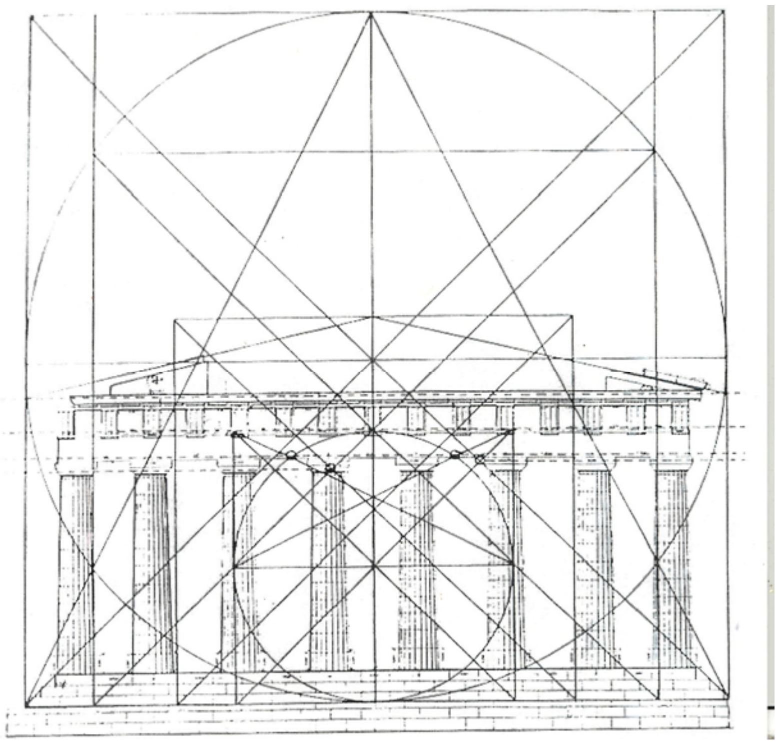


Math/Science Lesson Plans

DeeGee Lester, Director of Education

The Parthenon offers the rare opportunity for teachers to combine museum field trips with the math/science curriculum. The ancient Greeks made significant contributions to the foundations of math and science. Geometrical techniques developed by the Greeks centuries before the birth of Jesus are still used in surveying and building, measuring the earth, the creation of music, and in astronomical observations. The techniques, rules and formulas devised by these early pioneers in math and science continue to be used today by students and professionals in a variety of fields. The Parthenon itself, based upon the Golden Proportion and mathematical formulas to avert optical illusion, can serve as a *visual tool* to reinforce math concepts and explore the *aesthetics* of math.

<u>Lesson One:</u> ***Exploring the Foundations of Math & Science***

Goal:
The learner will discover the contributions of the ancient Greeks to math and science.

Standards: GLE.0606.1.7 through GLE 0806.1.7 (Historical context); √GLE 0806.1.3 (contributions of Pythagoras); √GLE 0806.1.4 (Relate to earth and science); Algebra I: GLE.3102.1.6; Algebra II: GLE 3103.1.6; Geometry: GLE.3108.1.6; Algebra I: √3102.1.17; Geometry: √3108.1.12;

Objectives:
As a result of this lesson the learner will know:

- The names and contributions of ancient Greek men and women to math and science.
- Where each name falls in a timeline of mathematical/scientific contributions.
- How the contributions of the Greeks differed and improved upon from those of earlier cultures such as the Egyptians and Babylonians.
- How modern mathematical and scientific "discoveries" are traced to those ancient roots.

Background:
Who would be the deity for math, science, and video games? Most students know that Athena is the goddess of war and wisdom. But many do not know that Athena was also the goddess of the useful arts. According to mythology, her gifts to mankind included letters and numbers and sequential order. As goddess of the useful arts, Athena taught the skills of weaving, making pottery, and fashioning utensils, each of which requires performing a *series of steps* that must be carried out in a *precise sequence* – skills also required in working a math problem, conducting a scientific experiment, or playing a video game.
(Source: Leonard Shlain, *Art and Physics: Parallel Visions of Space, Time & Light* (New York: Quill/William Morrow, 1991).

Historically, the ancient Greeks established many of the fundamental laws and theorems in math and science. The following activities acquaint students with these contributions.

1. *Exploring the roots of math and science.*
   Divide students into teams. Assign each team the task of investigating and reporting on the contributions of their individual. **Below are listed several names and a brief summery of their contribution.** Students should elaborate and expand on this listing by researching encyclopedias, books in the library, and by using the Internet with the name of the individual as the key word. In order to develop fundamental research skills, students should be encouraged to include in their reports a *combination of these sources* and not to rely solely on the Internet.

Thales of Miletus (c.630-550 B.C.)

The “father of Greek mathematics,” Thales initiated the requirement of *proofs*.

Pythagoras (c.570-490 B.C.)

Greek philosopher and founder of a prestigious school, he explored the relationship of mathematics and music, developed the “theory of means” connecting math with harmony, and advanced his famous “Pythagorean Theory.”

The Atomists

Democritus (460-357 B.C.); Epicurus (342-270 B.C.), and Lucretius (96-55 A.D.).

The Atomists advanced the notion that simple, indivisible, indestructible atoms formed the basic component of everything.

Praxitiles (400-320 B.C.)

Greek sculptor who devised the “8-head canon” used by sculptors in calculating human proportions for statues.

