



# **Mayan Mathematics and Architecture**

**Goals 2000 - Partnerships for  
Educating Colorado Students**

**In Partnership with the Denver Public Schools  
and the Metropolitan State College of Denver**

El Alma de la Raza Project



# Mayan Mathematics and Architecture

By Julie Murgel

Grades 5-8

Implementation Time  
for Unit of Study: 3 weeks

Goals 2000 - Partnerships for  
Educating Colorado Students  
El Alma de la Raza Curriculum  
and Teacher Training Project

Loyola A. Martinez, Project Director

El Alma de la Raza Series

# Mayan Mathematics and Architecture

## Unit Concepts

- Understand and use the Mayan numerical system
- Compare and contrast the Mayan numerical number system to the Egyptian, Roman, and Babylonian numerical systems
- Measure and calculate area, volume, and perimeter in a Mayan temple
- Create a three-dimensional Mayan temple
- Design a Mayan temple replica on the computer

## Standards Addressed by This Unit

### Math

Students develop number sense, understand and use appropriate math vocabulary, understand and use numbers and number relationships in problem-solving situations, and communicate the reasoning used in solving these problems. (M1)

Students develop spatial sense and use geometric concepts, properties, and relationships in problem-solving situations and communicate the reasoning used in solving these problems. (M4)

Students use a variety of tools and techniques to measure, apply the result in problem-solving situations, and communicate the reasoning used in solving these problems. (M5)

Students link concepts and procedures as they develop and use computational techniques, including estimation, mental arithmetic, paper-and-pencil, calculators, computers, and other manipulatives in problem-solving situations and communicate the reasoning used in solving these problems. (M6)

Students understand and use appropriate technologies to perform mathematical constructions and computations, simulate mathematical experiences, and to access, process, and communicate information related to the application of mathematics in problem-solving situations. (M7)

### Reading and Writing

Students write and speak for a variety of purposes and audiences. (RW2)

Students read to locate, select, evaluate, and make use of relevant information from a variety of media, reference, and technological sources. (RW5)

### Visual Art

Students know and apply visual arts materials, tools, techniques, and processes. (A3)

## Introduction

The Golden Age of the Maya Civilization existed from around 250 B.C. to A.D. 800. About seven million Mayan Indians still live in parts of Honduras, El Salvador, Guatemala, Belize, Nicaragua, and southern Mexico.

Two particularly intriguing elements of the Maya civilization are mathematics and architecture. The Mayan number system used base 20. Numbers were represented by dots and bars. Also, the number system contained the number zero, a concept unknown to the Greek and Egyptian civilizations.

Mayan architecture is a fascinating subject. The Maya built many ornate temples of great height. They put vaulted hollows inside the roof sections to reduce weight. The structures contained many chambers and rooms. Within the city of Tikal alone, there were 3,000 buildings and more than 200 monuments. In the Yucatan Puuc region there is evidence of great site planning and architecture techniques. The Puuc design—buildings faced with limestone, archways framed by round columns, and elite mosaics—is named after this area. Many of the designs contained figures such as turtles, gods, or humans.

## Implementation Guidelines

This unit is designed for students in grades 5–8. It is recommended that this unit be taught as an interdisciplinary unit with a social studies unit about the Ancient Maya Civilization. An assessment key as been provided for the lessons. Two lessons are about Mayan mathematics and four lessons are about Mayan architecture. Lesson 5 has been designed as a home project for students to complete while they are working on the rest of the unit in school.

## Instructional Materials and Resources

- |          |   |
|----------|---|
| Lesson 3 | Computer Internet access                      |
| Lesson 6 | Computer access: ClarisWorks 2.1, 3.1, or 4.1 |

## Lesson Summary

- Lesson 1      **Mayan Numbers**  
Identification, conversion, and use of Mayan Numbers.  
Mayan number chart
- Lesson 2      **Comparison of Number Systems**  
A comparison and contrast between the Mayan numeral system and the Roman, Egyptian, and Babylonian systems.
- Lesson 3      **Using the Internet**  
Exploration of Mayan mathematics and architecture.
- Lesson 4      **Mayan Architecture 1: El Castillo**  
Making a paper-folding Maya pyramid and calculating the perimeter, area, and volume of the pyramid.
- Lesson 5      **Mayan Architecture 2: Replica of a Mayan Ruin**  
Creating a model of a Mayan structure.
- Lesson 6      **Mayan Architecture 3: Computer Graphics**  
Drawing a Mayan structure on the computer.
- Lesson 7  
(Extended)      **Mayan Head Number Molds**
- Lesson 8  
(Extended)      **Mayan T-shirt**

# Lesson 1: Mayan Numbers

## What will students be learning?

### STANDARD(S)

Students develop number sense, understand and use appropriate math vocabulary, understand and use numbers and number relationships in problem-solving situations, and communicate the reasoning used in solving these problems. (M1)

Students link concepts and procedures as they develop and use computational techniques, including estimation, mental arithmetic, paper-and-pencil, calculators, computers, and other manipulatives in problem-solving situations and communicate the reasoning used in solving these problems. (M6)

### BENCHMARK(S)

Students construct and interpret number meaning through real-world experiences and the use of hands-on materials and relate these meanings to mathematical symbols and numbers.

Students model, explain, and use the four basic operations—addition, subtraction, multiplication, and division—in problem-solving and real world situations.

### OBJECTIVE(S)

Students will identify Mayan numbers.

Students will convert a base 10 number to a base 20 number (Mayan) and vice-versa.

Students will use Mayan numbers to add, subtract, multiply, and divide.

### SPECIFICS

The Maya used a base 20 number system. They symbolized their numbers using dot and bars; where a dot equaled 1 and a bar equaled 5.

## What will be done to help students learn this?

### INSTRUCTIONAL STRATEGIES

Task description

Guided practice

Independent practice

Graphic organizer

### PRELIMINARY LESSON PREPARATION

To ease understanding of base 20, it is recommended that the teacher review with the students the concept of base 10 and powers of 10.

### ACTIVITIES

After the teacher illustrates and describes the Mayan numeric system, practice identifying Mayan numbers on Worksheet 1. Observe how to convert a Mayan number to our number system and vice-versa. Then complete section 2 on Worksheet 1 and all of Worksheet 2. With the teacher, practice adding, subtracting, multiplying, and dividing Mayan numbers. Independently, practice solving math problems that contain Mayan numbers on Worksheet 3.

## Lesson 1 (cont.)

### RESOURCES/MATERIALS

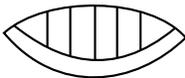
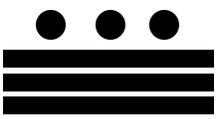
Mayan Mathematics Worksheets 1, 2, 3.

overhead transparency sheet of Mayan Number Chart

### ASSESSMENT

Use attached key to evaluate Mayan Mathematics Worksheets 1, 2, and 3.

## Mayan Number Chart

| Number | Mayan Form  | Number | Mayan Form  |
|--------|---|--------|---|
| 0      |    | 10     |    |
| 1      |    | 11     |    |
| 2      |    | 12     |    |
| 3      |    | 13     |    |
| 4      |  | 14     |  |
| 5      |  | 15     |  |
| 6      |  | 16     |  |
| 7      |  | 17     |  |
| 8      |  | 18     |  |
| 9      |  | 19     |  |

# Mayan Numbers: Worksheet 1

Name: \_\_\_\_\_

## Section 1

Directions: Using the Mayan Number Chart, identify each of the following numbers:

1.  = \_\_\_\_\_

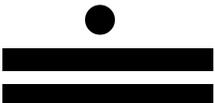
6.  = \_\_\_\_\_

2.  = \_\_\_\_\_

7.  = \_\_\_\_\_

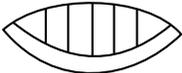
3.  = \_\_\_\_\_

8.  = \_\_\_\_\_

4.  = \_\_\_\_\_

9.  = \_\_\_\_\_

5.  = \_\_\_\_\_

10.  = \_\_\_\_\_

## Section 2

Directions: Convert and draw the Mayan numerical symbol for each number:

11. 12 = \_\_\_\_\_

16. 20 = \_\_\_\_\_

12. 17 = \_\_\_\_\_

17. 6 = \_\_\_\_\_

13. 4 = \_\_\_\_\_

18. 13 = \_\_\_\_\_

14. 11 = \_\_\_\_\_

19. 9 = \_\_\_\_\_

15. 10 = \_\_\_\_\_

20. 0 = \_\_\_\_\_

# Mayan Numbers: Worksheet 1 Answer Key

## Section 1

1.  = 2

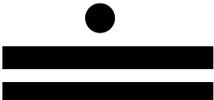
6.  = 4

2.  = 7

7.  = 9

3.  = 15

8.  = 5

4.  = 11

9.  = 6

5.  = 16

10.  = 0

## Section 2

11. 12 = 

16. 20 = 

12. 17 = 

17. 6 = 

13. 4 = 

18. 13 = 

14. 11 = 

19. 9 = 

15. 10 = 

20. 0 = 

# Mayan Numbers: Worksheet 2

Name: \_\_\_\_\_

**Directions:** Complete the following charts, using the example as a guide.

| Power of 20 | Mayan Number | Meaning         | Value  |
|-------------|--------------|-----------------|--------|
| 8000's      | ● ●          | $8000 \times 2$ | 16,000 |
| 400's       | ● ● ● ●      | $400 \times 4$  | 1,600  |
| 20's        | ● ● ●        | $20 \times 3$   | 60     |
| 1's         | ██████████   | $1 \times 5$    | 5      |

Total = 17,665

| Power of 20 | Mayan Number | Meaning         | Value |
|-------------|--------------|-----------------|-------|
| 8000's      |              | $8000 \times 6$ |       |
| 400's       |              | $400 \times 16$ |       |
| 20's        |              | $20 \times 5$   |       |
| 1's         |              | $1 \times 18$   |       |

Total =

| Power of 20 | Mayan Number                           | Meaning | Value |
|-------------|--|---------|-------|
| 8000's      | ●                                      |         |       |
| 400's       | ██████████                             |         |       |
| 20's        | ██████████<br>██████████               |         |       |
| 1's         | ██████████<br>██████████<br>██████████ |         |       |

