, and decagon. The book goes through the characteristics of each shape. Finally he decides that being a triangle is the best, because that's what all of his friends are.

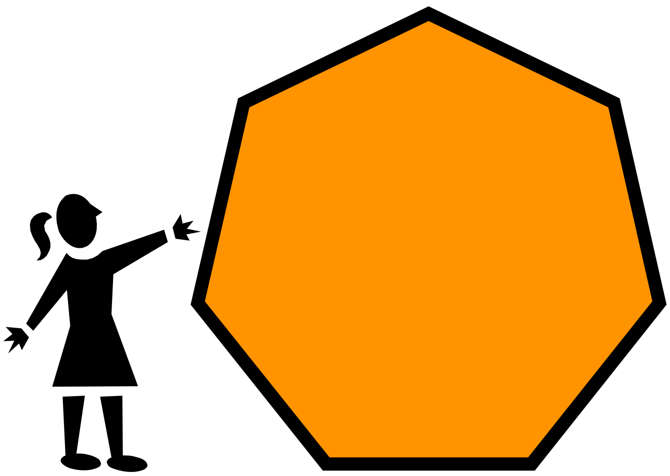
After the story is read, ask students to share the shapes that were mentioned in the book.

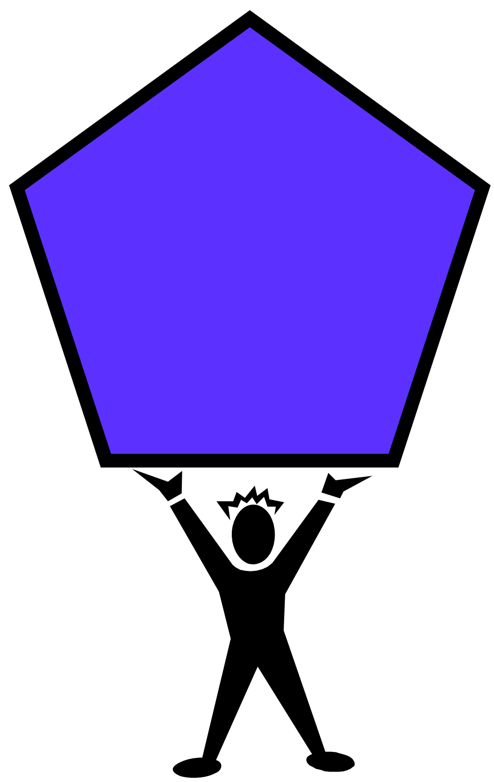
Ask students how shapes are named. Explain to students that you name a shape by the number of sides the shape has (a hexagon has 6 sides, a nonagon has 9 sides, etc.). Review the prefixes and their meanings (hex- means 6, pent- means 5, etc.). Distribute one geoboard and a few rubber bands (different colors if available) to each student. (If you don't have enough geoboards for all students, have students work in pairs.) On the overhead geoboard, model how to form each shape. Students should make the same shapes on their geoboards that you are making on the overhead geoboard. Give students 5-10 minutes to experiment making shapes on their geoboards. Have students pair up to discuss and compare the shapes that they made.

Closure:
Discuss, as a group, what the names of the shapes are and how they have gotten their names. Have the students write a short entry in their math journals about naming and

identifying geometric shapes. Explain that for the remainder of the period, they will draw and cut out a shape that was mentioned in the story. They will first draw the shape on a piece of graph paper (as large as possible) and then cut out the shape using scissors. Next, each student will trace the shape onto a piece of construction paper and cut out the shape. Then, each student will write the name of the shape in the center of the cut-out. All of the shapes will be placed on a bulletin board to create a "shape garden."

Assessment: When students are using the geoboards, assess the following: Are students following the directions? Do their shapes look the way they are supposed to? Can students identify and name the shapes? For the "shape garden" project, assess the following: Did students name their shapes correctly? Does each shape have the correct number of sides?

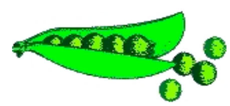




Shapely Activities

Many students learn better when they have hands-on experiences with the concepts. Here are several different kinds of activities designed to give students experience with shapes – creating them, categorizing them, describing them, etc.

- Precut construction paper rectangles, squares, circles, trapezoids, etc. Pretend you are a spider sitting on the ceiling. Create a map of your classroom using the precut shapes. Add details.
- Cut one side off a cardboard shoe box. Cut two hand-holes on the opposite side. Place an assortment of shapes inside the box. Person A inserts his hands into the box and tries to find two matching shapes. Person B verifies his choice, etc.
- In groups of two, three or four and using 6-8 yards of yarn, work together to make a square, rectangle, triangle, hexagon, pentagon, etc. How many corners will your shape have? How many sides? Will the sides be different sizes? Will the edges be straight or curved? Can you find similar shape objects in the room, playground, etc.?
- Using geometric shaped models, reproduce these using toothpicks and marshmallows (or carrot slices, frozen peas, play dough, clay, etc.)



- Make two equilateral triangles using five toothpicks. Make five triangles, using nine toothpicks; then take away three toothpicks to leave one triangle. Make four squares using twelve toothpicks.
- Go on a shape walk. Have students record the shapes they observe and where they find them.
- Divide the class into groups. Give each group one shape and have them record things that have the shapes they are carrying.
- "I'm thinking of a shape . . ." Person A thinks of a shape displayed from a collection of shapes on a table. He gives Person B a clue describing his shape. Person B tries to guess what the shape is each time a new clue is given. How many clues were needed to identify the secret shape?
- Use a tracer shape set and draw the various shapes. Fold the paper shapes to determine the various lines of symmetry. How many lines of symmetry does each shape have?

- Giving specific directions, children create shapes on the geoboard. Make a square and a parallelogram. Touch eleven pins altogether. Touch three pins twice.
    - Variation: make a pentagon that touches eight pins.

- Using pattern blocks, find out what you can do in one minute. How many triangles can you join together? How many squares, hexagons, etc.? What design did you make?

- Choose two geometric shapes. Talk about how the pieces are the same and different.

- Place a screen between two players. Person A makes a flat two-dimensional design using a geoboard. After creating the shape, Person A gives directions to Person B to create the same shape.

- Use tangram pieces to make a shape. Your partner creates the same shape. Create shapes with your tangram pieces and have your partner attempt to identify the shapes used. Discuss how many pieces were used. How many triangles, squares, parallelograms? How many pieces have sides of the same length? Discuss how pieces can be manipulated (slides, turns, flips) to fill in the outline of the shape objects.

- Fold paper to make shapes. Fold a square to make a rectangle; fold a rectangle to make a triangle; fold a rectangle to make a trapezoid; fold a trapezoid to make a diamond.

- Create shapes with four, five, six or eight toothpicks. Draw pictures of these shapes and name them.

- Use catalogues or magazines to find examples of various shapes. Bring empty containers from home and classify into groups.

Investigative Math

How is math important in the every day life of the regular adult? Interview your Mom and/or Dad to investigate the importance that math plays in their daily lives. Record their answers on the form. When you have finished, write a one-page paper on what you learned.

1. Where do you work?

____

2. What is your job title?

____

3. Briefly explain your job.

____

____

____

____

4. What skills in math are important to your job?

____

____

____

____

5. Please give examples of when you use these skills

____

____

6. On a scale of 1 to 10 (1 being low and 10 being high), how important is mathematics to your job? Why?

7. Problem solving is a life-skill. When do you problem-solve in your job?

8. What do you see as important in the study of mathematics?

9. Why is the study of mathematics important in school?

Searching For Terms

Name: Date:

Directions: Find the geometry terms in the puzzle.

