BUILDING THE GREAT PYRAMID

Dear Educator:

Building the Great Pyramid takes us back more than 4,500 years to the Great Pyramid of Egypt and uses stunning special effects and ground-breaking archeological findings to uncover many of the myths and mysteries surrounding the construction of this ancient wonder.

This breathtaking documentary tackles the age-old questions of how and why this phenomenon was built. Many engineers today believe that even with the help of 21st-century technology, they still could not build anything comparable to the Great Pyramid. It is aligned with the four points of the compass with a near-perfect precision, and its base, which covers 13 acres, is level to within less than one inch!

Building the Great Pyramid premiered on The Discovery Channel on March 2, 2003 (with several rebroadcasts scheduled throughout March—please check **www.youthmedia.com** for details) and is now available on DVD and VHS, with over 10 minutes of footage not shown on American television. This one-hour program features the most-up-to-date archeological discoveries, compiled and presented by the award-winning BBC Natural History unit, as well as elaborate computer graphics from the Oscar-winning special effects team that brought Ancient Rome to stunning life in *Gladiator*. The result of this collaboration is the first scientifically and historically accurate account of the construction of mankind's last surviving Ancient Wonder.

Youth Media International and BBC Video are proud to provide you with this teacher's guide to *Building the Great Pyramid*. The definitive story behind this ancient marvel is further brought to life through a unique fictional storytelling method. Construction is seen through the eyes of Nakht (the voice of Omar Sharif), one of the thousands of men who came to help build the desert giant. Nakht guides us through forty years of his labor, describing not only how this ancient marvel was painstakingly constructed, but also who built it and why.

The material in this guide is geared to middle-school science students and can be used effectively whether or not your students have seen *Building the Great Pyramid*. The activities featured include: constructing a pyramid, figuring out how ramps were used in the construction of the Great Pyramid and analyzing ancient measuring techniques that are still used.

Activity sheets can be used as a unit or modified as stand-alone activities. Extension activities have been included to challenge students as well.

These materials can be downloaded in electronic format from **www.youthmedia.com**. Please share them with fellow teachers. To ensure that you receive future mailings, please fill out and return the enclosed reply card. We welcome your comments and suggestions.

Sincerely,

Roberta Nusim

Roberta Nusim
Publisher

Target Audience

The activities in this program have been designed for middle-school science students in grades 6 to 8, but they can be extended to students in other grades who show an interest in Egyptology.

Program Components

1. This teacher's resource guide
2. Three reproducible student activity sheets
3. A teacher response card

Program Objectives

1. To introduce the concepts of angles, perpendicularity, measuring, scale and proportion
2. To examine ancient methods of construction and physics and how they apply today
3. To introduce the Pythagorean theorem and develop critical thinking skills

How To Use This Guide

- If necessary, modify activities to suit the interests and abilities of your students.
- It is not necessary to see *Building the Great Pyramid* to complete these activities, but viewing the series will enhance the learning experience.
- Use the extended activities to further expand on the ideas and discussions.

Overview

Building the Great Pyramid follows our guide, Nakht, from the time when he is first conscripted to work on the Great Pyramid of Giza until he works his way up to senior overseer. Through his eyes, you'll see the construction of the greatest tomb known to man. Brilliantly polished casing stones clad the pyramid and the top sparkles with a gold capstone. The base covers 13 acres and is level to within less than one inch! It is aligned to the four points of the compass to near-perfect precision. Inside, an intricate network of passageways leads to three chambers. In one, the King will be laid to rest in a vast granite sarcophagus along with unimaginable riches. Here, he will become a medium for all his subjects between heaven and earth, god and man, life and death, and all order will depend on him. *Building the Great Pyramid* will not just tell you, but show you, how these ancient people built this great monument—the last of the Seven Wonders of the Ancient World to have survived.