Aristotle (384-322 B.C.)

Scientist and one of the world’s premier philosophers, Aristotle served as tutor to Alexander the Great. His contributions include the classification of natural science and the identification and descriptions of 500 species.

Euclid (3rd century B.C.)

The most famous Greek mathematician and physicist, he was author of several books including *The Elements.*

Aristarchus (c. 310-230 B.C.)

Greek astronomer who determined the sun and not the earth was the center of the universe and that the earth rotated on its axis around the sun.

Archimedes (287-212 B.C.)

Developed the method of exhaustion by which he was able to compute areas and volumes to any desired accuracy. His many inventions included the screw and the catapult.

Erastosthenes (c. 276-195 B.C.)

Greek mathematician, astronomer, and geographer who developed the technique for computing the earth’s circumference and compiled a star catalog.

Apollonius of Perga (c. 260-185 B.C.)

He earned the title, “The Great Geometer” and is most famous for his efforts in conic sections.

Hipparchus (c. 180-125 B.C.)

He was the inventor of much of the mathematical vocabulary. As an astronomer, he catalogued over 1,000 stars. As a geographer, he applied mathematics to the determination of places on the earth's surface.

Ptolemy (100-178 A.D.)

An astronomer and "Father of Modern Geography," He devised the framework and vocabulary for geography. He also devised the principles of spherical trigonometry and astronomy.

Hypatia of Alexandra (c. 370-415 A.D.)

One of the first women who made a major contribution to math, she wrote a number of textbooks including *On the Conics of Appolonius.*

While researching their individual, students should be on the lookout for fun facts, controversies, and legends that bring their mathematician/scientist to life for classmates. For example, a student team might compare the school founded by Pythagoras with Plato's Academy or Aristotle's Lyceum while another team might demonstrate the displacement of water that caused Archimedes to run down the road shouting "Eureka!" When presenting their reports, the spokesperson for each group might also enjoy dressing as their character.

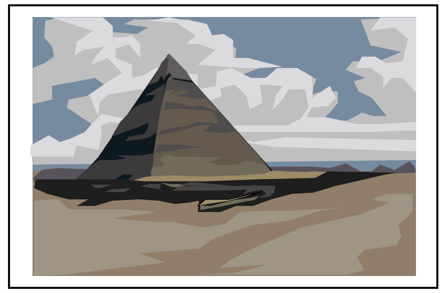
2. *Make a timeline.*

A timeline is an excellent visual tool to help students remember and to place people and events in the order of history. (Timelines are useful with a variety of subjects –history, language arts, visual arts, etc. – and are particularly helpful for test preparation). Now that students are acquainted with Greek mathematicians and scientists, ask them to **prepare a timeline** including names with bracketed dates for birth and death, theorems, inventions, etc**. When the class finishes ask them to look at their timeline to discover any overlapping that might indicate which mathematicians/scientists lived in the same time period and might have known each other or influenced each other's work; who built upon the findings of an earlier scholar; whether corrections were made by one mathematician for the work/formulas/inventions of an earlier mathematician; and how an invention built upon the foundations established by an earlier invention.**

3. *Tracing Greek advancements in math and science.*

The ancient Greeks were not the originators of mathematics or science. Earlier civilizations including the Egyptians and Babylonians used mathematics, simple machines, and even astronomy.

Students are familiar with the ancient *Egyptians'* use of hieroglyphics (picture representations) for both writing and numerals. But even the youngest can see that the base-10 system would be complicated for making mathematical calculations beyond simple addition. For example, the hieroglyphics required for larger numbers such as 5,789 requiring 29 figures! Imagine trying to write a math textbook using combinations of hieroglyphic figures. The Egyptians' may not have looked upon numbers in abstract ways, yet they came remarkably close to the Golden Ratio in their design for the Great Pyramid. The precision of Egyptian astronomical observations and calendar calculations were likewise impressive and made possible the prediction of Nile flooding.



By 2000 BC, the *Babylonians* had devised an advanced base-60 number system. Their specialty was the creation of mathematical tables for all sorts of things. Today we have access to ancient Babylonian text providing calculations for the digging of canals with tablets showing the required number of workers, the number of days for the digging, the wages of workers, etc. As with the Egyptians, the Babylonian numerical system proved difficult to interpret, using special number symbols that look complex.

In contrast to the mathematical practicality of the Egyptians and Babylonians, the *Greeks* began to explore the abstract qualities of mathematics. In the hands of philosophers, mathematics became an area of specialized study and argument, experimentation, and the formulation of *proofs.* Greeks such as Euclid, Archimedes, and Pythagoras devised rules, formulas, and theorems that are still in use more than 2,000 years later. In addition, the Greeks gave the world "square" and "cube' numbers, and portions of the Greek alphabet (such as π and Σ) are global symbols in mathematical equations.