A	L	I	N	E	S	E	G	M	E	N	T	A	S	P	E	R	S	Z	V
C	G	E	U	S	D	R	T	M	Y	E	L	P	I	P	Y	I	U	L	E
O	J	U	M	P	E	R	R	V	L	E	I	A	O	P	L	E	P	B	R
M	A	R	T	H	R	O	N	C	O	N	G	R	U	E	N	T	P	E	T
P	D	I	R	T	I	P	I	M	U	S	I	A	C	R	I	T	L	X	I
L	T	S	E	N	H	T	O	U	S	E	B	L	A	N	A	A	E	T	C
E	S	E	K	T	R	A	Y	R	U	P	D	L	R	E	X	L	M	E	L
M	E	L	R	E	H	O	D	S	O	N	M	E	A	S	S	A	E	R	E
E	O	G	V	A	W	L	E	C	O	L	O	L	R	A	D	O	N	I	A
N	H	N	F	E	L	L	O	R	I	D	A	L	C	V	I	R	T	O	N
T	I	A	C	L	R	E	I	T	E	A	C	I	H	E	E	R	A	R	G
A	O	R	B	A	O	T	Q	N	U	A	C	N	E	R	N	B	R	A	L
R	I	O	U	N	B	Y	I	U	E	E	H	E	K	T	I	U	Y	N	E
Y	L	I	L	I	B	A	S	C	D	S	R	S	A	E	K	D	A	G	S
A	L	R	L	M	I	L	H	A	L	W	I	V	I	X	E	D	N	L	R
N	I	E	E	A	N	E	Y	D	U	E	S	X	T	O	P	Y	G	E	O
G	N	T	A	D	J	A	C	E	N	T	A	N	G	L	E	S	L	S	O
L	O	N	T	L	S	H	W	H	W	A	L	N	E	T	E	A	E	S	D
E	I	I	I	E	U	A	R	V	A	R	D	B	G	O	L	T	S	T	T
S	S	O	N	T	R	A	N	S	V	E	R	S	A	L	N	O	F	F	I

line segment
vertical angles
complementary angles
intersecting lines
transversal
ray
congruent
supplementary angles
perpendicular lines
interior angles
vertex
adjacent angles
parallel lines
skew lines
exterior angles

Searching For Terms

Name: Date:

Directions: Find the geometry terms in the puzzle.

	L	I	N	E	S	E	G	M	E	N	T						S		V
C										E		P					U		E
O									L			A					P		R
M								C	O	N	G	R	U	E	N	T	P	E	T
P							I					A					L	X	I
L		S				T						L					E	T	C
E		E	K		R	A	Y					L					M	E	L
M		L		E								E					E	R	E
E		G	V		W							L					N	I	A
N		N				L						L		V			T	O	N
T		A					I					I		E			A	R	G
A		R						N				N		R			R	A	L
R		O							E			E		T			Y	N	E
Y		I								S		S		E			A	G	S
A		R												X			N	L	
N		E															G	E	
G		T	A	D	J	A	C	E	N	T	A	N	G	L	E	S	L	S	
L		N															E		
E		I															S		
S				T	R	A	N	S	V	E	R	S	A	L					

line segment
vertical angles
complementary angles
intersecting lines
transversal

ray
congruent
supplementary angles
perpendicular lines
interior angles

vertex
adjacent angles
parallel lines
skew lines
exterior angles

Biography Cards

Research a mathematician who has made a contribution to geometry. Write a short biography of the mathematician and summarize his/her contributions to geometry.

Timely Manner

Make an illustrated timeline using the history of geometry…

Picture Dictionary

Circle the set of all points in a plane a given distance from a given point.
Congruent equal measure
Hexagon a six-sided polygon
Heptagon a seven-sided polygon
Octagon an eight-sided polygon
Parallelogram a quadrilateral with both pairs of opposite sides parallel
Pentagon a five-sided polygon
Similar figures that have the same shape, but not necessarily the same size
Rectangle a quadrilateral with 4 right angles
Trapezoid a quadrilateral with exactly one pair of opposite sides parallel
Isosceles a trapezoid with the un-parallel opposite sides congruent
Triangle a 3-sided polygon
Equilateral a triangle with all sides congruent
Isosceles a triangle with at least two sides congruent
Right a triangle with a right angle
Scalene a triangle with no sides congruent

Geometry Ideas

The geometry strand helps children to describe, compare, classify, represent and relate to objects in their environment. Experiences with real objects that are both two-dimensional (plane) and three-dimensional (space) provide children with opportunities to discover attributes and relationships among the geometric shapes. Geometry can very easily be integrated with the visual art strand of the arts curriculum.

Following is a collection of geometry ideas that could be adapted for use in elementary classrooms.

- Precut construction paper rectangles, squares, circles, trapezoids, etc. Pretend you are a spider sitting on the ceiling. Create a map of your classroom using the precut shapes. Add details.
- Cut one side off a cardboard shoebox. Cut two hand-holes on the opposite side. Place an assortment of shapes inside the box. Person A inserts his hands into the box and tries to find two matching shapes. Person B verifies his choice, etc.
- Children can classify and sort three-dimensional shapes according to various attributes. Test to see which roll, slide or both.
- Place several familiar objects (e.g., ball, pencil, etc.) on a table. Have children view the objects for a limited time. Cover. Have children recall the cylinder shapes, spheres, etc.
- Variation: Play "20 Questions." Teacher chooses an object and the student must ask geometry questions to identify the object.
  - Teacher answers yes or no to questions. How many questions does it take?
- In groups of two, three or four and using 6-8 m of yarn, work together to make a square, rectangle, triangle, hexagon, pentagon, etc. How many corners will your shape have? How many sides? Will the sides be different sizes? Will the edges be straight or curved? Can you find similar shape objects in the room, school-yard, etc.?
- Using geometric shaped models, reproduce these using toothpicks and marshmallows (or carrot slices, frozen peas, Plasticine, etc.)
  - Variation: Create your own structures.

Make two equilateral triangles using five toothpicks. Make five triangles, using nine toothpicks, then take away three toothpicks to leave one triangle. Make four squares using twelve toothpicks.

- Go on a shape walk. Record the shapes you observe and where you find them.
  - Variation: Divide the class into groups. Give each group one shape and have them record things that have the shapes they are carrying.

- Children can create a geometry shape such as a square (Shape A) on the geoboard, then change Shape A into Shape B (a triangle shape) noting necessary movements and changes.

- Children can illustrate real-life shapes on the geoboard (e. g., a box, arrow, traffic signs, etc.)

- Person A mentally chooses a shape displayed amidst a collection of shapes on a table. He gives Person B a clue describing his shape. Person B tries to guess what the shape is each time a new clue is given. How many clues were needed to identify the secret shape?

- Using attribute blocks, make a one-way change train. Each shape differs from the previous one in only one attribute.
  - Variation: Make two-way or three-way change trains.

- Use a tracer shape set and draw the various shapes. Fold the paper shapes to determine the various lines of symmetry. How many lines of symmetry does each shape have?

- Giving specific directions, children create shapes on the geoboard. Make a square and a parallelogram. Touch eleven pins all together. Touch three pins twice.
  - Variation: make a pentagon that touches eight pins.

- Give each child a half-sheet of clean paper. Challenge children to cover complete area using pattern blocks.
  - Variation: match congruent (same size, same shape) two-dimensional figures using pattern blocks.

- Using pattern blocks, find out what you can do in one minute. How many triangles can you join together? How many squares, hexagons, etc.? What design did you make?

- Using geoshapes, build a freestanding tower in five minutes. Predict how tall it will be using comparisons in the classroom (e. g., bigger than a chain).

- Use nets and fold them. Identify the shape you created. Discuss differences and similarities between your shape and your friend's shape.

- Choose two geometric shapes. Talk about how the pieces are the same and different.