MAKING IT STRAIGHT

ACTIVITY ONE

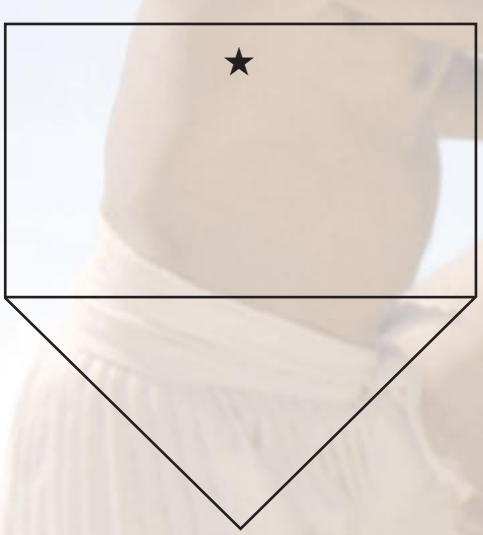
Materials

Scissors, masking tape, string, coin (preferably a penny or a nickel), cardboard, protractor

Concepts

Right angles, perpendicularity, use of a protractor, angle measurement, astronomy

Part A. Divide students in groups of three or more. One member should act as a holder, another as a measurer, the third as a recorder. Students may rotate these responsibilities.



PLUMB BOB TEMPLATE

Give students a piece of string cut to one meter. Then cut out the image of the plumb bob from this page. Use the image as a template on a piece of cardboard or other rigid material, such as a file folder. Using several pieces of masking tape, have students securely tape a coin (a penny will do) to one side of the image. They can punch a hole in the area marked with the star using a sharp object. Have them attach the string to the image by using a piece of tape to hold it tightly. It is important that the string be flush against the plumb bob to keep it straight. Tell your students to hold the string so that the bob is slightly off the ground. They can wrap excess string around their hand.

Students should come to the conclusion that the string measures perpendicularity and that gravity is the force that is pulling the bob toward the ground. Tell them that plumb lines are still used in construction today to assure that walls are perpendicular to floors.
Answers to Part A. 1. The force of gravity or simply gravity. 2. 90°, 3. 90°, 4. 90°, 5. 90°, 6. To keep them straight.

Part B. The Egyptians measured everything by the motion of the stars—the setting of their calendars, the flooding of the Nile—and they did so by noticing that all the stars moved. Everything in the night sky was in motion, except for one dark still point. Around that point two stars turned in a constant circle. Today we call those stars circumpolar stars but to Egyptians they were *The Indestructibles*, what they thought was the location of heaven itself. On one night each year, one of The Indestructibles stars was directly above the other. A plumb line held up and aligned with the two stars at that moment passed exactly through the point, fixing it with perfect accuracy. It was to this point that the Great Pyramid was aligned.

Put a large dot on the chalkboard. Use the plumb bob to place a second dot about 30cm directly below. Then draw several other dots at various distances and not aligned directly under the upper dot. Have students stand about three meters back and use the plumb bob to find which dot is directly below the upper dot.

Building the Great Pyramid tells us that the night sky appears to move around an empty point in space around which The Indestructibles moved yearly. Tell your students that if they observe the night sky in 2003, they would notice that the sky appears to move around a star called Polaris or the North Star. The position of the earth's axis, the point that seems to be the center of the rotation, has changed. (A 26,000-year period of rotation has been calculated partially by the study of Egyptian documents.)

Extended Activity

The method used by the Egyptians to determine if the base of a structure such as a pyramid has each of its sides perpendicular is called "squaring." To determine if a structure is "square," all a person has to do is measure the length of the distance to the opposite angles. Tell your students that these lengths are called *diagonals*. If the diagonals are equal, the sides are perpendicular (90 degrees). Tell students that a four-sided figure whose opposite sides are equal is a rectangle.

Ask students to find four objects that appear to be rectangular. Suggest that students look at desks, floor tiles, white board or anything else that appears to have its opposite sides equal.

Measure each diagonal and record its length. Is it really a rectangle? Then ask students to find three objects that they think are not rectangular and measure their diagonals. Have them confirm or disprove their original thinking.

MAKE YOUR OWN PYRAMID

ACTIVITY TWO

Materials

Oak tag paper, ruler, pencil, calculator, tape, protractor

Concepts

Scale, ratio/proportion, comparison, estimation

Part A. In this exercise, students will construct a scale model of the Great Pyramid. Explain to your students that the Great Pyramid is 3,000 times larger than the scale, so 1cm = 30m. Tell them that when it was built over 4,000 years ago, the Pyramid was 145.75 meters high (481ft), but over the years, it has lost 10 meters (30ft) off its top.