Total =

| Power of 20 | Mayan Number                           | Meaning | Value |
|-------------|--|---------|-------|
| 8000's      | ●                                      |         |       |
| 400's       | ● ● ● ●                                |         |       |
| 20's        | ██████████<br>██████████               |         |       |
| 1's         | ██████████<br>██████████<br>██████████ |         |       |

Total =

| Power of 20 | Mayan Number | Meaning         | Value |
|-------------|--------------|-----------------|-------|
| 8000's      |              | $8000 \times 4$ |       |
| 400's       |              | $400 \times 5$  |       |
| 20's        |              | $20 \times 8$   |       |
| 1's         |              | $1 \times 16$   |       |

Total =

| Power of 20 | Mayan Number             | Meaning | Value |
|-------------|--------------------------|---------|-------|
| 8000's      | ██████████               |         |       |
| 400's       | ██████████               |         |       |
| 20's        | ██████████<br>██████████ |         |       |
| 1's         | ● ●                      |         |       |

Total =

## Mayan Numbers: Worksheet 2 Answer Key

| Power of 20 | Mayan Number | Meaning         | Value  |
|-------------|--------------|-----------------|--------|
| 8000's      | ● ●          | $8000 \times 2$ | 16,000 |
| 400's       | ● ● ● ●      | $400 \times 4$  | 1,600  |
| 20's        | ● ● ●        | $20 \times 3$   | 60     |
| 1's         | ██████████   | $1 \times 5$    | 5      |

Total = 17,665

| Power of 20 | Mayan Number                                    | Meaning         | Value  |
|-------------|---|-----------------|--------|
| 8000's      | ●<br>██████████                                 | $8000 \times 6$ | 16,000 |
| 400's       | ●<br>██████████<br>██████████<br>██████████     | $400 \times 16$ | 6,400  |
| 20's        | ██████████                                      | $20 \times 5$   | 100    |
| 1's         | ● ● ●<br>██████████<br>██████████<br>██████████ | $1 \times 18$   | 18     |

Total = 54,518

| Power of 20 | Mayan Number                           | Meaning         | Value |
|-------------|--|-----------------|-------|
| 8000's      | ●                                      | $8000 \times 1$ | 8,000 |
| 400's       | ██████████                             | $400 \times 5$  | 2,000 |
| 20's        | ██████████<br>██████████               | $20 \times 10$  | 200   |
| 1's         | ██████████<br>██████████<br>██████████ | $1 \times 15$   | 15    |

Total = 10,215

| Power of 20 | Mayan Number                           | Meaning         | Value |
|-------------|--|-----------------|-------|
| 8000's      | ●                                      | $8000 \times 1$ | 8,000 |
| 400's       | ● ● ● ●                                | $400 \times 4$  | 1,600 |
| 20's        | ██████████<br>██████████               | $20 \times 10$  | 200   |
| 1's         | ██████████<br>██████████<br>██████████ | $1 \times 15$   | 15    |

Total = 9,815

| Power of 20 | Mayan Number                                | Meaning         | Value  |
|-------------|---|-----------------|--------|
| 8000's      | ● ● ● ●                                     | $8000 \times 4$ | 32,000 |
| 400's       | ██████████                                  | $400 \times 5$  | 2,000  |
| 20's        | ● ● ●<br>██████████                         | $20 \times 8$   | 160    |
| 1's         | ●<br>██████████<br>██████████<br>██████████ | $1 \times 16$   | 16     |

Total = 34,176

| Power of 20 | Mayan Number             | Meaning         | Value  |
|-------------|--------------------------|-----------------|--------|
| 8000's      | ██████████               | $8000 \times 5$ | 40,000 |
| 400's       | ██████████               | $400 \times 5$  | 2,000  |
| 20's        | ██████████<br>██████████ | $20 \times 10$  | 200    |
| 1's         | ● ●                      | $1 \times 2$    | 2      |

Total = 42,202

# Mayan Numbers: Worksheet 3

**Directions:** Using the Mayan numerical system, compute each problem. Be sure the final answer is in Mayan numerical symbols.

Name: \_\_\_\_\_

|  |   |  |         |  |
|--|---|--|---------|--|
|  | + |  | Total = |  |
|--|---|--|---------|--|

|  |   |  |         |  |
|--|---|--|---------|--|
|  | - |  | Total = |  |
|--|---|--|---------|--|

|  |   |  |         |  |
|--|---|--|---------|--|
|  | × |  | Total = |  |
|--|---|--|---------|--|

|  |   |  |         |  |
|--|---|--|---------|--|
|  | ÷ |  | Total = |  |
|--|---|--|---------|--|

# Mayan Numbers: Worksheet 3 Answer Key

|            |   |            |  |  |
|------------|---|------------|--|--|
| <br>11,346 | + | <br>11,006 | $8000 \times 2$<br>$400 \times 15$<br>$20 \times 17$<br>$1 \times 12$<br>Total = | $16,000$<br>$6,000$<br>$340$<br>$12$<br><hr/> $22,352$ |
|------------|---|------------|--|--|

Add across each line first. Check your answer by adding the two complete numbers.

|            |   |            |   |  |
|------------|---|------------|---|--|
| <br>11,346 | - | <br>11,006 | $8000 \times 4$<br>$400 \times 6$<br>$20 \times 5$<br>$1 \times 3$<br>Total = | $32,000$<br>$2,400$<br>$100$<br>$12$<br><hr/> $34,503$ |
|------------|---|------------|---|--|

Subtract across each line first. Check your answer by subtracting the two complete numbers.

|            |   |            |         |               |
|------------|---|------------|---------|---------------|
| <br>90,915 | × | <br>42,022 | Total = | 3,820,430,130 |
|------------|---|------------|---------|---------------|

|        |   |       |         |   |
|--------|---|-------|---------|---|
| <br>18 | ÷ | <br>6 | Total = | 3 |
|--------|---|-------|---------|---|

# Lesson 2: Analysis of Number Systems

## What will students be learning?

### STANDARD(S)

Students develop number sense, understand and use appropriate math vocabulary, understand and use numbers and number relationships in problem-solving situations, and communicate the reasoning used in solving these problems. (M1)

Students write and speak for a variety of purposes and audiences. (RW2)

### BENCHMARK(S)

Students construct and interpret number meanings through real-world experiences and the use of hands-on materials and relate these meanings to mathematical symbols and numbers.

Students prepare written and oral presentations using strategies such as list, outlining, cause/effect relationships, comparison/contrast, problem/solution, and narration.

### OBJECTIVE(S)

Students will compare/contrast the Mayan numerical system to other ancient number systems.

Students will prepare a comparison chart for three different ancient number systems.

### SPECIFICS

Primitive people used fingers, strings, and pebbles to count. Eventually people found ways to count by arranging numbers. Different number systems had different bases. There were systems of base 5, 10, 12, 20, and even 60. Many of the ancient number systems started with the number 1. However, the Mayan numerical system had a symbol for zero.

## What will be done to help students learn this?

### INSTRUCTIONAL STRATEGIES

Organizer

Student-directed activity

Summarizing

### ACTIVITY

Complete the charts for Roman numbers, Egyptian numbers, and Babylonian numbers on Worksheet 4. Refer to the number charts in an encyclopedia or to the information provided by the teacher. Compare and contrast the ancient number systems of the Romans, Egyptians, and Babylonians with the Mayan number system. Write a summary paragraph of your findings on Worksheet 5.

### RESOURCES/MATERIALS

encyclopedia: "N" for number systems

Mayan Number Chart

Worksheets 4 and 5

### ASSESSMENT

Use key to grade Worksheets 4 and 5.

# Number Systems: Worksheet 4

Name: \_\_\_\_\_

**Directions:** Complete the following charts, using the example as a guide.

**Roman Number System:**

The Romans used letters to symbolize numbers. They used two principles: the additive principle and the subtractive principle. For example, the number VI (6) uses the additive principle. The first symbol, V (5) is greater than the second symbol, I (1), so you add the two symbols. In the number IV (4), the second symbol, V (5) is greater than the first, I (1), so you subtract the first symbol from the second. The Romans used base 10 and started their number system at 1.

| Arabic   | Roman | Arabic    | Roman |
|----------|-------|-----------|-------|
| <b>1</b> |       | <b>6</b>  |       |
| <b>2</b> |       | <b>7</b>  |       |
| <b>3</b> |       | <b>8</b>  |       |
| <b>4</b> |       | <b>9</b>  |       |
| <b>5</b> |       | <b>10</b> |       |

**Egyptian Number System:**

The Egyptians used a base 10 number system. They represented their numbers with hieroglyphics (picture writing). The Egyptian system started at the number 1 and did not include symbols between 2 and 9. The position of the number did not change the value of the number.

| Arabic   | Egyptian | Arabic         | Egyptian |
|----------|----------|----------------|----------|
| <b>1</b> |          | <b>8</b>       |          |
| <b>2</b> |          | <b>9</b>       |          |
| <b>3</b> |          | <b>10</b>      |          |
| <b>4</b> |          | <b>100</b>     |          |
| <b>5</b> |          | <b>1000</b>    |          |
| <b>6</b> |          | <b>10,000</b>  |          |
| <b>7</b> |          | <b>100,000</b> |          |

**Mayan Number System:**

The Maya wrote their numbers from bottom to top. They used a base 20 system. They symbolized their numbers with bars and dots. They also had a symbol which represented zero. The Mayan number chart is in Lesson 1.

**Babylonian Number System:**

The Babylonian number system used base 60. They used groups of symbols to represent numbers. The first group illustrated the 1's place. The second group illustrated the 60's place, and so on. They used a wedge-like design for their symbol. By 1500 B.C., the Babylonians also developed a base 10 number system.

| Arabic   | Babylonian | Arabic    | Babylonian |
|----------|------------|-----------|------------|
| <b>1</b> |            | <b>6</b>  |            |
| <b>2</b> |            | <b>7</b>  |            |
| <b>3</b> |            | <b>8</b>  |            |
| <b>4</b> |            | <b>9</b>  |            |
| <b>5</b> |            | <b>10</b> |            |

**Arabic Number System:**

The Arabic number system uses base 10. It is the number system we use today in the modern world. The position of a number determines its value. The Arabic number system was not developed or used by ancient Arabs. In fact, the number system was developed in India. The number system was brought to Persia, where it was translated into Arabic and used by Arabic mathematicians. The Arabs introduced the system to Europe, where it became widely used.