- Choose a geoshape that is different in one way from another shape you choose. Find a piece that is different in two ways from another.

- Play "Chain Game" using attribute blocks. Person A puts down a piece. Person B joins a piece that is different in only two ways, etc. Game over when one player uses all his/her shapes or no one can use a piece.

- Place a screen between two players. Person A makes a flat two-dimensional design using five geoshapes without Person B seeing. Person A tells Person B how to make the same design without watching what Person B is doing.
- Variation: Use a geoboard. Person A creates a shape and gives directions to Person B to create the same shape.

- Place a ruler on the floor. Pretend this line is a mirror. Person A places a geoshape so that one edge touches the mirror line. Person B places his/her matching piece to make a mirror image.

- Use tangram pieces to make a shape. Your partner creates the same shape. Create shapes with your tangram pieces and have your partner attempt to identify the shapes used. Discuss how many pieces were used. How many triangles, squares, parallelograms? How many pieces have sides of the same length? Discuss how pieces can be manipulated (slides, turns, flips) to fill in the outline of the shape objects.

- Fold paper to make shapes. Fold a square to make a rectangle; fold a rectangle to make a triangle; fold a rectangle to make a trapezoid; fold a trapezoid to make a diamond.

- Create shapes with four, five, six or eight toothpicks. Draw pictures of these shapes and name them.

- Use catalogues or magazines to find examples of various shapes. Bring empty containers from home and classify into groups.

- What shapes are the mirrors in your house? Draw the shapes and identify them.
    - Variation: Identify all the different shapes in a car.

- Play a variation of "Simon Says" using position words (e. g., Simon says stand between two desks or, if outside, between two trees, etc.)

Adapted From:
Linda Longpre
Pre Cam Elementary School
La Ronge, Saskatchewan

- Picking Apart Geometry - Reinforce edges and vertices. Construct different geometric shapes using toothpicks as the edges and marshmallows as vertices. Count the toothpicks and then the marshmallows. Later, when teaching more abstract concepts, remind students to count the toothpicks or marshmallows.

- Pipe Cleaner Math - Make a set of geometry terms on 3x5 cards beforehand. Pair up the students and give each person his/her own pipe cleaner. While one partner in each pair puts his/her head down, show the other partners a geometry term on the card. Cover the card and then say, "go." All heads are now up and the students who saw the term quickly try to create the term by bending their pipe cleaners into that shape.

- Perimeter & Area Skate and Stomp! – Play this "follow-the-leader" type of activity, chanting "Add perimeter...add perimeter...add perimeter" and so on while stomping your feet and walking around the outer edge of the classroom. Quickly change to "Multiply area...multiply area...multiply area," but this time pretend to be "ice-skaters" and slide across the middle of the classroom as you continue to chant. Quickly switch back and forth between chants, skating and stomping. It might be quite silly, but the kids won't forget the difference between the terms!

- Use licorice sticks to teach parallel and perpendicular lines. They can also be used to teach angles. Cut licorice sticks to make sides… OR use pretzel sticks and icing. Ice (glue) the pretzels together to form obtuse, acute, and right angles.

- Partner up your students. Have them create types of lines and angles by lying on the floor. Students tend to remember best if they do concrete things with the geometry concepts.

- Introduce your students to geometry via the book, Sir Cumference and the Knights of the Round Table by Cindy Neuschwander and Wayne Geehan. It is a book with a lot of play on words. For example: Sir Cumference (circumference) is married to Lady Di of Ameter (diameter) and they have a son named Radius. Geo of Metry is another character. The book introduces the shapes and is told along the lines of Sir Arthur.

Randomgon

The game: Put the chart below on the board in front of the classroom. Select students to choose an attribute from each of the four categories. The first student may select 1a, 1b, 1c or 1d. The second student may select 2a, 2b, 2c and so on. Working in pairs, students try to come up with as many different polygons as possible with the selected attributes.

1: Select number of sides:

a.3 b.4 c.5 d.6

2. Select parallels:
   - a. no sides parallel
   - b. one pair parallel sides
   - c. two pairs parallel sides

3. Select angles:
   - a: no right angles
   - b. of least one right angle
   - c. every angle is a right angle

4. Select side lengths:
   - a. no sides the same length
   - b. two sides the same length
   - c: all sides the same length

Discussion: Students will find that while some combinations allow for many different polygons, others allow for only one, or none at all. For example, there are many ways to make a hexagon with one pair of parallel sides; there is only one way to make a quadrilateral with two pairs of parallels and all sides the same length, and it's impossible to make a right triangle with all sides equal in length.

Variations: Make different colored sets of cards from which students can select. A worthwhile and challenging extension is to find the probability that a shape with randomly chosen attributes is impossible – in order to accomplish this, one must examine each of the 108 combinations of attributes!

That's Mine!

The object of "That's Mine!" is to match a definition with a geometric figure. There are two decks of cards – one containing simple definitions, the other showing the geometric forms.

Directions

1. Shuffle the two decks separately. The dealer passes out the geometric deck to four players. Drawing the top card from the definition deck, he reads what is on the card.

2. The player with the matching geometric figure card calls out, "That's Mine!" He takes the definition card and lays it down with his card.

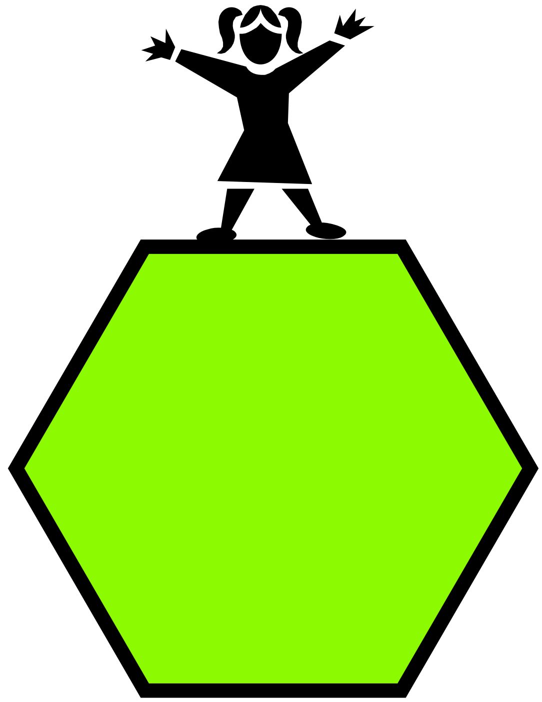
3. The first player to play all of the cards out of his hand wins the game.

That's Mine! Variation

The leader deals out the definition cards.
As he holds up a geometric figure card, the players must look for the correct definition.
If they can match it, they lay the pair down.
The first player to play all of the cards out of his hand wins.

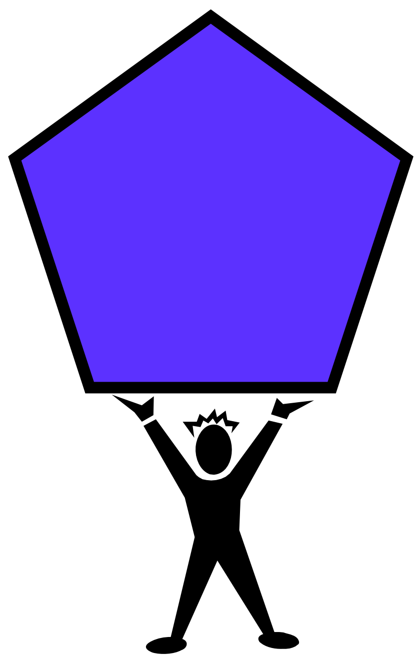
Hexagon

A hexagon is a six-sided plane figure.