On a piece of oak tag, have students measure a square with sides 7.7cm in length. Ask them to mark off the midpoint of each side and draw a 6.2cm line outward from each side of the square. Using the Pythagorean theorem, have them determine the length of the hypotenuse. Answer: $(3.85)^2 + (6.2)^2 = (7.29)^2$.

Each side of the square should generate two right triangles. Have students draw the triangles on all four sides. They must then cut the template out of the oak tag. Finally, to complete the pyramid, they will fold the triangles inward toward the center of the square and join two adjacent sides of the triangles with tape, continuing around the square until the pyramid is complete.

Part B.

1. Area of the base = (length of side)^2 = $(7.7)^2$ = 59.29cm

2. Area of each side of the pyramid = 1/2 bh = 1/2(7.7)(6.2) = 23.87cm

3. Surface area of the scale model = 4(23.87) + 59.29 = 154.77cm

Part C.

Tell students to divide each actual height by 30 and round to the nearest tenth or hundredth to obtain the scaled size. Any object they choose as a representation is acceptable. Then ask them to choose any other buildings around the world or in your own community and complete the chart.

Ask students to look up the heights of the following buildings:

Empire State Building: **http://www.esbny.com/** Actual height—443.2m to the top of the lightning rod. Scale height: 14.7cm

Eiffel Tower: **http://www.tour-eiffel.fr/teiffel/uk/** Actual height—324m to top of the flagpole. Scale height: 10.8cm

Leaning Tower of Pisa: **www.endex.com/gf/buildings/ltpisa/ltpinfo.htm** Actual height—55.8m. Scale height: 1.8cm

Extended Activity

Create scale models of the other two pyramids on the Giza Plateau: Khafre and Mankawre. Tell your students to use the Pythagorean theorem to determine the height of each triangle on each side of the square base.

Dimensions:

Khafre: BASE: 214.5m (on each side) HEIGHT: 143.5m

Mankawre: BASE: 110m (on each side) HEIGHT: 68.8m

RAISING THE BLOCKS

ACTIVITY THREE

Materials

Rubber bands (at least one per group), paper clips, marker, meter stick or ruler, large textbook, small weight capable of stretching the rubber band when held vertically

Concepts

Estimation, percent, research technique, scientific method, analysis

Part A.

Of the 2,300,000 blocks (each weighing around 2.5 tons) in the Great Pyramid, 70% are contained in the bottom third. Ask your students to calculate how many blocks this represents (1,610,000) and why they think that number is so high.

Tell your students that the area covered by the Great Pyramid can accommodate St. Peter's in Rome, the cathedrals of Florence and Milan in Italy, and Westminster Abbey and St. Paul's Cathedral in London combined. They may want to do some research to find out more about these structures.

Part B.

Students are to compare the stretching of a rubber band by a weight when the weight is held vertically on the end of the rubber band and when it is pulled up an inclined plane. When the rubber band is limp, have students mark a pair of dots 2cm apart in the center of the band. Then have students measure the distance between the dots when the object is attached and the band is stretched. A paper clip makes attachment easier. Students may use a textbook for the incline and raise the incline to see the effect of the force on the rubber band. The activity may be done quantitatively or qualitatively, depending on the abilities of the students. The greater stretching when the weight is suspended, compared to when the weight is pulled up the ramp, shows that it takes less force to lift a weight up a ramp than to lift it straight up.

Extended Activity

Divide the class into groups and have them research the following:
Religion: What were the religious beliefs of the Egyptians around 2,500 B.C.? What role did the Pharaoh play in this religion? What role did religion play in the Egyptians' everyday life? Why did the Egyptians build pyramids? How did the Great Pyramid fulfill their religious beliefs?

Who built the Pyramids?: What types of artisans were necessary? Were the builders slaves or conscripts? What skills were needed? What were the working and living conditions at the pyramid site?

Other Pyramids: Research at least three other pyramids and compare them to the pyramid at Giza. How is the pyramid at Giza unique? Find out about the inner chambers of the Great Pyramid at Giza.

The Nile River: What role did the Nile River play in the lives of the Egyptian people? How did the river affect the culture of the Egyptians? How was the Nile important to the building of the pyramids?