π

Celebrate Pi Day!
March 14th
(keyword: *Pi*)

The Pythagorean theorem is an example of the power of *"proofs"* on mathematical history. Pythagoras was not the first to use the *he supplied the first written proof*. Crude usage dated back over 1,000 years to the Babylonians and Egyptians. a) Ask students to devise a problem proving the Pythagorean theorem. Standards √0806.1.3. **b) Next, use three lengths of rope to illustrate how the ancient Egyptians constructed right triangles. Knot the ropes with units of 3, 4, and 5-knot spaces; then stretch them to form a triangle. The sum of the shortest side multiplied by itself plus the next longest side multiplied by itself should equal the longest side multiplied by itself (9+16=25). Egyptians discovered that the right triangle would always end up opposite the longest side. *(See also, Lesson Plan #4 for more on Pythagorean Theorem).***

4 *Tracing modern mathematics and scientific discoveries to their ancient root: Prime Numbers.*

Standards: GLE.0406.2.3 (can be added as a *check for understanding since there's not one in the standards at this level*); √0506.2.1.

Activity: Today's computers can locate the largest *prime numbers*. **(Ask students to find the definition of a prime number).** However, the ancient Greek mathematician, *Eratosthenes* (276-195 B.C.) invented a clever way to find prime numbers. The technique is called the *Sieve of Eratosthenes*. **Using the following directions, find the prime numbers that are less than 100. First, make a chart of numbers 1 through 100 in rows of ten (1-10, 11-20, 21-30, etc).**

1). 1 **is crossed out because it is not a prime number.**

2). Circle 2, **which is the smallest prime number. Next cross out every 2nd number that is a multiple of 2 (4, 6, 8, etc. to 100).**

3). Circle 3, **the next prime number. Now cross out every third number, all multiples of 3 (6, 9, 12, 15, etc. to 100). Some such as 6 and 12 will already be crossed out since they are multiples of 2).**

4). Circle the next open number, 5 **and again cross out every 5th number. (Some will already be crossed out and students will notice there are few open numbers remaining).**

5). Continue the process until all the numbers up to 100 are either crossed out or circled as prime numbers.

Activity: Students should be invited to explore other ties between modern scientific or mathematical discoveries and their ancient roots. Examples include but should not be limited to the following:

a) ***The Archimedean screw* and how it is used today in waste treatment plants. See if your community uses this devise to pump wastewater or explore a web site such as the following: www.mcs.drexel.edu/crorres/Archimedes/Screw/Applications.html**
b) **(High School level): Review the ancient Greek scientists and mathematicians listed above and locate the *Atomists*. Describe their theory and the later theories and models including the 1913 Rutherford-Bohr Planetary Model of the Atom and the 1924 Neils Bohr-Louis de Broglie Model of the Atom. How has atomic research and theory evolved in the 20th century?**

***C.* Ask students to research a unique geared device, *The Antikythera Mechanism* (Nature Magazine, issue #444, 30 November, 2006). This second century BC Greek box, discovered in a shipwreck in 1901 appears to be a technologically complex machine that calculated, displayed, and predicted celestial activity such as lunar and solar eclipses and was, in effect, the world's first *analog computer* designed over 2000 years ago. Following years of research, surface-imaging, and high resolution X-ray tomography of device fragments, archaeologists, scientists, and computer experts were able to decipher the inscriptions and reconstruct the complex geared functions that allowed ancient Greeks to track cycles within our solar system with amazing accuracy.**

Invite students to explore this amazing ancient device through journals such as Nature (listed above) or Scientific American (June 1959) as well as through Internet sources (keyword: Antikythera Mechanism.

<u>Lesson Two:</u> *Simple Machines*

Goal:
The learner will understand that the Ancient Greeks developed a very advanced civilization that continues to influence our lives in many ways.

<u>Standards: GLE.0806.1.7; CLE.3102.1.6; CLE.3103.1.6; CLE.3108.1.6.</u>

Objectives:
As a result of this lesson, the learner will:

- Be able to identify six simple machines
- Know how simple machines can lessen the effort needed to do a job.
- Know how simple machines work.
- Know how simple machines helped to build the Parthenon.
- Partner with a classmate and research the Internet to choose a simple machine to make.
- Create a project notebook.

Activities: (Incorporating math, science, history, art, and architecture)

1. *Defining and identifying simple machines*
   A *simple machine* is a tool with few or no moving parts. Simple machines date back to antiquity and were used in everyday tasks and in the construction of buildings, monuments, and even irrigation systems. The pyramids, the Parthenon, and the Roman aqueducts are all the products of simple machines. The simplicity of these machines and the common need for tools that would be easy to make and handle, means that even remote societies invented and used similar objects.

   Identify six simple machines:

   Lever: A lever is a simple machine consisting of a rigid body such as a board or metal bar resting on a turning point called a *fulcrum.* The weight to be moved or lifted is called a *load.* **Ask students to draw an example of a lever in action (such as a board lifting a large rock, a hammer pulling a nail from a board, or two children playing on a seesaw**). In each picture students should identify the lever (L), the fulcrum (F), and the load or weight (W).

   Inclined Plane: An inclined plane is a flat surface that is higher on one end to ease the effort in moving a load from one level to another. **Ask students to draw an example of an inclined plane (a ramp, a slide, or a slanted road).** In each picture students should identify the inclined plane (I) and the load or weight (W). An inclined plane can be used to move objects up to a higher level or down to a lower level. Which direction is easier?

   Wedge: A wedge is made up of two inclined planes that meet and form a sharp edge. The wedge is used to split two objects apart when pressure or force is applied. **Ask students to draw an example of a wedge (a knife, fork, nail or ax).** In their drawings children should show how applied force (F) to the wedge (W) splits the object (O).