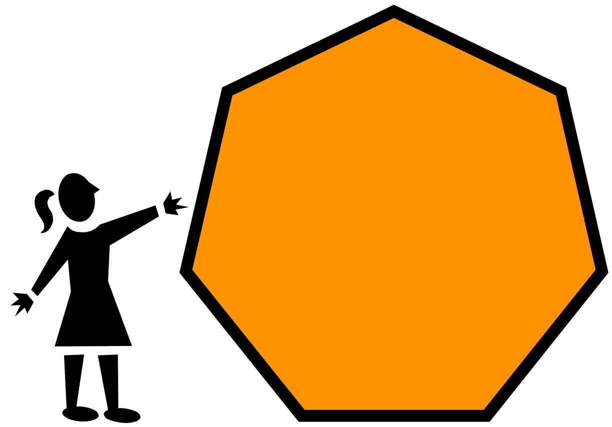
Pentagon

A pentagon is a polygon having five equal sides. Each interior angle measures 108 degrees.



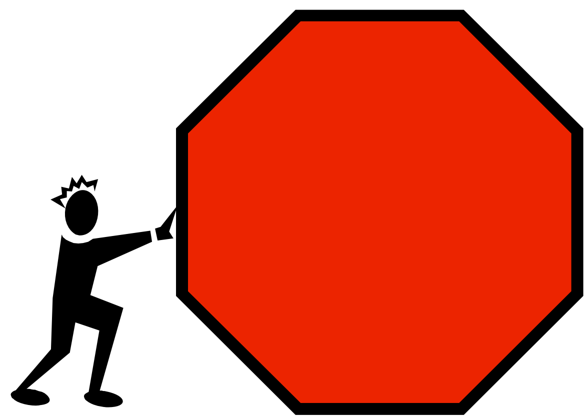
Heptagon

A heptagon is a seven-sided plane figure.



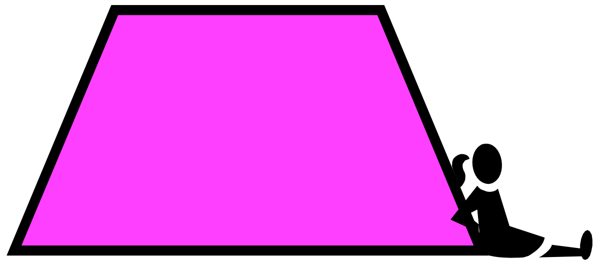
Octagon

An octagon is a polygon having eight equal sides. Each interior angle measures 135 degrees.



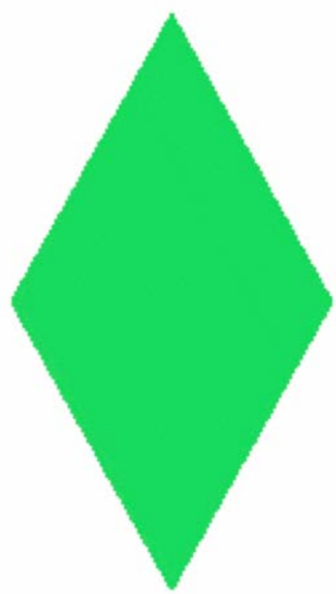
Trapezoid

A trapezoid is a quadrilateral pane figure having one pair of parallel sides.



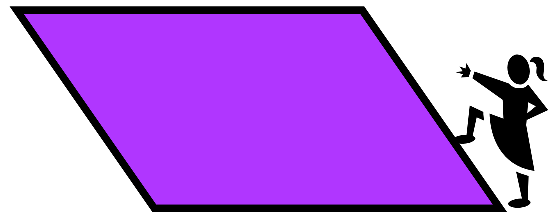
Rhombus

A rhombus is a plane figure having four sides of equal length. The opposite sides are equal.



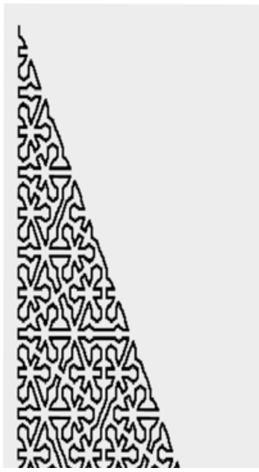
Parallelogram

Each pair of opposite sides is equal in length and parallel; opposite angles measure the same.



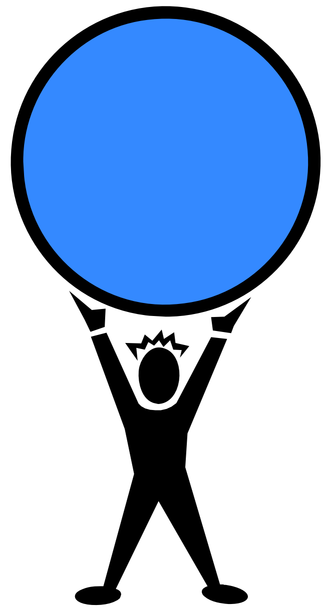
Right Triangle

A right triangle has three sides and three angles. One of the angles measures 90 degrees. The other angles are "acute" (each measures less than 90 degrees.)



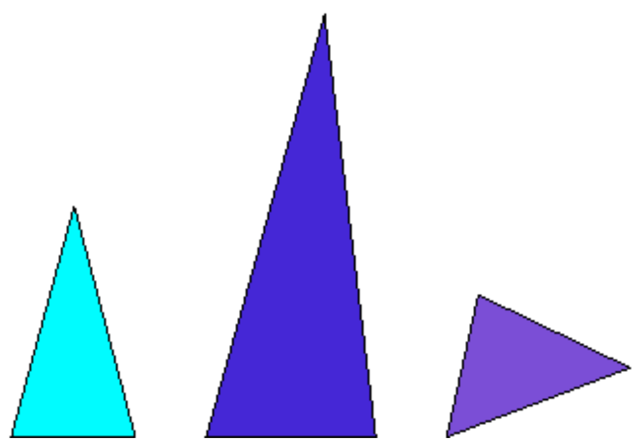
Round Angle

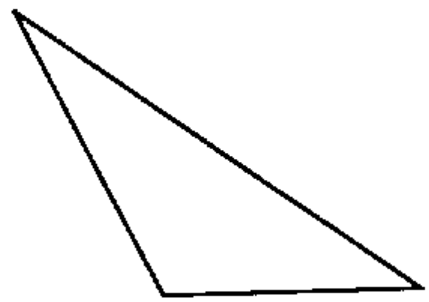
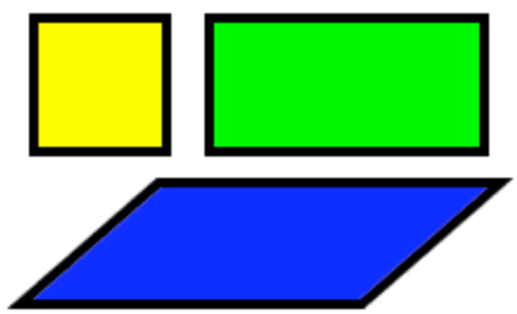
A "round" angle contains 360 degrees or a complete revolution.



Acute Triangle

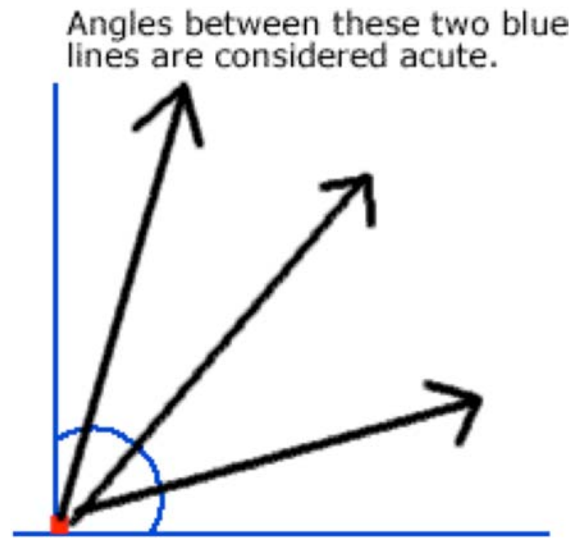
Each of the three angles measure less than 90 degrees.