Climate and Geography: What kind of climate did Egypt have? Where is Egypt located geographically? Describe the topography, natural resources, and national products of ancient Egypt and modern Egypt.

History: What was the world like more than 4,500 years ago in Egypt? With what other countries did Egypt compete, trade and coexist? Did Egypt have any enemies? Find out about King Khufu and other kings who had pyramids built.

Resources

Building the Great Pyramid DVD and VHS from BBC Video
Building the Great Pyramid, by Kevin Jackson and Jonathan Stamp, Firefly Books, 2003.
Building the Great Pyramid on The Discovery Channel Web site: http://www.discovery.com/games/pyramid/pyramid.html
Egyptian Museum: http://homepage.powerup.com.au/~ancient/museum.htm
Downloadable educator's guide at www.youthmedia.com

Building the Great Pyramid is available on DVD and VHS wherever videos are sold. It retails for $14.98 (DVD) and $9.95 (VHS). The DVD extras include hours of behind-the-scene features, interviews, photo galleries and fact files.

Youth Media International
P. O. Box 305, Easton, CT 06612 (203) 459-1562
www.youthmedia.com

Reproducible Master

MAKING IT STRAIGHT

ACTIVITY ONE

Part A. The base of the Great Pyramid at Giza covers 13 acres and is level to within less than one inch! In *Building the Great Pyramid*, we saw that a building and measuring device called a plumb bob was used. A plumb bob is simply a weight that comes to a point on its bottom and is suspended on a long string. The term plumb comes from *plumbum*, the ancient word for lead. The modern chemical symbol for lead is Pb from this ancient name.

Follow your teacher's directions for making a plumb bob.

Now, here are a few things to figure out with your plumb bob.

1.What makes the plumb bob seem to be attracted to the floor?

_____

_____

2. Keeping the plumb slightly above the floor and using the protractor, what is the angle the bob makes with the floor?

_____

3. Move your plumb bob to other parts of the room and measure the angle it makes with the floor in at least two other places. What are the angles there?

_____

4. Choose any wall. Using the plumb bob and protractor, what is the angle the wall makes with the floor?

_____

5. Now go to a corner. What is the angle there?

_____

6. Why do you think the Egyptians used the plumb bob in the construction of houses, temples and pyramids?

_____

Khufu's priest uses a pendulum to align the pyramid site with the stars.

The conscripts strategically position the pyramid's capstone.

Part B. In *Building the Great Pyramid*, we learn that the Egyptians measured everything by the motion of the stars—the setting of their calendars, the flooding of the Nile—and they did so by noticing that all the stars moved. Everything in the night sky was in motion, except for one dark still point. Around that point two stars turned in a constant circle. Today we call those stars *circumpolar stars* but to Egyptians they were *The Indestructibles*, the location of heaven itself. On one particular night each year, one star was directly above the other. A plumb line held up against the two stars at that moment passed exactly through the point, fixing it with perfect accuracy. It was to this point that the Great Pyramid was aligned.

Your teacher will place large dots on the board. Stand about three meters away and follow your teacher's directions to determine which is in a straight line. What are your findings?

_____

_____

_____

_____

In *Building the Great Pyramid*, we learn that the night sky appeared to move around an empty point in space around which the two stars revolved yearly. If you were to observe the night sky in 2003, you would notice that the sky appears to move around a star called Polaris or the North Star. What do you think might account for this difference?

_____

_____

Reproducible Master

MAKE YOUR OWN PYRAMID

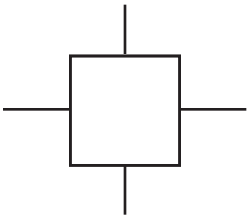
ACTIVITY TWO

Part A. As seen in *Building the Great Pyramid*, the Great Pyramid at Giza began with a square base. In fact, if you take a horizontal cross-section of the Great Pyramid at any level, you'd find a square.

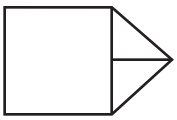
Now, you're going to construct a scale model of the Great Pyramid. The Great Pyramid is 3,000 times larger than your scale model. Therefore, the scale 1cm = 30m is needed to complete the construction.