# Number Systems: Worksheet 4 Answer Key

## Roman Number System:

The Romans used letters to symbolize numbers. They used two principles: the additive principle and the subtractive principle. For example, the number VI (6) uses the additive principle. The first symbol, V (5) is greater than the second symbol, I (1), so you add the two symbols. In the number IV (4), the second symbol, V (5) is greater than the first, I (1), so you subtract the first symbol from the second. The Romans used base 10 and started their number system at 1.

## Egyptian Number System:

The Egyptians used a base 10 number system. They represented their numbers with hieroglyphics (picture writing). The Egyptian system started at the number 1 and did not include symbols between 2 and 9. The position of the number did not change the value of the number.

## Mayan Number System:

The Maya wrote their numbers from bottom to top. They used a base 20 system. They symbolized their numbers with bars and dots. They also had a symbol which represented zero. The Mayan number chart is in Lesson 1.

## Babylonian Number System:

The Babylonian number system used base 60. They used groups of symbols to represent numbers. The first group illustrated the 1's place. The second group illustrated the 60's place, and so on. They used a wedge-like design for their symbol. By 1500 B.C., the Babylonians also developed a base 10 number system.

## Arabic Number System:

The Arabic number system uses base 10. It is the number system we use today in the modern world. The position of a number determines its value. The Arabic number system was not developed or used by ancient Arabs. In fact, the number system was developed in India. The number system was brought to Persia, where it was translated into Arabic and used by Arabic mathematicians. The Arabs introduced the system to Europe, where it became widely used.

| Arabic | Roman | Arabic | Roman |
|--------|-------|--------|-------|
| 1      | I     | 6      | VI    |
| 2      | II    | 7      | VII   |
| 3      | III   | 8      | VIII  |
| 4      | IV    | 9      | IX    |
| 5      | V     | 10     | X     |

| Arabic | Egyptian | Arabic  | Egyptian |
|--------|----------|---------|----------|
| 1      | /        | 8       | /// //   |
| 2      | //       | 9       | //// //  |
| 3      | ///      | 10      | ∩        |
| 4      | ////     | 100     | ∩        |
| 5      | /////    | 1000    | ∩        |
| 6      | ////     | 10,000  | ∩        |
| 7      | ////     | 100,000 | ∩        |

| Arabic | Babylonian | Arabic | Babylonian |
|--------|------------|--------|------------|
| 1      | ∟          | 6      | ∟∟∟∟       |
| 2      | ∟∟         | 7      | ∟∟∟∟∟      |
| 3      | ∟∟∟        | 8      | ∟∟∟∟∟      |
| 4      | ∟∟∟∟       | 9      | ∟∟∟∟∟∟     |
| 5      | ∟∟∟∟∟      | 10     | ∟∟∟∟∟∟∟    |

# Number Comparison: Worksheet 5

Name: \_\_\_\_\_

**Directions:** Use the number charts on Worksheet 4 and the Mayan number chart to complete this page.

1. Compare and contrast the Roman number system and the Mayan number system.

|                     |
|---------------------|
| <b>Likenesses:</b>  |
| <br><br><br>        |
| <b>Differences:</b> |
| <br><br><br>        |

2. Compare and contrast the Egyptian number system and the Mayan number system.

|                     |
|---------------------|
| <b>Likenesses:</b>  |
| <br><br><br>        |
| <b>Differences:</b> |
| <br><br><br>        |

3. Compare and contrast the Babylonian number system and the Mayan number system.

|                     |
|---------------------|
| <b>Likenesses:</b>  |
| <br><br><br>        |
| <b>Differences:</b> |
| <br><br><br>        |

# Number Comparison: Worksheet 5 Answer Key

1. Compare and contrast the Roman number system and the Mayan number system.

**Likenesses:**

Numbers 1–4 are symbolized with a single symbol.

Numbers greater than 6 are symbolized with the symbols for 5 and 1.

**Differences:**

Mayan system had a symbol for zero; Roman system did not

Roman system had additive and subtractive principles.

Roman system used base 10 and Mayan system used base 20.

2. Compare and contrast the Egyptian number system and the Mayan number system.

**Likenesses:**

**Differences:**

Egyptian system used base 10 and the Mayan system used base 20.

Mayan system had a symbol for zero; Egyptian system did not.

The position of a numeral was significant in the Mayan system but not in the Egyptian.

3. Compare and contrast the Babylonian number system and the Mayan number system.

**Likenesses:**

**Differences:**

The Babylonian system used base 60 and the Mayan system used base 20.

The Mayan system had a symbol for zero; the Babylonian system did not.

# Lesson 3: Internet Search

## What will students be learning?

### STANDARD(S)

Students develop number sense, understand and use appropriate math vocabulary, understand and use numbers and number relationships in problem-solving situations, and communicate the reasoning used in solving these problems. (M1)

Students read to locate, select, evaluate, and make use of relevant information from a variety of media, reference, and technological sources. (RW5)

### BENCHMARK(S)

Students construct and interpret number meanings through real-world experiences and the use of hands-on materials and relate these meanings to mathematical symbols and numbers.

Students understand the structure, organization, and use of various media, reference, and technological sources as they select information for their reading, writing, and speaking purposes.

Students paraphrase, summarize, organize, evaluate, and synthesize information.

### OBJECTIVE(S)

Students will increase their understanding of the Mayan numerical system and Mayan architecture by using the Internet as a resource.

### SPECIFICS

Mathematics: The Mayan number system can be located on the Internet at many different addresses.

Architecture: The Maya built entire cities containing many different types of structures, including temples, pyramids, castles, housing units, markets, and plazas. In fact, the Maya even built courts to play a hand ball game. The Mayan cities were ceremonial cities rather than commerce cities. This can be witnessed in the types of buildings constructed. Students should be able to find many sites on the Internet that contain colorful pictures of these architectural structures.

## What will be done to help students learn this?

### INSTRUCTIONAL STRATEGIES

Student-directed activity

Reading comprehension

### PRELIMINARY LESSON PREPARATION

Obtain signed Internet permission slips before allowing students to use the Internet. Review process of how to retrieve information on the Internet with students.

### ACTIVITY

Search for “Maya” by using a search engine. Record any URLs that refer to Mayan numbers and/or architecture. Summarize your findings on Worksheet 6.

## Lesson 3 (cont.)

### RESOURCES/MATERIALS

Internet permission forms

Internet access

Summary sheet (WS 6)

URLs:

<http://www.okcommerce.com/terra/cultures/mayan/mayan1.html>

History of Mayan Culture

<http://www.kn.pacbell.com/wired/fil/pages/huntmayancivi.html>

Digging for the Ancient Maya

<http://www.astro.uva.nl/michielb/maya/links.html>

<http://www.civilization.ca/membris/civiliz/maya/mmc01eng.html>

### ASSESSMENT

Summary sheet (Worksheet 6) demonstrates thorough research.



# Lesson 4: Mayan Architecture 1—El Castillo

## What will students be learning?

### STANDARD(S)

Students develop spatial sense and use geometric concepts, properties, and relationships in problem-solving situations and communicate the reasoning used in solving these problems. (M4)

Students use a variety of tools and techniques to measure, apply the result in problem-solving situations, and communicate the reasoning used in solving these problems. (M5)

Students link concepts and procedures as they develop and use computational techniques, including estimation, mental arithmetic, paper-and-pencil, calculators, computer, and other manipulatives in problem-solving situations and communicate the reasoning used in solving these problems. (M6)

### BENCHMARK(S)

Students recognize, draw, construct, describe, and analyze geometric shapes in one, two, and three dimensions.

Students understand and apply the attributes of linear dimensions, capacity, weight, mass, time, temperature, perimeter, area, volume, and angle measurement in problem-solving situations.

Students develop, use, and analyze algorithms and formulas.

### OBJECTIVE(S)

Students will construct a replica of a Mayan pyramid.

Students will measure and compute the perimeter, area, and volume of a replica of a Mayan pyramid.

### SPECIFICS

The replica is a model of El Castillo, a four-stairway pyramid at Chichén Itzá. The Maya are believed to have celebrated a manifestation of the god Kukulcan, the feathered serpent at this pyramid. During the spring and fall equinoxes, a serpent appears to slither down El Castillo. In fact, Maya still celebrate this occurrence today.

Formulas needed to complete the lab sheet are:

Perimeter of a rectangle/square = Two Lengths + Two Widths ( $2L + 2W$ )

Area of a rectangle/square = Length x Width ( $A=L \times W$ )

Volume of a rectangle/square = Length x Width x Height ( $A=L \times W \times H$ )

## What will be done to help students learn this?

### INSTRUCTIONAL STRATEGIES

Teacher modeling

Hands-on activity

Independent practice

## Lesson 4 (cont.)

### PRELIMINARY LESSON PREPARATION

Teacher should construct a model of El Castillo for the students to use as a guide. When copying patterns on a photocopier, be careful not to cut off borders or change sizes of patterns. Piece 1 is the entire page, and might confuse students when they go to measure and cut. Also, the teacher should review with the students how to use a ruler and calculate area, perimeter, and volume. Complete the perimeter and area section on Worksheet 7 first, while the patterns are flat. Wait until the pieces are put together to calculate the volume, so that the students can see the actual height. Please note that area was calculated of the pieces flat, not as the surface area of rectangular prisms.

### ACTIVITY

Before beginning the paper-folding activity, complete table 1 and 2 on Worksheet 7. Then, construct the replica of El Castillo by following the guidelines. After completing the pyramid, complete the third table on Worksheet 7.

### MATERIALS

colored pencils/markers  
rulers  
glue  
El Castillo Lab: Worksheet 7  
pyramid pieces  
El Castillo Temple Guideline Sheet

### ASSESSMENT

Score lab sheet (Worksheet 7) by using the key. Score the pyramid by visual observation.

# El Castillo Lab: Worksheet 7

Name: \_\_\_\_\_

**Directions:** Calculate the perimeter, area, and volume of El Castillo, by measuring the dimensions of the two-dimensional pieces on following pages and using the formulas indicated.