Obtuse Triangle One of the three angles measures more than 90 degrees.	
Parallelogram Each pair of opposite sides is equal in length and parallel; opposite angles measure the same.	

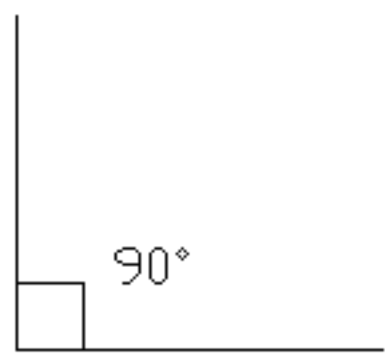
Acute Angle

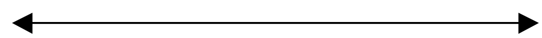
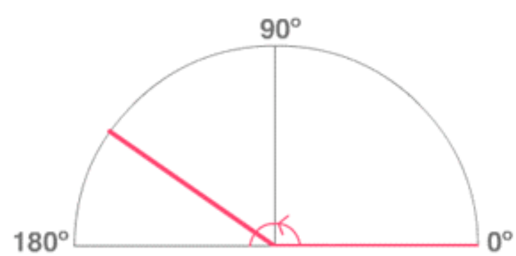
An acute angle is less than a right angle(less than 90 degrees)



Right Angle

A right angle measures 90 degrees. The two rays are perpendicular.



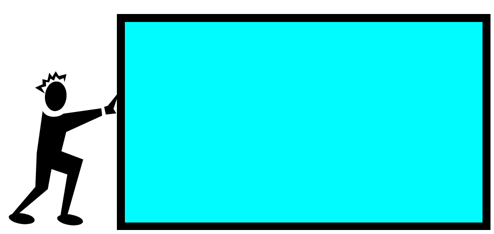
Straight Angle A straight angle has 180 degrees or two right angles.	
Obtuse Angle An obtuse angle is one that contains more than 90 degrees but less than 180 degrees.	

Isosceles Triangle

Two of the three sides are of equal length. The angles opposite the equal sides measure the same.

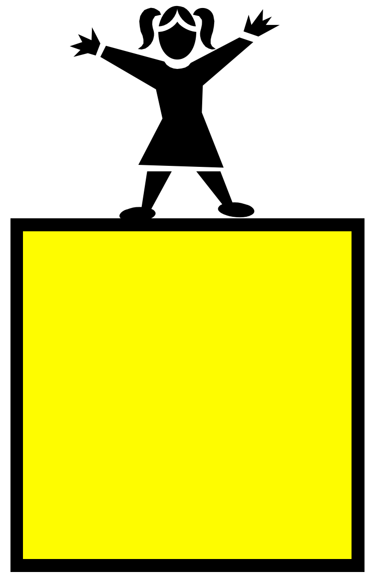
Rectangle

Each pair of opposite sides are equal in length and parallel. A rectangle contains four right angles.



Square

A square is a polygon having four equal sides and four right angles.



Star Burst

Materials: White art paper, pencil, ruler, colored pencils, colored paper for mounting, scissors

Directions:

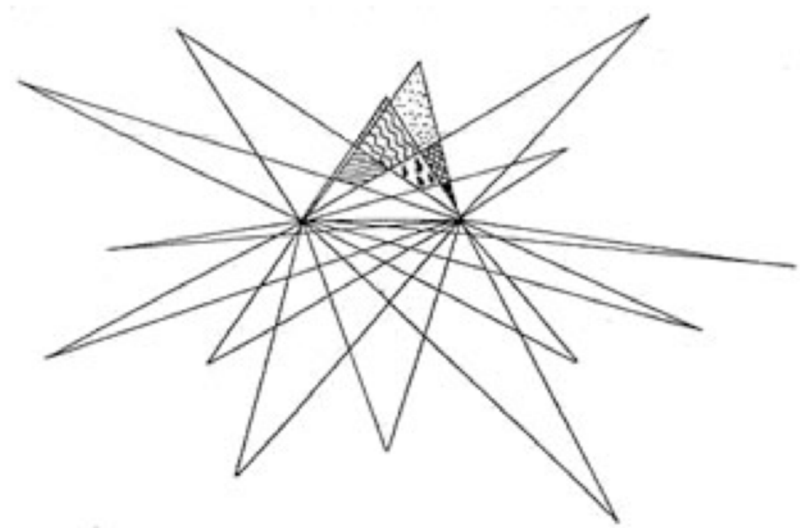
1. Place 2 dots 3-5 inches apart in the center of the paper. Very lightly label each dot "1" and "2". Connect the 2 dots, with the ruler, to create a horizontal line segment.

2. Draw 15 to 20 dots all over the paper (dots may not be along the horizontal line segment and area if the line segment were extended to edge of paper). The dots should be scattered around on the paper (some should be near the edges). These will be the points (angles) on the design. The fewer the dots, the easier the design for young children.

3. Use a ruler for every line segment. (Students have a tendency to want to draw the segments free-handed. A straight line is needed.)

4. Color the design using colored pencils. Options could include using only 2 colors. The 2 colors could be chosen after the discussion of primary, secondary and complimentary colors has taken place. You may color spaces with just solid colors and with texture.

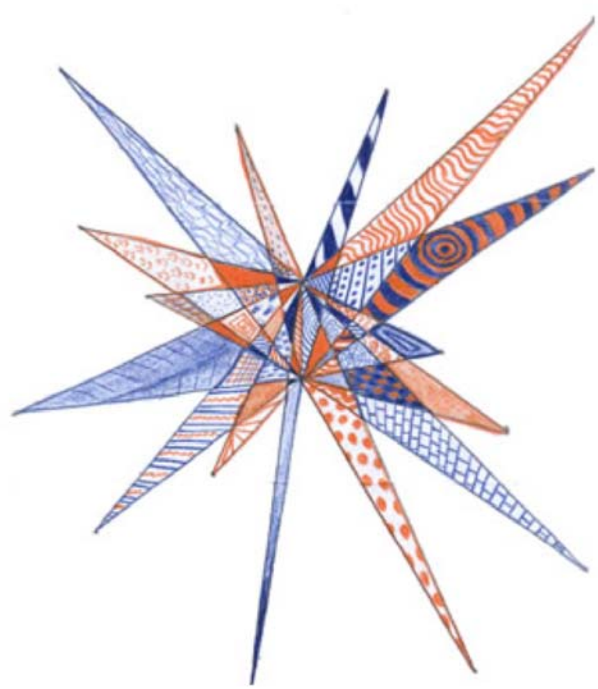
For every space colored with a solid color, there must be at least 2 with a texture or design. The sample below allows 7 spaces to be left white.



5. Cut the star burst from the white paper, leaving a small border of white outlining the design. Mount on black or other colored paper.

6. Possible discussion:

- Name the triangles created
- How many line segments were needed? What if we reduced the number of dots to 10? Etc.
- What was the largest angle created? Size?
- What was the smallest angel created? Size?
- How many total triangles can you find in the design? Quadrilaterals? Pentagons? Hexagons? Etc.