Screw: A screw is also made from an inclined plane, but this time the inclined plane winds around itself. A screw can hold objects together or be used to raise or lower solids or liquids such as water from one level to another. **Ask students to draw an example of a screw (a jar lid, light bulb, or a car jack).**

Wheel and Axle: An axle is a rod that goes through a wheel allowing it to turn more easily. This simple machine allows us to roll things from place to place. **Ask students to draw a picture of a wheel and axle (a car, roller skates, or door knob).**

Pulley: A pulley combines a wheel and a rope to create a simple machine capable of lifting a heavy load. The rope fits into a groove in the wheel with one end of the rope attached to the load. When you pull the other end of the rope, the load is lifted. **Ask children to draw an example of a pulley (the mechanism that hoists the flag on a flag pole, a construction crane or the apparatus that raises window blinds).**

2. *Associating simple machines with construction of the ancient Parthenon.* **Remember that the Parthenon was built 438 years before the birth of Jesus and constructed on top of the Acropolis, the highest point in Athens, rising approximately 200 feet above the city. The Greeks quarried marble from Mount Pentelicon and transported the marble approximately ten miles to the Acropolis.** Ask students to look over the list of simple machines (lever, inclined plane, wedge, screw, wheel & axle, and pulley) and determine which machines would be used to construct the ancient temple and how those machines were used in cutting, transporting, and lifting the marble.

3. *Creating a project notebook*
   Students may work individually or in teams to make an example of a simple machine (such as a pulley, wheel & axle, etc) to demonstrate to the class. In addition, students may create a project notebook including directions for construction of their simple machine, along with definitions and examples (drawings or magazine pictures) of the six types of simple machines and their answers to the question in activity #2.

Lesson Three:

Mathematical Calculations: The Source of Parthenon Beauty

Goal:

The learner will discover the relationship between mathematics and the aesthetic beauty of the Parthenon.

Standards: GLE 0806.1.7; √3102.1.6; √3103.1.6; √3108.1.6.

Objectives:

As a result of this lesson the learner will know:

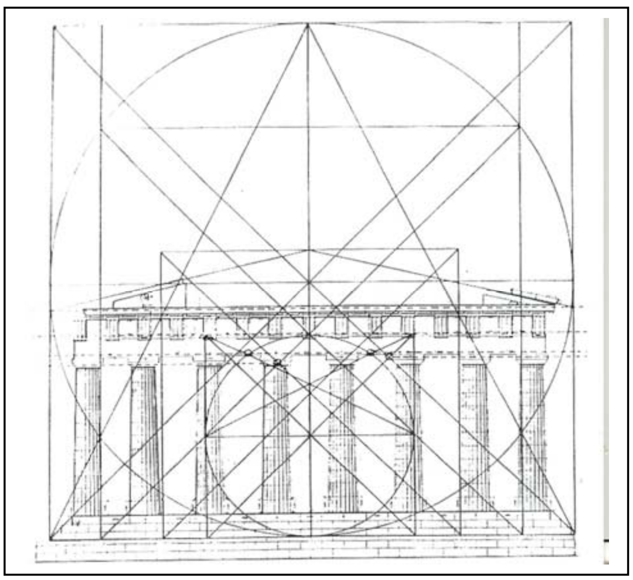
- The significance of the Golden Rectangle in regard to aesthetic appeal.
- How the Greeks used math in overcoming problems with optical illusion.
- The importance of balance and symmetry in building design and sculpture.
- How math calculations contributed to the aesthetic appeal of the Athena sculpture.

Background:

The ancient Greeks would love the dynamics of modern math, science, and technology – the computer, the split-second communications of the Internet and the cell phone, and the research into complex DNA. They would be especially excited by our "Golden Age of Astronomy" as mathematical calculations figure prominently in every aspect of today's space age – from launching the space shuttle and making adjustments to the Hubble Telescope to exploring new solar systems and black holes. All these advances reinforce the notions of the Greek philosopher and mathematician, **Pythagoras.** His philosophy was distinguished by its description of *Reality* in terms of arithmetical relationships. Pythagorean mathematics had tremendous influence on the famous Greek philosopher **Plato** who, along with his followers at the Academy, *believed that a study of mathematics held the key to all understanding.* Carved above the doorway leading into the Academy of Plato (423-348 B.C.) were these words: *Let no one ignorant of Geometry enter here."*

To the ancient Greeks, it was not numbers themselves that were important as the Egyptians and Babylonians believed, but the relationship between the numbers. These relationships were known as *ratios* and *proportions.* Through experimentation and the careful analysis and proof of findings, the ancient Greeks had already proven connections between math and nature, math and music, math and conceptual judgement. For example, a comparison of two things (mother:father, water:air, dog:cat) that we learn as babies is the most basic process of intelligence and the elementary basis for *conceptual judgment*, or how we figure things out. This comparison of two different things or ideas or quantities is a ***ratio*** or a measure of difference expressed in the formula *a:b* or *a* is to *b*.