1. Perimeter is the sum of the distance around a geometric figure: for a rectangle,  $P = 2L + 2W$ .

| Piece | Length | Width | $P = 2L + 2W$ |
|-------|--------|-------|---------------|
| 1.    |        |       |               |
| 2.    |        |       |               |
| 3.    |        |       |               |
| 4.    |        |       |               |

Total perimeter =

2. Area is the amount of space inside a flat geometric figure: for a rectangle,  $A = L \times W$ .

| Piece | Length | Width | $A = L \times W$ |
|-------|--------|-------|------------------|
| 1.    |        |       |                  |
| 2.    |        |       |                  |
| 3.    |        |       |                  |
| 4.    |        |       |                  |

Total area =

3. Volume is the amount of space inside a three-dimensional geometric figure:  $V = L \times W \times H$ .

| Piece | Length | Width | Height | $V = L \times W \times H$ |
|-------|--------|-------|--------|---------------------------|
| 1.    |        |       |        |                           |
| 2.    |        |       |        |                           |
| 3.    |        |       |        |                           |
| 4.    |        |       |        |                           |
| 5.    |        |       |        |                           |

Total volume =

# El Castillo Lab: Worksheet 7 Answer Key

1. Perimeter is the sum of the distance around a geometric figure: for a rectangle,  $P = 2L + 2W$ .

| Piece | Length     | Width     | $P = 2L + 2W$ |
|-------|------------|-----------|---------------|
| 1.    | 8.5 inches | 11 inches | 39 inches     |
| 2.    | 7.5 inches | 10 inches | 35 inches     |
| 3.    | 6.5 inches | 9 inches  | 31 inches     |
| 4.    | 5.5 inches | 8 inches  | 27 inches     |

**Total perimeter = 132 inches**

2. Area is the amount of space inside a flat geometric figure: for a rectangle,  $A = L \times W$ .

| Piece | Length     | Width     | $A = L \times W$         |
|-------|------------|-----------|--------------------------|
| 1.    | 8.5 inches | 11 inches | 93.5 inches <sup>2</sup> |
| 2.    | 7.5 inches | 10 inches | 75 inches <sup>2</sup>   |
| 3.    | 6.5 inches | 9 inches  | 58.5 inches <sup>2</sup> |
| 4.    | 5.5 inches | 8 inches  | 44 inches <sup>2</sup>   |

**Total area = 271 inches<sup>2</sup>**

3. Volume is the amount of space inside a three-dimensional geometric figure:  $V = L \times W \times H$ .

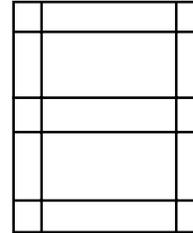
| Piece | Length     | Width      | Height   | $V = L \times W \times H$ |
|-------|------------|------------|----------|---------------------------|
| 1.    | 6.5 inches | 4.0 inches | 1 inch   | 26.00 inches <sup>3</sup> |
| 2.    | 5.5 inches | 3.5 inches | 1 inch   | 19.25 inches <sup>3</sup> |
| 3.    | 4.5 inches | 3.0 inches | 1 inch   | 13.50 inches <sup>3</sup> |
| 4.    | 3.5 inches | 2.5 inches | 1 inch   | 8.75 inches <sup>3</sup>  |
| 5.    | 3.0 inches | 2.0 inches | 2 inches | 12.00 inches <sup>3</sup> |

**Total volume = 79.50 inches<sup>3</sup>**

# Mayan Architecture: El Castillo Temple Guideline Sheet

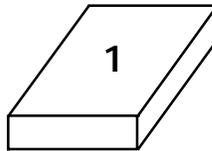
These seven steps are directions for completing the El Castillo Temple.

1. Color and decorate all parts of the Mayan Temple.
2. Cut out all sections of the temple.
3. Starting with piece 1, make folds and cuts on marked areas.

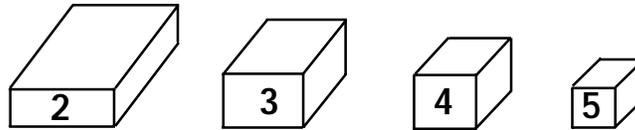


**Piece 1**

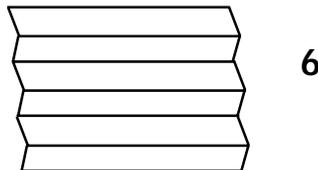
4. Using glue, fasten the corners and sides of piece 1 to form a rectangular prism.



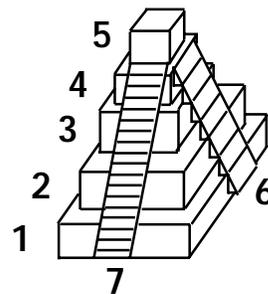
5. Repeat steps 3 and 4 to put together pieces 2, 3, 4, and 5.



6. To make four staircases, fold pieces 6, 7, 8, and 9 like an accordion.

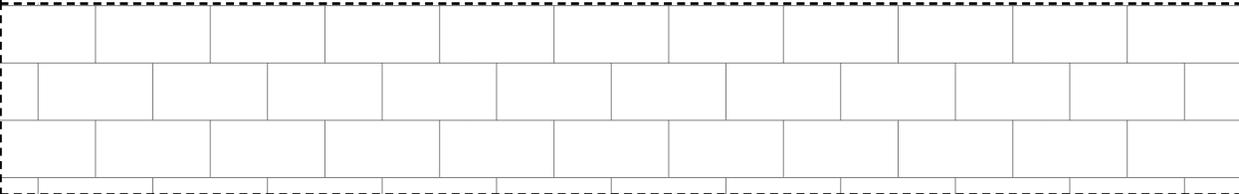
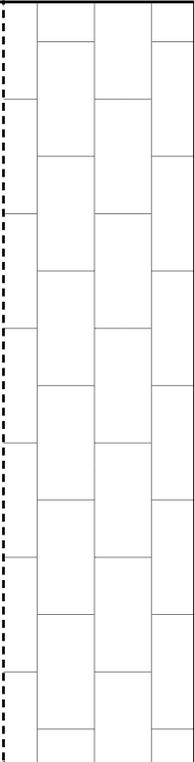
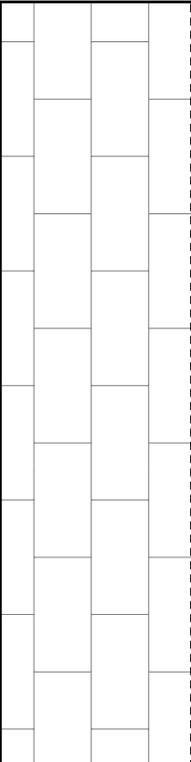
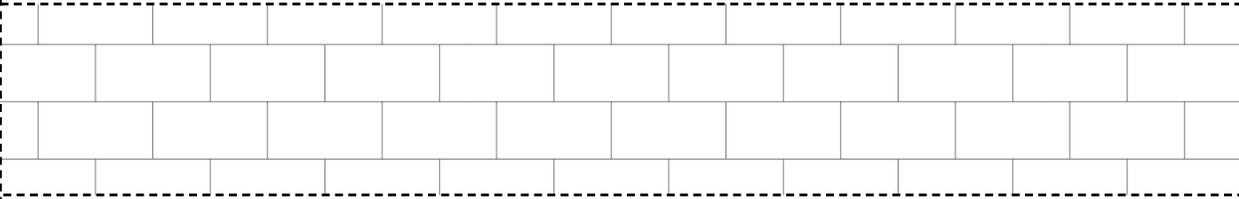


7. To assemble the temple use the following sequence of steps.
  - A. Glue piece 2 centered on top of piece 1.
  - B. Glue piece 3 centered on top of piece 2.
  - C. Glue piece 4 centered on top of piece 3.
  - D. Glue piece 5 centered on top of piece 4.
  - E. Glue the 4 staircases on each side of the pyramid.