The Art of Geometry

Nine Patch

Objective:
To increase knowledge in the area of geometry and visual arts by creating quilt squares

Prior to Lesson:
It is best to cut all of the squares to save time, put the students' squares in their bag ready to hand out, thread should be cut before project - 18 inches long, parent volunteers are needed as well, it would be nice to include community quilters to help

Materials:
material, needles, thread, rulers, pencils, plastic baggies, scissors

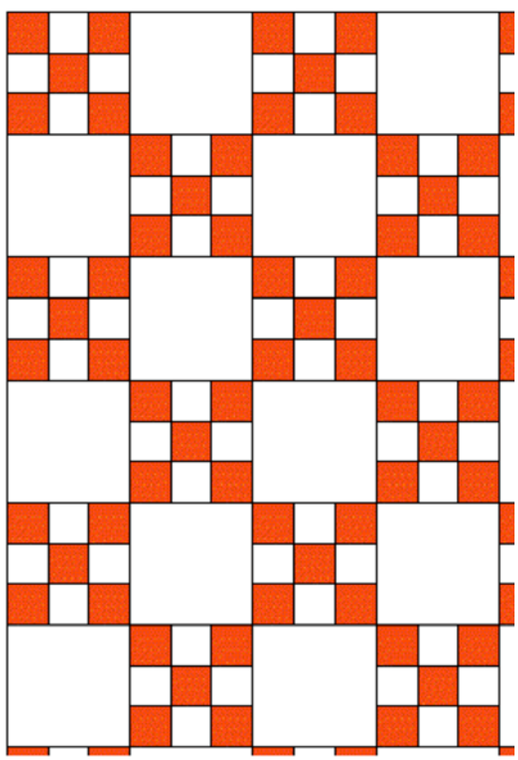
Procedures:
1. Discuss quilts with students. Include the purposes of quilts and how math and art are in quilts.
2. Discuss what a nine-patch block looks like.
3. Discuss how some quilts have patterns. Have students define the word "pattern."
4. Have students create patterns with square tiles or squares cut out from construction paper.
5. Have students select their own group members and decide upon a theme and colors. Limit the colors to two.
6. Discuss how much material will be needed to purchase at the store. If each square has to start out 4 1/2 by 4 1/2 inches, and each student will need nine squares, how much material is needed of each color? Explain to the students that 1/4 of an inch overlaps when sewing, which results in the square's ending measurements to be 4 inch squares. The nine-patch block will be 12 inches in length and height.
7. Take the students' request of colors and themes to a local quilt shop or store that sells fabric. Purchase extra in case of a mistake when cutting out squares. At this time also purchase thread and needles for the students. It is also helpful to purchase quarter inch quilter's rulers to mark sewing lines on the fabric.
8. Send a letter home to parent requesting volunteers.

9. Check with the local quilt stores, churches, or parents to find experienced quilters. Both the community involvement and the experience will be an added benefit!
10. After purchasing the material, cut squares to be 4 1/2 by 4 1/2 inches and cut thread to be 18 inches long.
11. Once squares are cut, pass out plastic baggies and have students put their names on the front.
12. Lay squares on a table and have students one at a time come and pick out their 9 squares. Have the students place their baggies in a basket designated for their group.
13. Arrange desk in groups of 12 or 9. Label each group a number for organizational purposes. Place group's basket in the middle, which should contain: thread, baggies of student's material, needles, quarter inch quilter's rulers and pencils to mark sewing lines.
14. Depending on your volunteers, you can demonstrate and instruct in small groups or large groups.
15. Instruct students on how to thread a needle. Teach students how to knot the thread at the end.
16. Students need to mark their sewing lines. Have students lay out the top row of squares facing printed side up. Take the right square and flip it on top of the middle square. The backside of the right square should be on top. Using the quarter inch quilter's ruler and pencil, place the ruler on the right edge of the flipped over square. Using the pencil, mark a line showing 1/4 inch from the edge.
17. Once the sewing line has been marked, have students pick up their thread and needle. Remind students to keep the material together just as it is. Explain to the students that they will be sewing in an up and down pattern on the marked line. Starting on the edge of the fabric, have the student stab the needle down through the material on the sewing line. Pull the needle all the way through. Have the student stab the needle up through again 1/8 of an inch away from the last stitch. Let students know that there should be 8 to 10 stitches per every inch of fabric.
18. Once the student has sewn across the entire line, show students how to knot the thread at the end.
19. Have students gently pull apart their squares to see the seam. Have the student place the squares back on their desk facing up. Students should have two blocks sewn together and the left block remaining.
20. Flip the left block onto the middle block. The backside of the left block should be facing up. On the left edge, mark the sewing line.
21. Using the same technique, sew the blocks together.
22. Continue to do this procedure for all three rows. Once they are complete, the rows must be sewn together.

23. Lay all three rows facing up on the desk. Flip the top row onto the middle row. The backside of the top row should be facing up. Using the ruler, mark the sewing line at the top of the flipped over row. Sew the rows together.
24. Once finished, place the material back on the desk facing up. The top row and the middle row should be connected. Flip the bottom row onto the middle row. The backside of the bottom row should be facing up. Mark the sewing line at the bottom of the flipped over row. Sew the rows together.
25. This should complete the nine-block square.
26. The teacher or a quilter can then sew the block together to make the quilt top.

Web Resources:

http://www.riverdeep.net/current/2001/11/112601_quiltedmath.jhtml
http://surfaquarium.com/newsletter/quilt.htm
http://www.womenfolk.com/historyofquilts/
http://www.historyofquilts.com/



Adapted from: http://www.lessonplanspage.com/MathArtofGeometryNinePatchQuilt58.htm

The Great Pyramid

Facts about the great pyramid:

The Great Pyramid is the most remarkable building in existence on the face of our planet today. It was built with such precision that our current technology cannot replicate it. This pyramid is so precisely constructed that until recently (with the advent of laser measuring equipment) scientists were not able to discover some it's subtle symmetries (not to mention duplicate them). Among other aspects, there are also very exact geometric relationships between all the structures in the pyramid complex at Giza.

It is facts such as these that should raise questions as to the commonly accepted (and mostly mistaken) interpretations of its purpose, history and construction, as well as the history of our society (and especially the so-called 'pre-history' of mankind). There are many answers out there; all you have to do is look.

Here are some facts that have recently been re-discovered about this structure...

General:

- The pyramid is estimated to have about 2 300 000 stone blocks weighing from 2-30 Tons each with some weighing as much as 70 tons.
- There is so much stone mass in the pyramid that the interior temperature is constant and equals the average temperature of the Earth, 20 Degrees Celsius.
- Two types of limestone were used for construction. A soft limestone either pure or nummulitic was used for the bulk of the core blocks and a hard white limestone for the mantle. Hard limestone becomes more polished with age.
- The base of the pyramid covers 55 000m2 (592 000 ft2) with each side greater than 20 000m2 (218 000 ft2) in area.
- The outer mantle was composed of 144 000 casing stones, all highly polished and flat to an accuracy of 1/100th of an inch, about 100 inches thick and weighing about 15 tons each.
- The average casing stone on the lowest level was 5 ft. long by 5 ft. high by 6 ft. deep and weighed 15 tons.

- The mortar used is of an unknown origin. It has been analyzed and its chemical composition is known but it can't be reproduced. It is stronger than the stone and still holding up today.
- The cornerstone foundations of the pyramid have ball and socket construction capable of dealing with heat expansion and Earthquakes.
- There are no hieroglyphics or writing in the Great Pyramid.
- With the mantle in place, the Great Pyramid could be seen from the mountains in Israel and probably the moon as well. Its polished surfaces would have reflected light like a beacon.
- Aligned True North: The Great Pyramid is the most accurately aligned structure in existence and faces true north with only 3/60th of a degree of error. The position of the North Pole moves over time and the pyramid was exactly aligned at one time.
- Centre of Land Mass: The Great Pyramid is located almost at the centre of the landmass of the Earth. At one stage in its history it may certainly have been. The east/west parallel that crosses the most land and the north/south meridian that crosses the most land intersect in two places on the Earth, one in the ocean and the other at the Great Pyramid.
- The relationship between Pi (π) and Phi (Φ) is expressed in the fundamental proportions of the Great Pyramid.