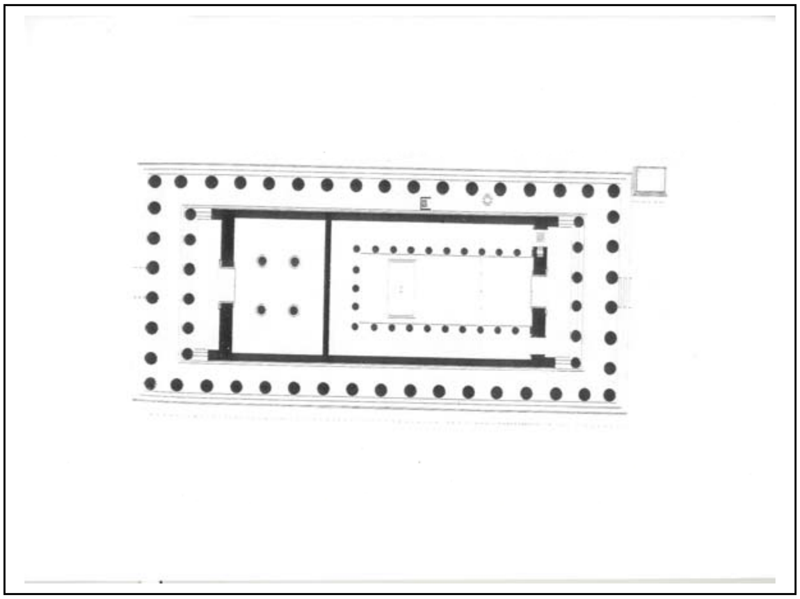
A ***proportion*** is more complex because it is the relationship equivalency between two ratios, or *one element is to the second element as the second element is to the third.* It is more subtle and profound than the simple difference in a ratio and is known in Greek thought as an ***analogy.*** Students should keep these mathematical terms in mind as they explore characteristics of Greek architecture, especially their reliance upon the *Golden Rectangle* (also referred to as the *Golden Proportion)* and *optical illusion* in designing and constructing the ancient Parthenon.



Activities:
The following exercises meet the following standards:

1. *The Golden Rectangle or Golden Proportion*
Standards GLE.0606.4.; GLE.0706.4; √can be used as check for understanding since there's not one in the standards for golden proportion.

The Greeks also saw the relationship between math and beauty and proved their theory that geometry is a way to create beauty and to give the illusion of perfection. These early mathematicians observed many proportional relationships in the natural world. One proportion that appears most often is the ***Golden Proportion.*** It is the ratio between two dimensions of a plane figure or the divisions of a line such that *the smaller is to the larger as the larger is to the sum of the two,* represented by the ratio 1:1.618 or roughly 3 to 5 or 4 to 9. The ancient Greeks considered this to be the perfect proportion and it shows up in nature as the *golden spiral* (evident in natural objects ranging from sea shells to pine cones) and the *golden rectangle* which figures prominently in ancient architecture, especially the Parthenon. The foundation of the Parthenon is composed of two golden rectangles corresponding with the two rooms of the building.



Describe the Golden Proportion as it relates to the Parthenon. ***(The ratio of the two rooms whereby the smaller is to the larger as the larger is to the sum of the two rooms.)*** The exterior of the Parthenon likewise fits into the golden proportion so that *the ratio of the entablature* (the area from the top of the columns to the top of the roof) *is to the column as the column is to the sum of the two.* The same proportion appears again inside the Naos that houses Athena. The double decking of columns surrounding the stature adds to the scale of the statue through the golden proportion whereby the top column is to the lower as the lower column is to the sum of the two.

Make a Golden Rectangle:

Construct a Square (A, B. C. D with A & B at the top left and right and D & C at the lower left and right).
Mark E as the midpoint between DC.
From midpoint E, draw a diagonal line to B.

Extend the line DC so that the vertical line BC is the midpoint of EF.
Using a compass anchored at E, swing an arc from B to F.
Extend a vertical line from F to G; then extend the line AB to G.
You have a Golden Rectangle.

2. *Optical Illusion*

Mathematical theories and computations were crucial to the *illusion* of perfection that sets apart the Parthenon from other architectural structures. An **optical illusion** is often the result of our eye structure (specifically, the curvature of the retina), oscillation as our eyes shift between two figures, or tricks played by our minds. In constructing the Parthenon the ancient Greeks understood that the straight lines on buildings, when viewed from a distance, often appear to curve in unintended directions. In their efforts to construct a visually perfect building, the ancient Greeks calculated and made architectural adjustments. The three most important are:

Curvature of the horizontal lines
Inclining of vertical lines
Slight bulge, or *entasis* of the columns.