1. Draw a square on a piece of oak tag with each side measuring 7.7cm in length.

2. Now, mark off the midpoint of each side. From the midpoint of each side, draw a 6.2cm length line outward, as you see below. Use a protractor to draw the line, making sure it is at a 90° angle.



3. Then, connect the end of your outward line to the corner of the square, forming two right triangles on each side. Draw the triangles on each of the four sides of the square.



The laborers haul stone blocks into the King's burial chamber using an A-frame and ropes.

Using the Pythagorean theorem ($a^2 + b^2 = c^2$), determine the length of the hypotenuse. What's your answer?

_____

4. Cut out the template. Fold each triangle side along the edges of the square toward the center of the square base.

5. Align the sides of triangles and tape into place. Repeat until the pyramid is complete.

Part B. Using the dimensions of your scale model, determine the following.

1. What is the area of the base of the scale model pyramid?
   Formula:
   Area = (length of sides)^2 _____

2. What is the area of each of the large triangles (each face of the pyramid)? Formula: Area = 1/2 base x height.

_____

3. Calculate the total surface area of the scale model.
   Formula: 4(area of the large triangles) + area of the base = total surface area

_____

Part C. As we discussed above, our scale is 1cm = 30m. In the chart below, fill in the blanks to show actual heights, scaled heights and other objects that represent the scaled-down heights.

OBJECT	ACTUAL HEIGHT	SCALED HEIGHT (1CM=30M)	OBJECT TO REPRESENT SCALED-DOWN HEIGHT
Great Pyramid	145.75m	4.9cm	Paper pyramid
Statue of Liberty	92m	3cm	Paper clip
Sears Building	443m	14.8cm	
Average person	1.7m	.05m	
Eiffel Tower			
Leaning Tower of Pisa			
Empire State Building			

RAISING THE BLOCKS

ACTIVITY THREE

Part A. It took more than 20,000 people more than 20 years to build the Great Pyramid at Giza for King Khufu. The pyramid's large square base covers about 13 acres and is aligned to the four points of the compass in near-perfect precision.

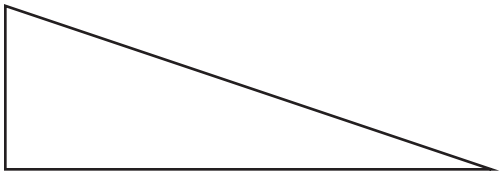
If 2,300,000 blocks of stone were used to build the Great Pyramid and 70% were used in the bottom third, how many stone blocks were dragged there?

_____

Why do you think a majority (70%) of the building materials were used on the lower level?

_____

Part B. The simple machine that enabled the Egyptians to build such tall structures is the inclined plane. As some people were building the base of the pyramid, others were constructing ramps (inclined planes of sand, dirt and scrap building material that enabled the builders to push the stones to the next level). As the pyramid grew, so did the height of these ramps.



INCLINED PLANE

You can make an inclined plane in your classroom or at home.

1. You will need a rubber band, a paper clip, a metric ruler and a textbook.
2. Make two dots on the rubber band that are two centimeters apart.
3. Choose an object such as a small weight, a metal pen, keys or any object that will cause the rubber band to stretch. Attach the weight to the rubber band using the paper clip.
4. Hold the rubber band vertically so it can stretch, and measure the distance between the dots you drew on the rubber band.

The conscripts pull a 50-ton block of stone up a ramp to the King's burial chamber.

The conscripts cut the stone in the Khufu Quarry.

5. Record your findings below.
6. Lay your textbook flat on your desk and have your partner raise one end of the book off of the surface of the desk. This book will serve as a ramp.
7. Place an object such as another book under the raised end of the book. Measure the height of your "ramp."
8. Gently pull the object up the ramp, measuring the distance between the dots on the rubber band. You may do your measuring while pulling the object vertically and calculating the distance between the dots, just before it moves. Record both the height of the ramp and the distance between the dots below.
9. Repeat four more times, at four different heights. Record in the data table.

Vertical height (cm) of ramp	Distance between dots (cm)
1. _____	1. _____
2. _____	2. _____
3. _____	3. _____
4. _____	4. _____
5. _____	5. _____

What advantage does using the inclined planes have over lifting an object?

_____

_____

How do you think the Egyptians used the inclined plane in building the Pyramid?

_____

_____