Numbers of relevance:

- The length of a base is 9131 Pyramid Inches from corner to corner in a straight line.
- The length of a base side at the base socket level is 9 131 Pyramid Inches or 365.24 Pyramid Cubits.
- The length of a base side at sidereal socket level is 9 131.4 Pyramid Inches or 365.256 Pyramid Cubits.
- The length of the perimeter at the sidereal socket level is 36 525.63629 Pyramid Inches.
- The perfect formula height of the pyramid including the missing apex is 5 813.2355653763 Pyramid Inches, calculated from perimeter of base divided by 2 Pyramid Inches.
- The height to the missing apex is 5 812.98 Pyramid Inches.
- The volume of the pyramid is: V = 1/3 base area x height = 161559817000 cubic Pyramid Inches = 10339828.3 cubic Pyramid Cubits. [(5813.2355653 Pyramid Inches)/3 * 9 131 Pyramid Inches * 9 131 Pyramid Inches]

Precision of engineering:

- The four faces of the pyramid are slightly concave, the only pyramid to have been built this way.
- The centers of the four sides are indented with an extraordinary degree of precision forming the only 8 sided pyramid. The effect is not visible from the ground or from a distance but only from the air, and then only under the proper lighting conditions.
- The granite coffer in the "King's Chamber" is too big to fit through the passages and so it must have been put in place during construction.
- Microscopic analysis of the coffer reveals that it was made with a fixed-point drill that used hard jewel bits and a drilling force of 2 tons.
- The coffer was sawn out of a block of solid granite. This would have required bronze saws 8-9 ft. long set with teeth of sapphires. Hollowing out of the interior would require tubular drills of the same material applied with a tremendous vertical force.
- The Great Pyramid had a swivel door entrance at one time. Swivel doors were found in only two other pyramids: Khufu's father and grandfather, Sneferu and Huni, respectively.
- It is reported that when the pyramid was first broken into that the swivel door, weighing some 20 tons, was so well balanced that it could be opened by pushing out from the inside with only minimal force, but when closed, was so perfect a fit that it could scarcely be detected and there was not enough crack or crevice around the edges to gain a grasp from the outside.
- If the height of the pyramid is taken as the radius of a circle, then the circumference of this circle is the same as the perimeter of the base. This provided the complimentary squaring of a circle and circling of a square. The key to this relationship is knowledge of the value of Pi and designing the angle of the pyramid to be exactly 51 degrees, 51 minutes, and 14.3 seconds.

Embedded Constants:

- Tropical Year or Calendar Year: The length of a base side is 9131 Pyramid Inches measured at the mean socket level, or 365.24 Pyramid Cubits, which is the number of days in a year [9 131/25 = 365.24, accurate to 5 digits]. The perimeter of the base divided by 100 = 365.24, the number of days in a year. [9 131 Pyramid Inches * 4 / 100, accurate to 5 digits]

- Tropical Year: The length of the Antechamber used as the diameter of a circle produces a circumference of 365.242 (accurate to 6 digits).
- Tropical Year: The ratio of the lengths of the Grand Gallery to the solid diagonal of the King's Chamber times 100 equals the number of days in a tropical year. [(1 881.5985600 / 51.516461) * 100 = 365.242200, accurate to 8 digits]
- Sidereal Year: The length of the antechamber of the King's Chamber times Pi = length of a sidereal year [116.26471 Pyramid Inches * 3.14159 = 365.25636 days, accurate to 8 digits]
- Sidereal Year: The length of a base side at sidereal socket level is 365.256 Pyramid Cubits. [accurate to 6 digits]
- Mean Distance to the Sun: Half of the length of the diagonal of the base times 10^6 = average distance to the sun
- Mean Distance to Sun: The height of the pyramid times 10^9 represents the mean radius of the Earth's orbit around the sun, or Astronomical Unit (AU). [5813.235565376 Pyramid Inches x 10^9 = 91848816.9 miles]
- Mean Distance to Moon: The length of the Jubilee passage times 7 times 10^7 is the mean distance to the moon. [215.973053 Pyramid Inches * 7 * 10^7 = 1.5118e10 Pyramid Inches = 238,865 miles]
- Sun's Radius: Twice the perimeter of the bottom of the granite coffer times 10^8 is the sun's mean radius. [270.45378502 Pyramid Inches* 10^8 = 427316 miles]
- Earth's Polar Radius: The Sacred Cubit times 10^7 = polar radius of the Earth (distance from North Pole to Earth's centre) [25 Pyramid Inches * 10^7 * (1.001081 in / 1 Pyramid Inches) * (1 ft / 12 in) * (1 mi/ 5280 ft) = 3950 miles]
- Earth's Polar Radius: The Pyramid embodies a scale ratio of 1/43200. The height * 43200 = 3938.685 miles, which is the polar radius of the Earth to within 11 mi.
- Radius of the Earth: The curvature designed into the faces of the pyramid exactly matches the radius of the Earth.
- Equatorial Circumference of the Earth: The Pyramid embodies a scale ratio of 1/43200. The perimeter of the base * 43200 = 24,734.94 miles, which is within 170 miles of the equatorial circumference of the Earth.

- Earth's Volume: The product of the pyramid's volume and density times 10^15 equals the ratio of volume to density of the Earth. [10339823.3 cubic cubits * 0.4078994 * 10^15 = 4.21760772 x 10^21 cubic cubits = 259.93 x 10^9 cubic miles]

- Earth's Mass: Mass of the pyramid = volume * density = 10339823.3 cubic cubits * 0.4078994 Earth density = 4217497. The mass converted to pyramid tons = 4217607.72 * 1.25 = 5,272,010 pyramid tons. Since the mean density of the Earth was defined as 1.0, then the mass of the Earth is 10^15 times the mass in pyramid tons = 5.272 x 10^21 pyramid tons = 5.99 x 10^24 Kg

- Speed of Earth around the Sun: The Pyramid Inch times 10^8 = the speed of the Earth around the sun, circa 2600BCE

- Mass of the Earth: The weight of the pyramid is estimated at 5955000 tons. Multiplied by 10^8 gives a reasonable estimate of the Earth's mass.

- Average Land Height: The average height of land above sea level for the Earth is 5449 inches. This is also the height of the pyramid.

- The Light Equation: The height of the Great Pyramid, minus the height of the capstone represents one-millionth the time it takes light to travel the mean radius of the Earth's orbit around the sun (1 astronomical unit) using 1 Pyramid Inch equals 24 hours (mean solar day). [(5813.2355653 - 103.0369176) /10^6 = .0057101986+ days = 493.36116 seconds = 8 minutes, 13.36 seconds]

- The Velocity of Light: With distance of one A.U. known and the transit time of light for this same distance the velocity of light can be found. [91848816.9 miles / 493.36+ seconds = 186169.5 miles/sec]

- The Sun's Parallax: The size of the Earth as viewed from the Sun and expressed as an angle and generally taken to be 1/2 the diameter at the equator (Solar Equatorial Parallax) is 8.9008091 seconds of arc using 91848817 miles as the mean distance to the sun and 3963.4914 miles as the equatorial radius. The distance between the mean socket level and the height of the leveled bedrock is 8.9008 Pyramid Inches.

Astronomical:

- The Descending Passage pointed to the pole star Alpha Draconis, circa 2170-2144BCE. This was the North Star at that point in time. No other star has aligned with the passage since then.