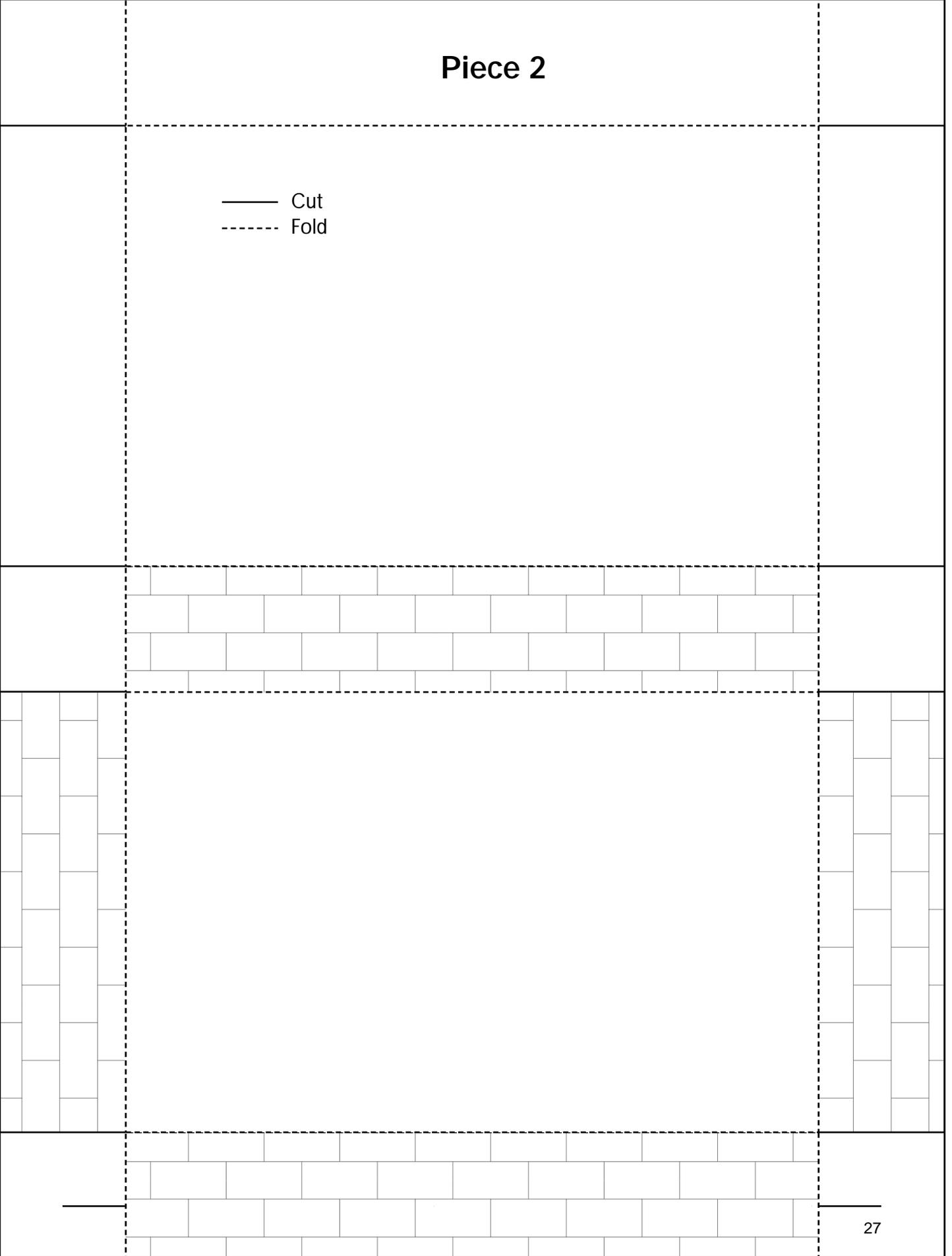
# Piece 1

— Cut  
- - - - - Fold



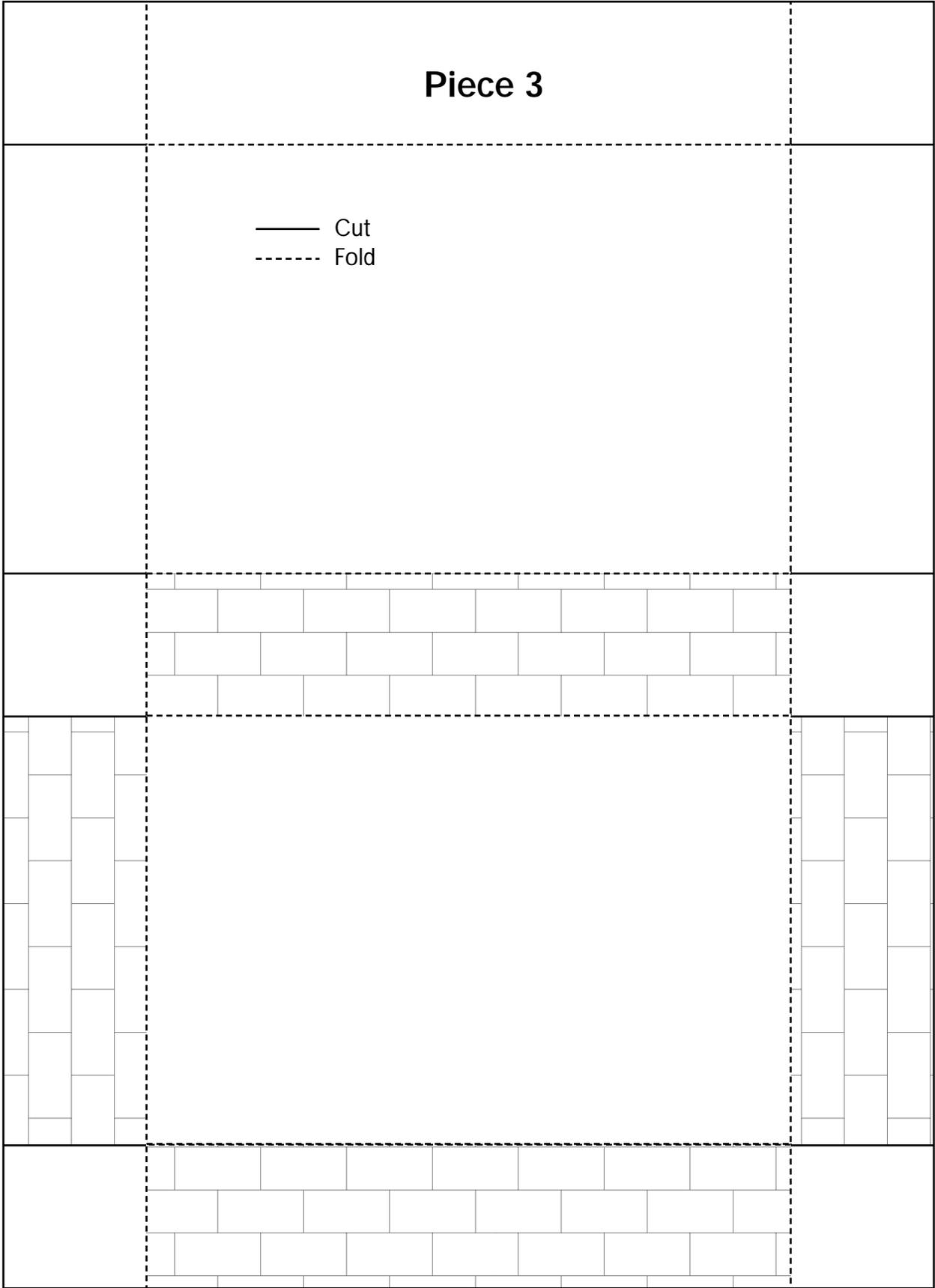
# Piece 2

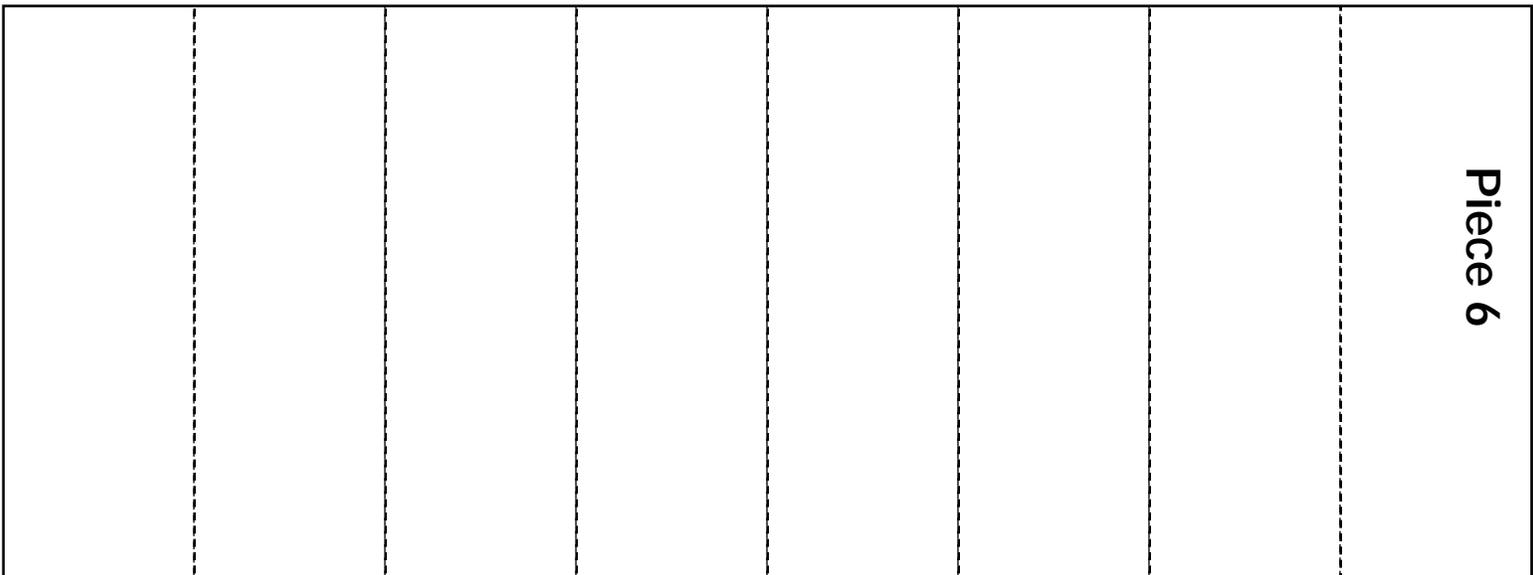
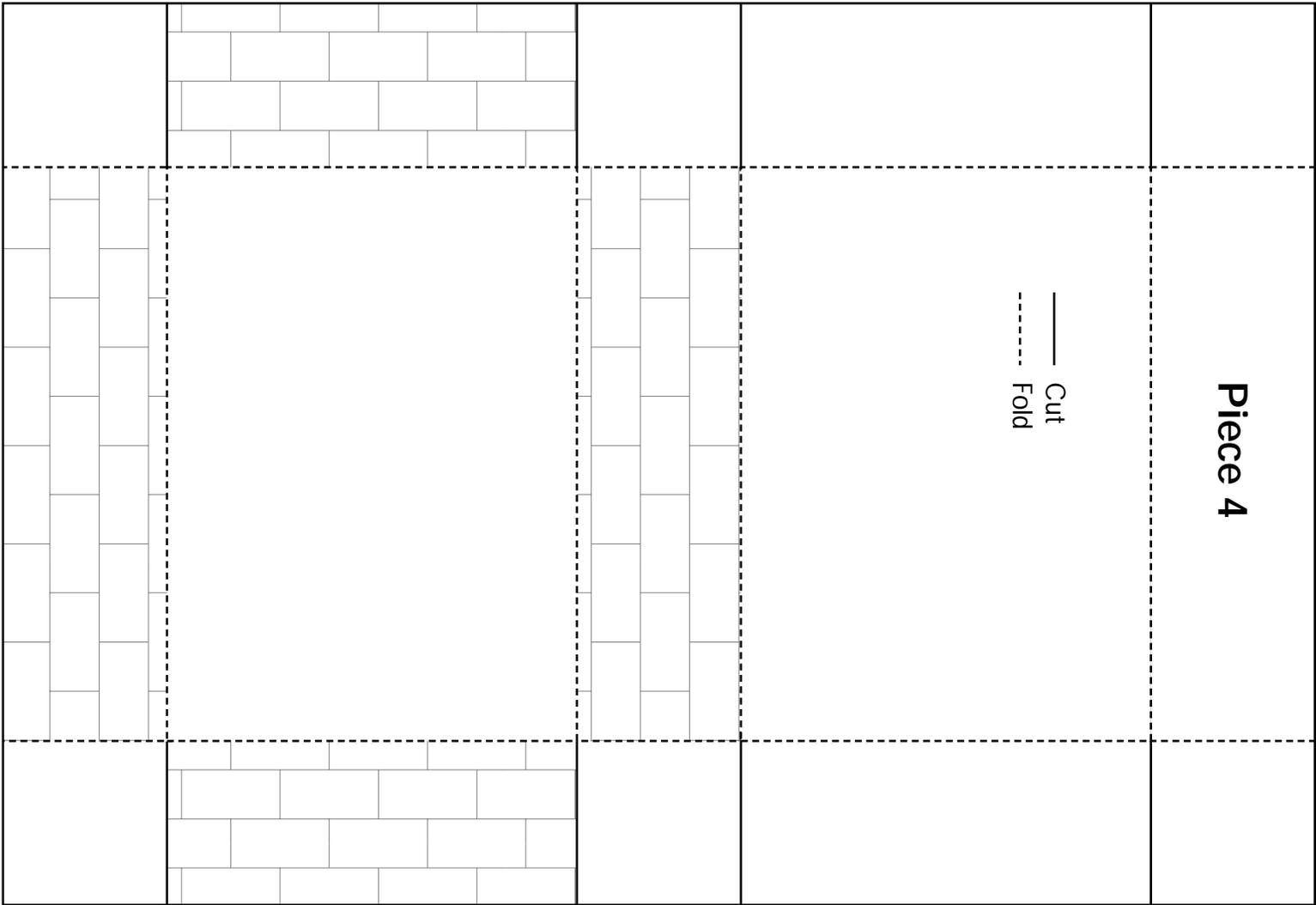
— Cut  
- - - - - Fold