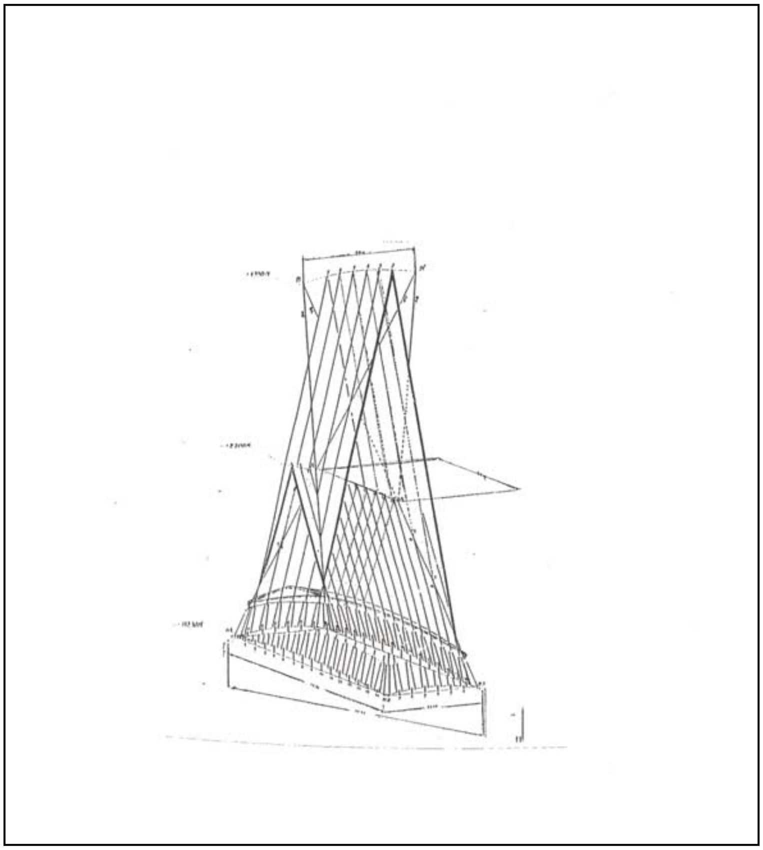
They knew, for example, that straight, *horizontal lines*, such as the floor or ceiling, often appear to sag when viewed from a distance. To compensate, they constructed these lines on a curve – higher in the center and curving down on the ends.

They also understood that *vertical lines*, such as walls and columns, could appear to lean outward from the building. To compensate for this illusion, the Greeks made all vertical lines tilt in slightly. Likewise, the entasis provided a third source of curvature to the lines of the building.

Other architectural refinements included minute adjustments in the setting of metopes and triglyphs, and the alignment and setting of columns. Through mathematical calculation and careful measurement to determine the exact degree of curvature, the Greeks assured these slight architectural adjustments created the graceful lines and *illusion of perfection* that make the Parthenon an architectural wonder.

Field Trip Observation Activity:

Look closely at the building during your field trip. How many of these refinements can you spot? Where must you be standing in order to detect these architectural adjustments? These architectural refinements contribute to the illusion of what image as one looks down the row of columns on the porches?



3. *Spatial Sense and Geometric Concepts*
Standards: GLE 0606.1.1 (math language); GLE 06061.7 through GLE 0806.1.7 (connection with real world); GLE 0806.3.5 (slope).

As mentioned earlier, the ancient Greeks' constant striving for balance, symmetry, and perfection was reflected in all aspects of their art, architecture, public lives and personal fulfillment. Balance and symmetry were considered the hallmark of perfection. For example, in the personal live the goal was a perfect balance of intellectual, physical, and spiritual development. This is reflected in their use of gymnasiums as not merely a place to "work out" physically, but as a place for study and participation in intellectual discussion with the great philosophers. The art and architecture also reflected this desire for perfect ***balance*** and ***symmetry.*** Take a moment to discuss what these words mean to you. **Balance** *is the combining of elements to create equilibrium.* ***Symmetry*** *is the arrangement of parts on opposite sides of a boundary so that the two halves are identical or mirror images.* **Following your field trip to the Parthenon in Nashville, discuss the building's architecture and details**

including the Pediments, Friezes, and Athena Statue. How do each of these reflect balance and symmetry?

4. *Proportion in the Athena Statue*

Praxitiles was a fourth century BC Greek sculptor of great reknown. He is credited with developing the **8-head canon** by which schulptors figure the proportions of the human body. This canon states that the size of the human body may be measured accurately and conveniently using the head size as a standard unit. With this measure, the adult body is approximately 8 heads tall. Alan LeQuire, sculptor of the Nashville Athena statue states, “It works for me. My head is 9” tall from chin to the top of the head and I am 6’ (or 72” tall). 8x9=72.”

As the ancient Greeks understood, distance can produce optical illusions that in art and architecture force the adjustment of lines in order to achieve the appearance of perfection. As we stand in the Naos and admire Alan LeQuire’s sculpture of Athena, what our eye sees is a perfectly proportioned figure. But, like the ancient Greeks, Alan understood that wherever we sit or stand in the Naos, we are looking at the 41’10” statue of Athena from a weird angle. In order to achieve the *illusion* of proportional perfection in his statue, Alan had to make adjustments to the sculpture. In other words, he turned to math. Lets look at just one of his adjustments: the size of Athena’s head. We have already explored **the 8-head canon** used in sculpting human figures. Alan understood that in order to achieve the illusion of perfection, he would have to increase the head size of Athena. Beginning with the 41’10” statue, he *subtracted* the 5 ft. base and the 4 ft. helmet, leaving 32’10” for the head and body of Athena.

A) **Now convert 32’10” into inches.**
B) **By dividing these inches by 8, you’ll get the size of Athena’s head according to the 8-head canon.**
C) **In order to increase the head size, divide the total number in “A” by 7 to give you the actual size of the head on the statue.**

<u>Lesson Four:</u> *Measurements and Calculations*

Goal: The learner will use practical skills to solve problems relating to the Nashville Parthenon.

Objectives:

As a result of this lesson the learner will:

- Identify geometric shapes, orders or patterns on the Parthenon’s exterior or interior.
- Determine the circumference of Athena’s shield.
- Determine the number of rotations necessary to roll the shield from its current location in the Naos to the doors.
- Display an understanding of the Pythagorean Theorem.