- The 344ft length of the Descending Passage provides an angle of view of only +/- 1/3 of a degree. Alpha Draconis has not been in alignment for thousands of years. The next alignment will be with the North Star, Polaris, in about 2004CE. Polaris in Greek means "Satan".

- The southern shaft in the King's Chamber (45 deg, 00 min, 00 sec) pointed to the star Al Nitak (Zeta Orionis) in the constellation Orion, circa 2450BCE The Orion constellation was associated with the Egyptian god Osiris. No other star aligned with this shaft during that Epoch.

- The northern shaft in the King's Chamber (32 deg, 28 min, 00 sec) pointed to the star Alpha Draconis, circa 2450BCE

- The southern shaft in the Queen's Chamber (39 deg, 30 min, 00 sec) pointed to the star Sirius, circa 2450BCE Sirius was associated with the Egyptian goddess Isis and is also part of a unique ceremony practiced by the African Dogon tribe.

- The northern shaft in the Queen's Chamber (39 deg, 00 min, 00 sec) pointed to the star Ursa Minor, circa 2450BCE

- Pyramids mirror Orion Constellation: The pyramid positions on the ground are a reflection of the positions of the stars in the constellation Orion circa 10400BCE Five of the 7 brightest stars have pyramid equivalents: The 3 great pyramids of Khufu, Khafra, and Menkaura for the belt of Orion, the pyramid of Nebka at Abu Rawash corresponds to the star Saiph, the pyramid at Zawat al Aryan corresponds to the star Bellatrix. The only two missing star positions are for Betelgeuse and Rigel.

- Marks Spring Equinox: Due to the angle of the sides of the pyramid vs. its latitude, it casts no shadow at noon during the spring equinox.

- Precession of the Equinoxes: The sum of the pyramid's two base diagonals in Pyramid Inches = length of the Precession of the Equinoxes (25827 years)

- Precession of the Equinoxes: The distance from the ceiling of the King's Chamber to the apex of the pyramid = 4110.5 Pyramid Inches. Which is the radius of a circle whose circumference = the precession of the equinoxes. [4110.5 * 2 * Pyramid Inches = 25827]

- Precession of the Equinoxes: The perimeter of the 35th course of blocks, which is much thicker than any of the other courses, gives a figure for the precession of the equinoxes.

Units of Measurement:

- The Pyramid Inch (PI) = 1.0011 present inches, and 1.0010846752 British Inches.

- The Pyramid Cubit or Sacred Cubit = 25 pyramid inches.

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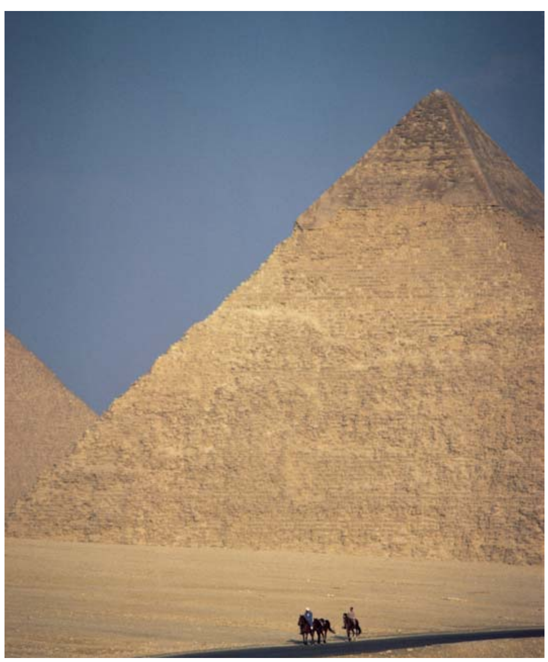

Resources

Websites

http://www.elainefitzgerald.com/jeopardygeometry.ppt
http://jc-schools.net/PPTs-math.html
http://www.math.dartmouth.edu/~matc/math5.geometry/unit5/unit5.html
http://www.geocities.com/EnchantedForest/Tower/1217/math.html
http://www.bulletinboardpro.com/BB15.html
http://dimacs.rutgers.edu/nj_math_coalition/framework/ch07/ch07_03-04.html
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http://www.lessonplanspage.com/MathAngles-IntSciSSArt3.htm
http://www.harcourtschool.com/glossary/math04/index6.html (luckie)
http://school.discovery.com/homeworkhelp/bjpinchbeck/bjmath.html
http://puzzlemaker.school.discovery.com/MathSquareForm.html
http://dmoz.org/Kids_and_Teens/School_Time/Math/
http://www.amathsdictionaryforkids.com/
http://library.thinkquest.org/2647/geometry/glossary.htm

Geometry Junkyard
Recreational and computational geometry, from coloring puzzles to hyperbolic geometry.
http://www.ics.uci.edu/~eppstein/junkyard/topic.html
Grade Level: Grade 5-12

2-D and 3-D Objects
Explore tutorials about the three-dimensional world, read a museum article about Plato's contribution to the study of the third-dimension, and use interactive tools to build, unfold and manipulate 3-D objects.
http://www.boxermath.com/plp/modules/three_d.shtml
Grade Level: Grade 7-12

2-D to 3-D Morphing
These instructions will teach you how to make pyramids, cubes and octahedrons.
http://pbskids.org/cyberchase/games/23dgeometry/
Grade Level: Grade 2-4

3.14ever
Explore the many different facts, myths, and purposes of pi.
http://library.thinkquest.org/CR0213924/
Grade Level: Grade 5-9

A Geometric Investigation of (a+ b)2
Explore an interactive demonstration of why (a b)2=a2 2ab b2.
http://illuminations.nctm.org/ActivityDetail.aspx?ID=127
Grade Level: Grade 9-12

Adam Ant
This Web lesson will teach you how to measure perimeters.
http://www.beaconlearningcenter.com/WebLessons/AdamAnt/default.htm
Grade Level: Grade 3-5

Learning Math: Geometry
A video- and Web-based course for K-8 teachers; 12 half-hour video programs, course guide, and Web site; graduate credit available
http://www.learner.org/resources/series167.html

Literature Books

Adler, David – Shape Up!
Berenstain, Stan - Old Hat, New Hat
Budney, Blossom - A Kiss is Round
Burns, Marilyn – The Greedy Triangle
Crews, Donald - Ten Black Dots
Ellis, Julie – What's Your Angle, Pythagoras?
FlashKids, Editors – Geometry (Flash Chart Series)
Friskey, Margaret - Three Sides and a Round One
Gillham, Bill - Let's Look for Shapes
Hill, Eric - Spot Looks at Shapes
Hoban, Tana- Circles, Triangles and Square
Hoban, Tana – Cubes, Cones, Cylinders, & Spheres
Hoban, Tana – Shapes, Shapes, Shapes
- Dots, Spots, Speckles and Stripes
- Round and Round and Round
- Shapes and Things
- Shapes, Shapes, Shapes

Jenkin, Bob H. – 61 Cooperative Learning Activities for Geometry Classes
Lionni, Leo - Pezzettino
Meiselman, Laura – What's Your Angle? And 9 More Math Games
Morgan, Sally - Squares and Cubes
Mower, Pat – Geometry Out Loud
Neushwander, Cindy - Sir Cumference and the Knights of the Round Table
Neushwander, Cindy – Mummy Math: An Adventure in Geometry
Neushwander, Cindy – Sir Cumference and the Sword in the Cone
Neushwander, Cindy – Sir Cumference and the First Round Table
Neushwander, Cindy – Sir Cumference and the Great Knight of Angleland
Pienkowski, Jan - Shapes
Pluckrose, Hentry - Shape - Pattern
Silverstein, Shel - The Missing Piece
Smith, Albert - Cut and Assemble 3-D Geometric Shapes