# Piece 3

— Cut  
- - - - - Fold



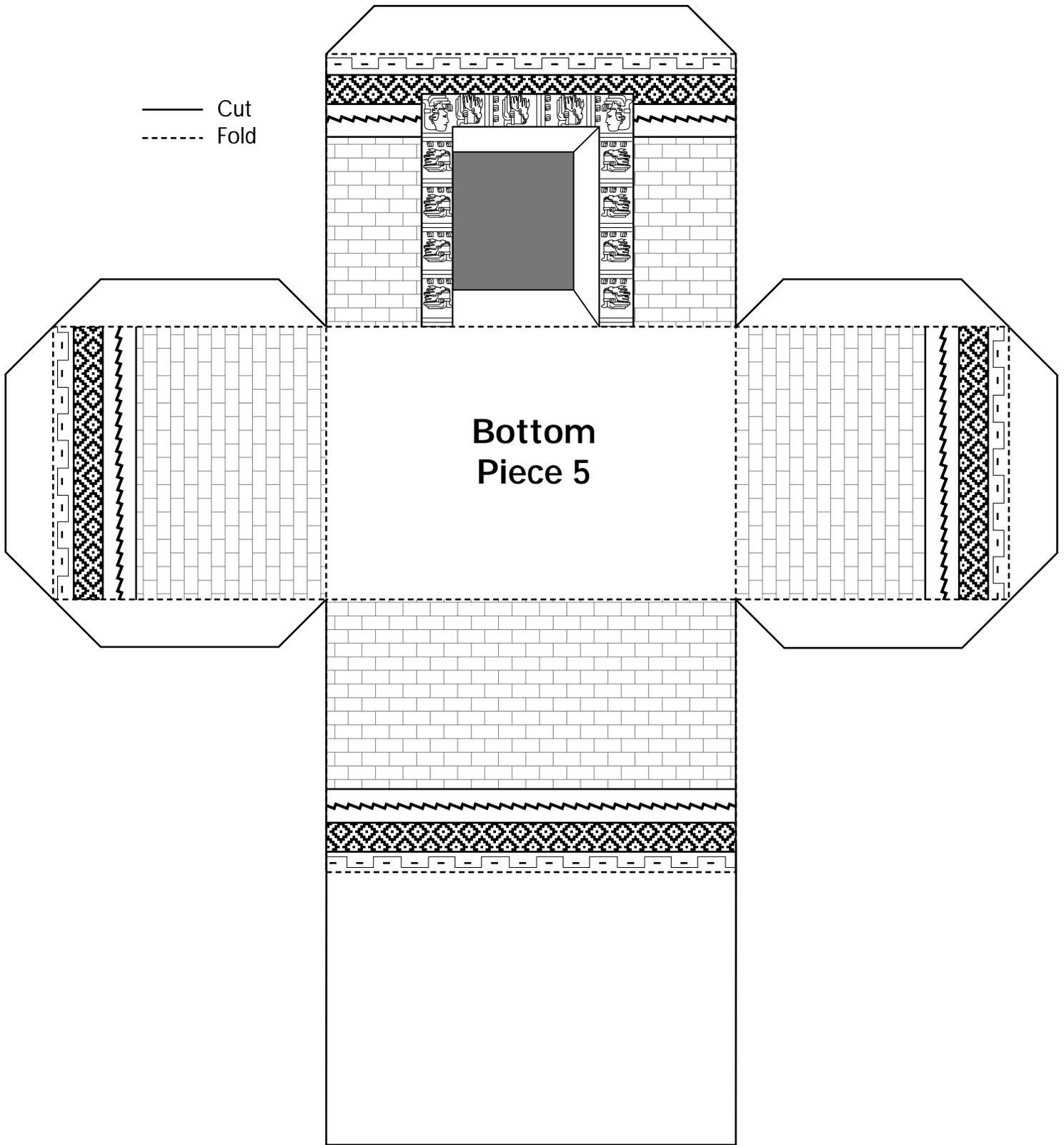


**Piece 7**

**Piece 8**

**Piece 9**

— Cut  
- - - - - Fold



# Lesson 5: Mayan Architecture 2— Replica of a Mayan Ruin

## What will students be learning?

### STANDARD(S)

Students develop spatial sense and use geometric concepts, properties, and relationships in problem-solving situations and communicate the reasoning used in solving these problems. (M4)

Students use a variety of tools and techniques to measure, apply the results in problem-solving situations, and communicate the reasoning used in solving these problems. (M5)

Students link concepts and procedures as they develop and use computational techniques, including estimation, mental arithmetic, paper-and-pencil, calculators, computers, and other manipulatives in problem-solving situations and communicate the reasoning used in solving these problems. (M6)

Students write and speak for a variety of purposes and audiences. (RW2)

### BENCHMARK(S)

Students recognize, draw, construct, describe, and analyze geometric shapes in one, two, and three dimensions.

Students understand and apply the attributes of linear dimensions, capacity, weight, mass, time, temperature, perimeter, area, volume, and angle measurement in problem-solving situations.

Students develop, use, and analyze algorithms and formulas.

Students write and speak for a variety of purposes.

### OBJECTIVE(S)

Students will design their own replica of a Mayan ruin (palace, temple, pyramid, plaza, sweathouse, or house).

Students will measure and compute the volume of their ruin.

Students will describe in writing their replica of a Mayan ruin and explain the steps they used to build their ruin.

### SPECIFICS

This lesson has been written as a home project to correlate with the work being done in school. It is a wonderful way to get parents/guardians involved with the students academic work.

Attached is a detailed explanation of the assignment to be sent home with the students. Recommended time frame for completion: three weeks.

## Lesson 5 (cont.)

### What will be done to help students learn this?

#### INSTRUCTIONAL STRATEGIES

Questioning  
Student-directed activity  
Summarizing  
Sequencing  
Discussions  
Idea diagram

#### PRELIMINARY LESSON PREPARATION

Have pictures of Mayan ruins available for students to analyze. Below is a list of books that have wonderful illustrations of Mayan architecture. The teacher might consider creating a few examples of ways students could construct their ruin.

#### ACTIVITY

As a class, read and discuss the directions for the project. Brainstorm ideas for the project. Fill out the project contract and return it to the teacher. Allow 10–15 minutes of each class day to answer any questions or concerns regarding the assignment.

Complete the Idea Diagram and return it within a week of beginning the project.

At home, create a Mayan ruin that correlates with guidelines. (Use the scoring rubric as a guide also.) Calculate and measure the volume of your ruin. Write a detailed explanation of your ruin and the steps that were used to build your model.

#### RESOURCES/MATERIALS

student contracts  
Idea Diagram (Worksheet 8)  
Project Guidelines  
scoring rubric  
books:

*Lost Cities of the Maya* by Claude Baudez and Sydney Picasso  
*The Maya World* (rev. ed.) by Elizabeth P. Benson  
*Excavations in the Great Plaza, North Terrace, and North Acropolis of Tikal* by William Coe  
*Désiré Charnay: Expeditionary Photographer* by Keith F. Davis  
*Mesoamerica's Ancient Cities* by William M. Ferguson and Arthur H. Rohn  
*Maya Ruins in Central America in Color* by William M. Ferguson and John Q. Royce  
*Pre-Columbian Architecture of Mesoamerica* by Doris Heuyden  
*A Guide to Ancient Maya Ruins* (2nd ed., rev.) by C. Bruce Hunter  
*The Art and Architecture of Ancient America* by George Kubler  
*An Album of Maya Architecture* by Tatiana Proskouriakoff  
*America's Ancient Cities* by Gene S. Stuart

## Lesson 5 (cont.)

### ASSESSMENT

Complete the scoring rubric for each student.

### SCORING RUBRIC:

4. Replica demonstrates creativity along with accuracy. The summary is well written and free of grammatical errors. Exceptional problem-solving skills are evident.
3. Replica is well-constructed but lacks creativity. The summary is readable and contains few grammatical errors. Problem-solving skills are used effectively.
2. Replica is completed but lacks creativity and accuracy. The summary contains many errors that interfere with the reading. Problem-solving is sound, but may be incomplete.
1. Replica is incomplete. The summary is incomplete or contains many grammatical errors. Problem solving is fragmented.

# Mayan Architecture 2: Replica of a Mayan Ruin

## Student Contract

Name of Student: \_\_\_\_\_

I, \_\_\_\_\_,

have read the guidelines and scoring rubric and understand the project assigned to me.

I agree to complete my Mayan Architecture Project by \_\_\_\_\_ (due date).

I have explained the Mayan Architecture Project to my parent/guardian(s).

Signature of Student: \_\_\_\_\_

Signature of Parent/Guardian: \_\_\_\_\_

Signature of Teacher: \_\_\_\_\_

## Mayan Architecture 2: Replica of a Mayan Ruin

Dear Parent/Guardian,

Students are currently studying Mayan mathematics and architecture. We have examined the Mayan numerical system, investigated Mayan numbers and Mayan architecture on the Internet, and assembled a folded-paper Mayan pyramid.