- Estimate the number of degrees in an obtuse angle.
- Determine the density of one of the bronze doors.
- Solve an ancient mathematical riddle.

Activities:

1. *Identifying Shapes and Patterns*
Using your Parthenon field trip, photographs of the Parthenon, or diagrams of the Doric and Ionic Orders, **locate the following shapes, order, or patterns** on the Parthenon's exterior and interior**:**

A Circle____________	A Triangle_______________
A Square _______________	A Rectangle _____________
Greek Key Pattern____________	Egg & Dart Pattern_________
Ionic Capital _____________	Doric Capital ____________

(Note: If you are using photos, look in the dictionary for examples of unfamiliar patterns such as the Greek Key or the Egg and Dart Pattern before answering the question).

A **volumetric shape** is a three-dimensional version of a two-dimensional shape. For example, a ball or sphere is a volumetric version of a circle. Can you name the volumetric versions of the following shapes: a square, a rectangle, a triangle? Can you locate volumetric shapes in the Parthenon?
Standards:√0406.4.21; √0406.4.17.

2. *Determining Circumference.*
Pi (π) is the sixteenth letter of the Greek alphabet. It is approximately 3.14159 representing the ratio of the circumference to the diameter of a circle. Let's figure the circumference of Athena's shield that has a diameter of 15 ft. using the formula, **Circumference =diameter x π.**
Standards: GLE.0406.4.1, GLE.0406.4.2; GLE.0406.4.3; √0606.4.12; √0606.4.13.

3. *Determining Rotations:*
Which number (diameter or circumference) would be necessary in determining how many rotations it would take to roll Athena's shield from its present location to the east door of the Parthenon? Now, **write a formula for the problem with the distance being 65'47". How many rotations would be required to roll the shield to the door?**
Standards: √0606.4.16.

4. *Pythagorean Theorem:*
Standards: GLE 0806.1.7; √0806.1.3; GLE 0806.4.1; √0806.4.1; √0806.4.2; spi 0806.4.1; spi 0806.4.2.
The **Pythagorean Theorem** states that *the sum of the squares of the lengths of the sides of a right triangle is equal to the square of the length of the hypotenuse.* Now let's consider the huge bronze doors of the Nashville Parthenon: the opening of the entire doorway is 14' with each

door measuring 7’ across, 24’ tall and weighing 7.5 tons. On your field trip to the Parthenon, note the semi-circular arc that forms a track in the floor at each door. By opening a door to the center of the art we form a right angle with the opening. Each side of the right triangle is 7 ft. **Using the Pythagorean theorem, find the length of the hypotenuse.**

Pythagorean Baseball:
www.pbs.org/wgbh/nova/proof/puzzlw/baseball)

Standards: GLE.0806.4.1; √0806.4.1; √0806.4.2; √0806.1.3; spi.0806.4.1; spi.0806.4.2.

5. *Estimate Angles:*
During your Parthenon field trip, you will see a model of a crane in the lower lobby near the video. It is roughly the shape of an obtuse angle. An **obtuse angle** *is an angle greater than 90 degree and less than 180* degrees. Use the spokes on the crane to estimate the number of degrees in the obtuse angle.

6. *Solve an Ancient Riddle:*
We do not know when Greek mathematician Diophantus lived (sometime between 100 and 400 A.D.). But thanks to a riddle created by an admirer, we know the age of Diophantus when he died. If you think computer games are challenging, try to solve this riddle to find his age at death.

> *Diophanus’ youth lasted 1/6 of his life. He grew a beard after 1/12 more of his life. After 1/7 more of his life, Diophantus married. Five years later he had a son. The son lived exactly ½ as long as his father, and Diophantus died just four years after his son’s death. All of this totals the number of years Diophantus lived.*

(Hint: Review of fractions will be helpful here:
$(1/6)n + (1/12)n + (1/7)n + 5 + (1/2)n + 4 = n$

Sources and Reading Suggestions:

Books:
A great place to start in firing up young students’ enthusiasm for math is with the collection of books by Theoni Pappas (World Wide Publishing/Tetra).

- *The Adventures of Penrose the Mathematical Cat* (1997). In story form, this delightful book introduces children to math concepts. Even the table of contents ignites the curiosity of young readers: “*Penrose meets the fractal dragon”; Penrose discovers the mathematics of soap bubbles”; “Penrose solves the case of the missing square”; to name a few.*
- *The Further Adventures of Penrose* (2004).
- *Math Talk: Mathematical Ideas in Poems for Two Voices* (1991). This brilliant

integration of math and language arts brings verbal learners and imaginative young minds to a new appreciation for mathematics. It makes a great participatory introduction to math at the beginning of the school year.

- *The Music of Reason: Experience the Beauty of Mathematics Through Quotations* (1995). Quotations introduce students to math and imagination, math and the arts, math and history, math and humor, and math and infinity, to name a few of the topics.
- *Franctals, Googles, and Other Mathematical Tales* (1993). What student could resist a math book with chapter titles such as *"Leonhard the Magic Turtle"* (topology and networks); *"Penrose Meets Lo Shu"* (magic squares); or *Doctor Spacemath,"* (logic problems).
- *The Joy of Mathematics: Discovering Mathematics All Around You* (1986)
- *More Joy of Mathematics* (1991)
- *The Magic of Mathematics* 1994) This trio of books introduces children to the many ways math can be enjoyed and appreciated through wonderful examples, games, and puzzles that make math concepts relevant to their lives.
- *Math Footprints: Discovering Mathematical Impressions All Around Us* (1999). From weather to architecture, this book makes students aware that they are surrounded by math.
- *Math-A-Day Calendar* (published annually). Explore a mathematical concept, challenge, or puzzle each day with your students.

Some other great choices:

- *Measure Up! A Bug Contest* by Frank Wilson (2003). A wonderful book for early elementary, especially appealing during Olympic years.
- *Exploring Math With Books Kids Love* by Kathryn Kaczmanski (1998). Combines math and language arts to explore math concepts through popular children's lit.
- *A Passion for Mathematics: Numbers, Puzzles, Madness, Religion, and the Quest for Reality* by Clifford A. Pickover (2005).
- *Vision in Elementary Mathematics* by W.W. Sawyer (2003 edition of 1964 classic).

High School level:

1. Bernal, J.D. *A History of Classical Physics* (NY: Barnes & Noble Books, 1972). This high school level book provides a brief, but excellent historical background for mathematics.
2. Clagett, Marshall. *Greek Science in Antiquity* (Mineola, NY: Dover Publications, Inc., 2001 ed.). A high school level exploration of the origins and development of Greek scientific theory – an easy read for those without scientific backgrounds.
3. Darling, David. *The Universal Book of Mathematics: From **A**bracadabra to **Z**eno's Paradoxes* (Hoboken, NJ: John Wiley & Sons, Inc., 2004). This book is and easy to use Mathematics dictionary and a great resource for teachers and students.
4. Hambridge, Jay. *The Parthenon and Other Greek Temples: Their Dynamic Symmetry* (New Haven: Yale University Press, 1974). Out of print and difficult to find, this book would be useful for students interested in architecture and engineering of the Parthenon.
5. Huntley, H.E. *The Divine Proportion: A Study in Mathematical Beauty* (Mineola, NY: Dover Publications, Inc., 1970). High school/college level book exploring aesthetics and universal order. A heavy, but wonderful read with exercises.
6. Klein, Jacob. *Greek Mathematical Thought & the Origin of Algebra* (Mineola, NY: Dover Publications, Inc. 1992). The development and impact of Greek number concept, mathematical thought, and achievement.

7. Livio, Mario. *The Golden Ratio: The Story of Phi, The World's Most Astonishing Number* (New York, NY: Broadway Books, 2003). An interesting and beautifully written book demonstrates, better than most, the integration of mathematics into all aspects of human history through the evolution of *phi.* This would be a great book combining mathematics with language arts, visual arts, and world history.
8. Mlodinow, Leonard. *Euclid's Window: The Story of Geometry from Parallel Lines to Hyperspace* (NY: A Touchstone Book, 2001) Another wonderful book integrating math with language arts and world history as the reader travels through five revolutions in geometry. It is funny, cleverly written, and a dramatic story.
9. Schimmel, Annemarie. *The Mystery of Numbers* (New York: Oxford University Press, 1993). This delightful book explores numbers through a revealing look at their meaning and use in folk lore, literature, symbolism and superstition throughout history and across cultures.
10. **Shlain, Leonard. *Art & Physics: Parallel Visions of Space, Time & Light* (NY: Quill/William Morris, 1991). This book, along with Simon Shama's *The Power of Art,* reveals the amazing foreshadowing of scientific breakthrough by visionary artists throughout history. A wonderful integration of science and the visual arts with world history and a great way for teachers in these specialized areas of study to demonstrate to students how the movement of history weaves together these diverse ideas and visions.**

Web Sites:

1. **www.perseus.tufts.edu/GreekScience/Students/Mike/geometry.html**.
2. **www.coe.uh.edu/archive/science/science_lessons/scienceles1/finalhome.htm**
3. **www.groups.dcs.st-andrews.ac.uk/~history/Mathematicians/Euclid.html**
4. **www.groups.dcs.st-andrews.ac.uk/~history/Mathematicians/Ptolemy.htl**
5. **www.math.utah.edu/~alfield/Eratosthenes.html**
6. **www.aleph0.clarku.edu/!djoyce/java/elements/html**
7. **www.home8.swipnet.se/~w80790/Works/Hypatia.htm**
8. **www.saitjoe.edu/~shf3124/Pythagoras.html**
9. **www.groups.dcs.st-andrew.ac.uk/~history/HistTopics/Babylonian_mathematics.html**
10. **www.groups.dcs.st-andrew.ac.uk/~history/HistTopics/Egyptian_mathematics.html**
11. **www.mcs.drexel.edu/crorres/Archimedes/Screw/Applications.html**
12. **www.mlahanas.de/Greeks/Inventions.htm**
13. **www.mlahanas.de/Greeks/ArchimedesGears.htm**.
14. **www.coolmath.com/home.htm**
15. **http://math.rice.edu/`lanius/Lessons/**
16. **http://halexandria.org/dward101.htm**
17. **www.studyplans.com/mathe,at.htm**
18. **www.geometrycode/sg/index.shtm/**
19. **www.mlahanas.de/Greeks/Kythera.htm**
20. **www.pbs.org/wgbh/nova/proof/puzzlw/baseball**
21. **www.geology.ucdavis.edu/~GEL115/115CH17oldirrigation.html**