While we continue to study Mayan mathematics and architecture, the students will have a homework assignment that will be due on \_\_\_\_\_. This homework assignment is expected to take three weeks to complete.

Listed below are guidelines and a list of choices. Please read through the guidelines and choices with your student. Your student needs to complete the attached student contract and return it to me tomorrow.

If you have any questions or concerns regarding this homework assignment, please contact me. Also, if none of the following choices are appropriate for your student, please contact me to discuss other options.

Sincerely,

---

### Guidelines

1. Each student must complete the learning contract, idea diagram, and description page, along with a model of a Mayan ruin.
2. The Choice List contains many different ways to create a Mayan ruin.
3. The ruin can be two- or three-dimensional.
4. The model must not be bigger than 1 foot  $\times$  1 foot  $\times$  1 foot.
5. Acceptable materials:

|                    |                            |
|--------------------|----------------------------|
| paint              | cardboard                  |
| colored pencils    | tag board                  |
| markers            | modeling clay              |
| glue               | Popsicle sticks            |
| toothpicks         | dough (see recipe)         |
| wire               | papier-mâché (see recipes) |
| newspaper          | tissue paper               |
| balsa wood         | nails                      |
| construction paper | dough                      |
6. If you want to use a material or choice that is not listed, please consult the teacher for approval.
7. If you are unable to get any of the materials you need, please consult teacher to discuss options.

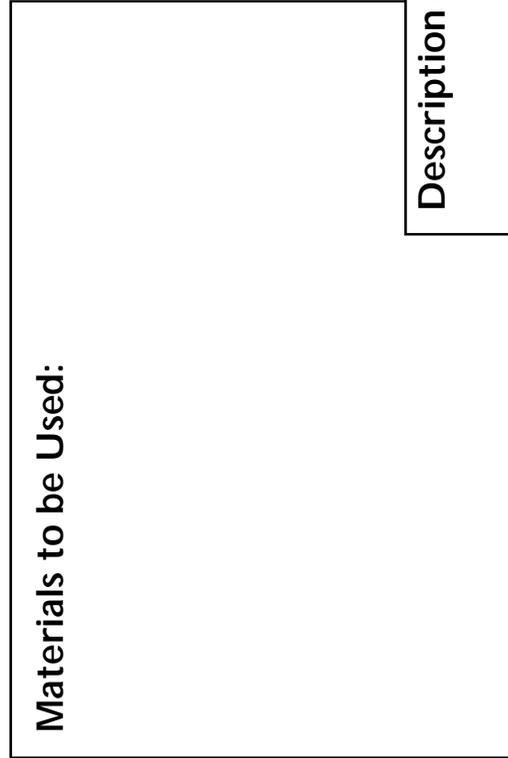


# Mayan Architecture 2 Idea Diagram

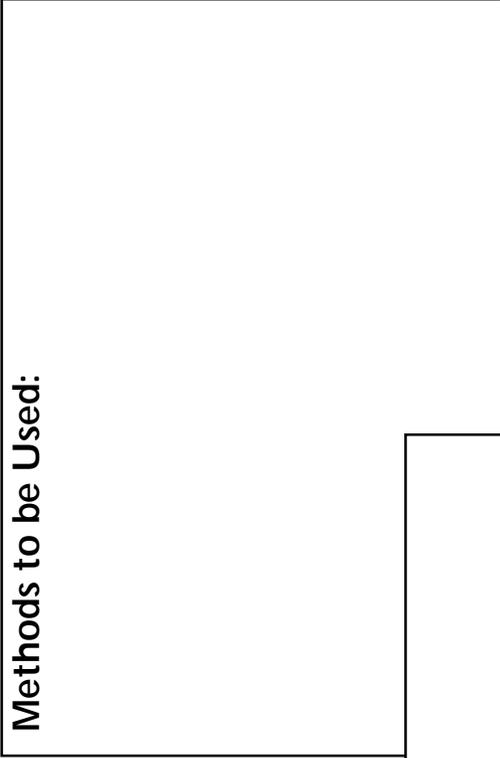
Name \_\_\_\_\_ Mayan Ruin to be replicated: \_\_\_\_\_

Choice Number: \_\_\_\_\_

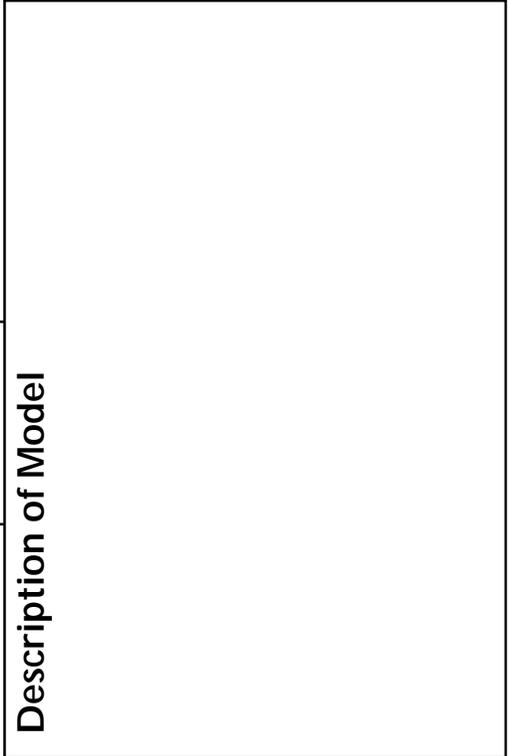
**Materials to be Used:**



**Methods to be Used:**



**Description of Model**



# Lesson 6: Mayan Architecture 3—Computer Graphics

## What will students be learning?

### STANDARD(S)

Students understand and use appropriate technologies to perform mathematical constructions and computations, simulate mathematical experiences, and to access, process, and communicate information related to the application of mathematics in problem-solving situations. (M7)

### BENCHMARK(S)

Students use appropriate traditional and electronic technologies in a variety of formats to extend and enhance mathematical learning and to simulate mathematical models, concepts, and problem-solving situations.

### OBJECTIVE(S)

Students will use appropriate technology to create a graphic design of a ancient Mayan temple.

### SPECIFICS

Ah Cacaw, the greatest city sovereign of Tikal, began the construction of Temple I and Temple II in Tikal. The temples were very ornamental and of great height. With these two temples, Ah Cacaw set the standard for Mayan architecture. The son and grandson of Ah Cacaw, Yaxkin and Chitam, developed Tikal with temple-pyramids, a palace compound, ball courts, market places, and a sweathouse. It is believed that 40,000 people once inhabited the city of Tikal.

## What will be done to help students learn this?

### INSTRUCTIONAL STRATEGIES

Student-directed activity

Computer-assisted instruction

### PRELIMINARY LESSON PREPARATION

Before giving the assignment to the students, the teacher should complete the assignment, using one of the examples and the tip sheet to make a computer-generated drawing of the temple of Tikal.

### ACTIVITIES

After the teacher explains the directions for the activity, use the tip sheet and examples to make your own temple of Tikal. Create the temple using the software ClarisWorks (Drawing).

### RESOURCES/MATERIALS

instruction (tip) sheet

examples

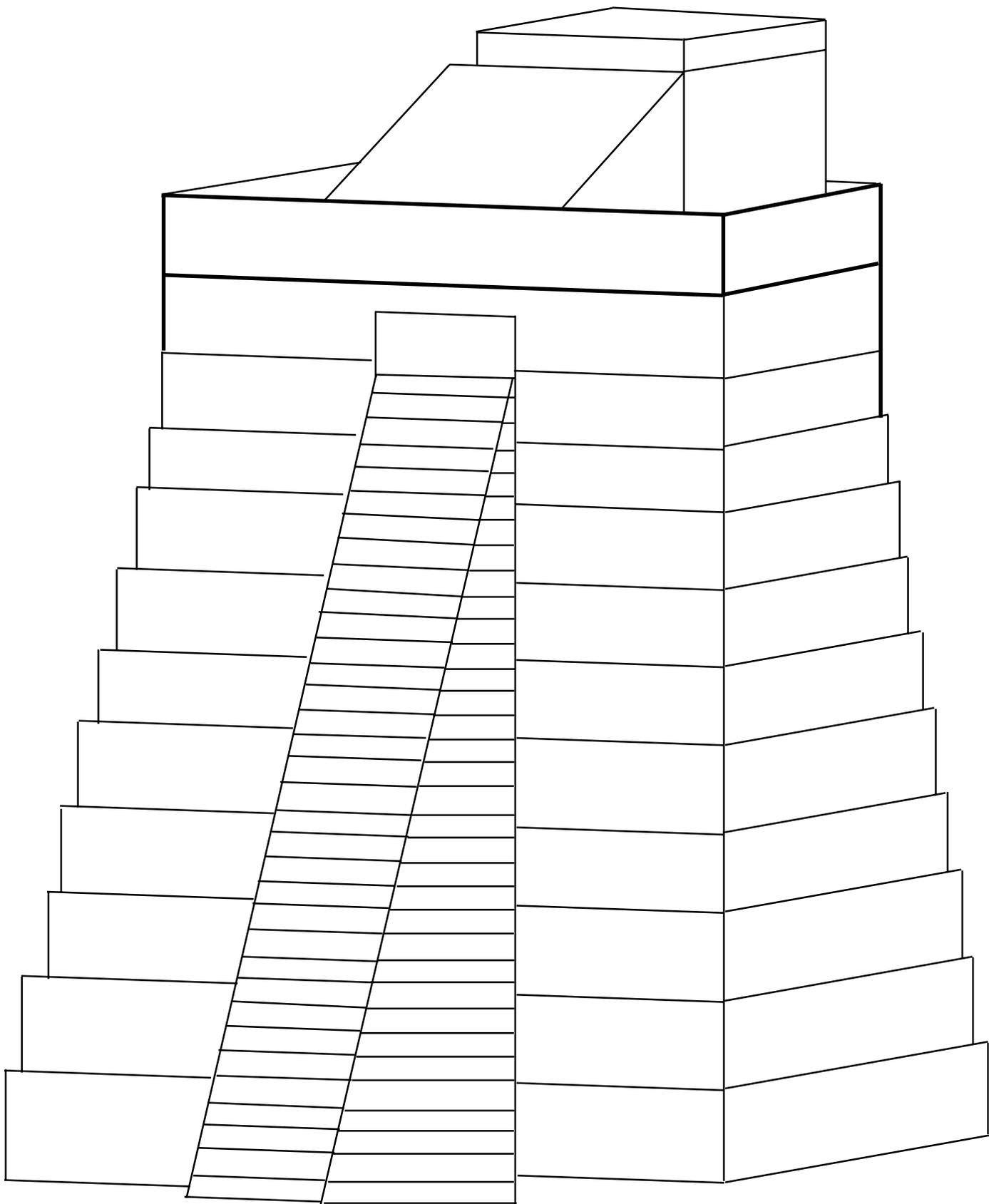
computer access to ClarisWorks or Word Perfect

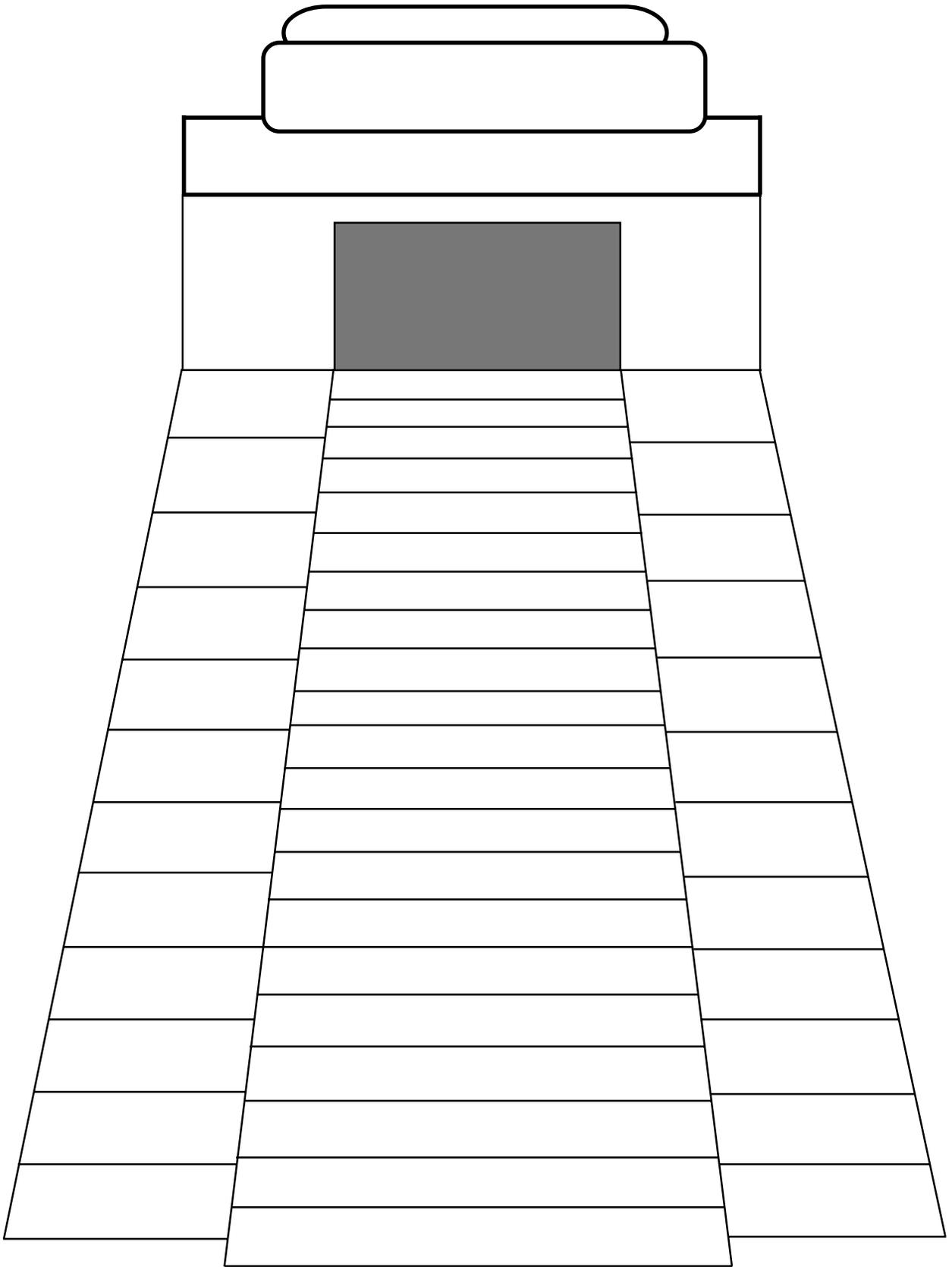
### ASSESSMENT

Using the examples as guides, evaluate each student's temple.

## Architecture 3: Instruction (Tip) Sheet

1. First open **ClarisWorks-Drawing**.
2. Using the **tool box** on the left-hand side of the screen, click on the **line** with your mouse.
3. Draw lines using your mouse on the grid. (**Click and drag**)
4. Click on the line in the tool box each time to start a **new line**.
5. Using only lines, begin to create a temple. Start at the bottom of your paper.
6. **To move a line**, click on the arrow key in the tool box. Click on the line you wish to move. Your line is highlighted if it has two little black boxes on each end. Now you can move the line with your mouse or cursor keys.
7. **To erase a line**, click on the arrow key in the tool box. Click on the line you wish to erase. Your line is highlighted if it has two little black boxes on each end. Now push the delete button on the keyboard.
8. To draw a **rectangle**, click on the square in the tool box. Then using your mouse draw a rectangle on the grid. (Click and drag diagonally)
9. To write **letters or numbers**, click on the **A** in the tool box. Then draw a text box on the grid. Once you have a text box, you can type inside the box.
10. **To thicken lines**, click on the box that contains three lines on the bottom of the tool box. Then choose a thickness.
11. **To color or shade** in an area, click on the box that has colors or the box next to the color box. Then choose the color or shade you want.





# Lesson 7 (Extended): Mayan Head Number Molds

## STANDARD(S)

Students know and apply visual materials, tools, techniques, and processes. (A3)

## BENCHMARK(S)

Students use elements of art, principles of design, and style to create a work of art.

## OBJECTIVE(S)

Students will mold a Maya Head Number out of clay.

## SPECIFICS

Students can select one of the Mayan Head Numbers (0–19) to create. Head numbers can be found on the internet at the URL below. For younger students, photocopy and enlarge the number heads to cover an area of 36 square inches (6 × 6) of clay.

## ACTIVITY

Choose a head number to mold. Using a rolling pin, roll out clay one inch thick with an area of about 6 inches × 6 inches. Trace the shape of the head number onto the clay with a plastic knife. Bake the clay in an oven or kiln for 1 hour and 45 minutes to 2 hours at 250°. After the clay has been baked, paint the head number.

## RESOURCES/MATERIALS

rolling pins

plastic knives

head number patterns

paint

paintbrushes

oven/kiln

25 pounds of white clay or use this recipe:

3 cups flour

1¼ cups warm water

1 cup salt

URL: <http://www.astro.uva.nl/michielb/maya/links.html>

## ASSESSMENT

Visually assess quality of mold.

# Lesson 8 (Extended): Mayan T-shirt

## What will students be learning?

### STANDARD(S)

Students know and apply visual materials, tools, techniques, and processes. (A3)

### BENCHMARK(S)

Students use elements of art, principles of design, and style to create a work of art.

### OBJECTIVE(S)

Students will design a Mayan temple t-shirt.

### SPECIFICS

Students can draw a temple by hand or use their computer design from Lesson 6. They may also add a background to the design. Encourage creativity.

## What will be done to help students learn this?

### ACTIVITY

Place pattern of Mayan temple in between the front and back of the T-shirt. Be sure to put something between the front and back of the shirt to prevent bleeding. Trace the pattern with a permanent marker. Add a background or other elements if desired. Then place white T-shirt over a coffee can. Pull shirt tight and secure with a rubber band. Using a pipette or eyedropper, drop rubbing alcohol onto the design. Keep moving shirt and securing to can, until rubbing alcohol has been applied to the entire design. After the shirt has air-dried, place in the dryer on high to set design.

### RESOURCES AND MATERIALS

permanent markers of various colors

pipettes or eyedroppers

rubbing alcohol

white cotton T-shirts

Mayan temple patterns

coffee cans

rubber bands

### ASSESSMENT

Visually assess quality of T-shirt.

# Unit Assessment

## How will students demonstrate proficiency?

### PERFORMANCE TASK

Divide class into groups of 3 to 4 students. Each group will design their own ancient Mayan city.

Each group must apply the knowledge from Lessons 1–6 to their cities by designing a city map and oral presentation.

The map must contain the following items:

1. Five different Mayan structures
2. Ten Mayan symbol numbers or head numbers
3. An area measurement
4. A perimeter measurement
5. A city name

After the maps are constructed, the groups will prepare a presentation providing information on their ancient city architectural plan. The presentation should answer the following questions:

1. What was the function of each structure in the city?
2. How were Mayan numbers used in the city?
3. Why was each structure placed where it was?
4. What architectural style was on the structures?
5. How did you solve for area and perimeter of your city?

### SCORING RUBRIC:

4. Superior presentation that answers all prompts with well-organized reasoning and creativity. The map contains all components and demonstrates exceptional mathematical problem-solving skills.
3. Effective presentation that answers all prompts, but lacks creativity and organization. The map contains all components and problem-solving strategies are used effectively.
2. Marginal presentation that answers some of the prompts, but needs revisions. The map contains most of the components and mathematical problem-solving is sound, but may be incomplete.
1. Unsatisfactory presentation that shows misunderstandings of prompts. The map has little work done and fragmented evidence of problem-solving process.

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The Canadian Museum of Civilization's Mayan civilization site. Great for general information on the civilization and culture.

## About the Author

Julie Murgel was born in Anaconda, Montana. She received a bachelors degree in elementary education from Carroll College, Helena, Montana. She began studying Spanish classes in high school and continued to study Spanish in college. She is currently pursuing a masters degree in education at Regis University.

Julie has taught in Denver Public Schools for three years as a middle school bilingual mathematics teacher. Prior to teaching in Denver, Julie taught third grade in Las Vegas, Nevada.

Julie's interest are in mathematics, science, and art. She enjoys creating challenging hands-on activities for her math classes. During the summer, Julie enjoys teaching geology.