Olga Koroleva
2015 Summer Institute on China

Surface Area of a Compound Solid

Class
10th -12th Grade Geometry

Standards
1. G-GMD Geometric Measurement and Dimension
    a. Visualize relationships between two-dimensional and three-dimensional objects
    b. Identify the shapes of two-dimensional cross sections of three-dimensional objects.
2. G-MG Modeling with Geometry
    a. Apply geometric concepts in modeling situations
    b. Use geometric shapes, their measures, and their properties to describe objects.
    c. Apply geometric methods to solve design problems.

Organizing Questions
1. How do you estimate dimensions of an object?
2. How do you calculate the surface area of the compound solids?
3. How much time does it take to create a replica of a cave painting?

Introduction
The Mogao Caves in the city of Dunhuang is a UNESCO cultural heritage site. The Getty Research Center is helping the Dunhuang Academy with the conservation of Cave 85. The conservation team inspects the art and decides what is the best way to slow down deterioration. The Getty Center is also preparing an exhibition of full-scale replicas of Caves 285, 275, and 320.

This lesson, in addition to fulfilling Common Core geometry standards, will educate students on the process of creating the cave replicas. Students will calculate the dimensions of one of the caves and then calculate the area of the mural. Then they will create their own replica of a part of the cave paintings, which they will use to estimate the total amount of time that the Dunhuang Academy artists used to replicate the cave. This lesson should be done after students have learned how to calculate areas of quadrilaterals and triangles

Objectives
1. Students will analyze the compound solids
2. Students will calculate the surface area of a compound solid
3. Students will create a drawing congruent to the original and reflect on time and effort spent

4. Students will appreciate the complexity of creating a replica

Materials

1. Images of caves 320, 275, 285, and replica of the cave 45, 1 set to show class
2. Dimensions of caves 285 and 45, 1 handout per student or write on board
3. Images of cave 285 murals (make copies from book, postcards, and / or internet), 1 per student
4. Timer, 1 for class use
5. Paper and pencils for drawing, 1 of each per student

Equipment

1. Computer
2. Projector
3. Internet access
4. Chromebooks
5. Fan Jinshi "The Caves of Dunhuang". The Dunhuang Academy in Collaboration with London Editions, Hong Kong. 2010
6. "The Selections of Copied Art Works of Dunhuang Sink Panel", Chef Designer Li Kai.1997
7. http://public.dha.ac.cn/content.aspx?id=164733419009
8. https://en.wikipedia.org/wiki/Mogao_Caves

Teacher preparation

1. Review the PowerPoint presentation before the lesson.
2. Prepare paper and pens before class. You could also use paints and/or colored pencils. You will need the following colors: black, blue, green, red, yellow, and brown.
3. Prepare samples of drawings for students to copy. Some should include people, and some should include simple geometric designs so that students who are not very good artists can still replicate the drawings.

Time

Two 50-minute class periods

Procedures

Day 1 (50 minutes)

1. Introduce Mogao caves to the students. Show pictures of several caves with slanted walls. Discuss the importance of the walls: to release the stress on the vertical walls and to prevent the cave from breaking in case of an earthquake.
2. Divide students into groups of four. Have each group identify what geometric solids make up the caves' structure.
3. Using pictures of a person standing next to one of the cave walls, have students estimate the cave's dimensions: width, depth, and height.
4. Have students calculate the total surface area of the cave walls and ceilings using dimensions provided by the teacher.

5. Review the calculations as a class.

Day 2 (50 minutes)

1. Inform the class of the Getty Center's upcoming exhibition on the Mogao grottoes. Give a brief explanation of the process of creating cave replicas.
2. Distribute paper and pencils (as well as paint and/or colored pencils if you decide to use them).
3. Distribute sample drawings to the students and post some on walls and/or PowerPoint. If using PowerPoint and Chromebooks, make sure that one of the slides provides a full-scale image of the drawings that students can copy off of their Chromebooks.
4. Let students work on replicating a drawing for 20-30 minutes. Use a timer to keep track of the time.
5. Ask students to calculate the area that they were able to paint during the given time.
6. Using the surface area calculated the previous day, have students create a ratio to estimate the time needed to replicate the cave's murals. This can be done in class or as a homework assignment.
7. Compare the time students received as a result of their calculations with the actual time it takes to create a replica. Discuss the discrepancies between the answer and actual time.

Day 3 (Extension)

1. Class creates a scale replica of a cave. One group can be responsible for building the cave.
2. Four groups create replicas of the walls and the ceiling. If a cave contains statues, another group can recreate them.
3. Last group overlooks the process and puts everything together. The cave can be put on plastic floor so the inside of it can be easily seen.

Assessment

1. Calculations -- Teacher evaluates the calculations of the area of the compound solid.
2. Presentation -- Students share their replicas with the class.
3. Estimations -- Teacher collects time estimate for creating the replica of the cave.
4. Quiz -- Have students calculate the volume of the cave using dimensions given in the beginning of lesson 1.

Notes

1. It is possible to collaborate with art teacher so that students' drawing can be evaluated according to art class rubrics.
2. It is possible to collaborate with physics teacher so that the geometry of the walls can be discussed in further detail.

SURFACE AREA OF A COMPOUND SOLID

Created by Dr. Koroleva

Granada Hills Charter High School

What Country Is This?

Edge of Gobi Desert in China

Mogao Caves

Dunghuang, China

Buddhist Art

4^{th} – 14^{th} century

Cave 285

List shapes you see in your notebook

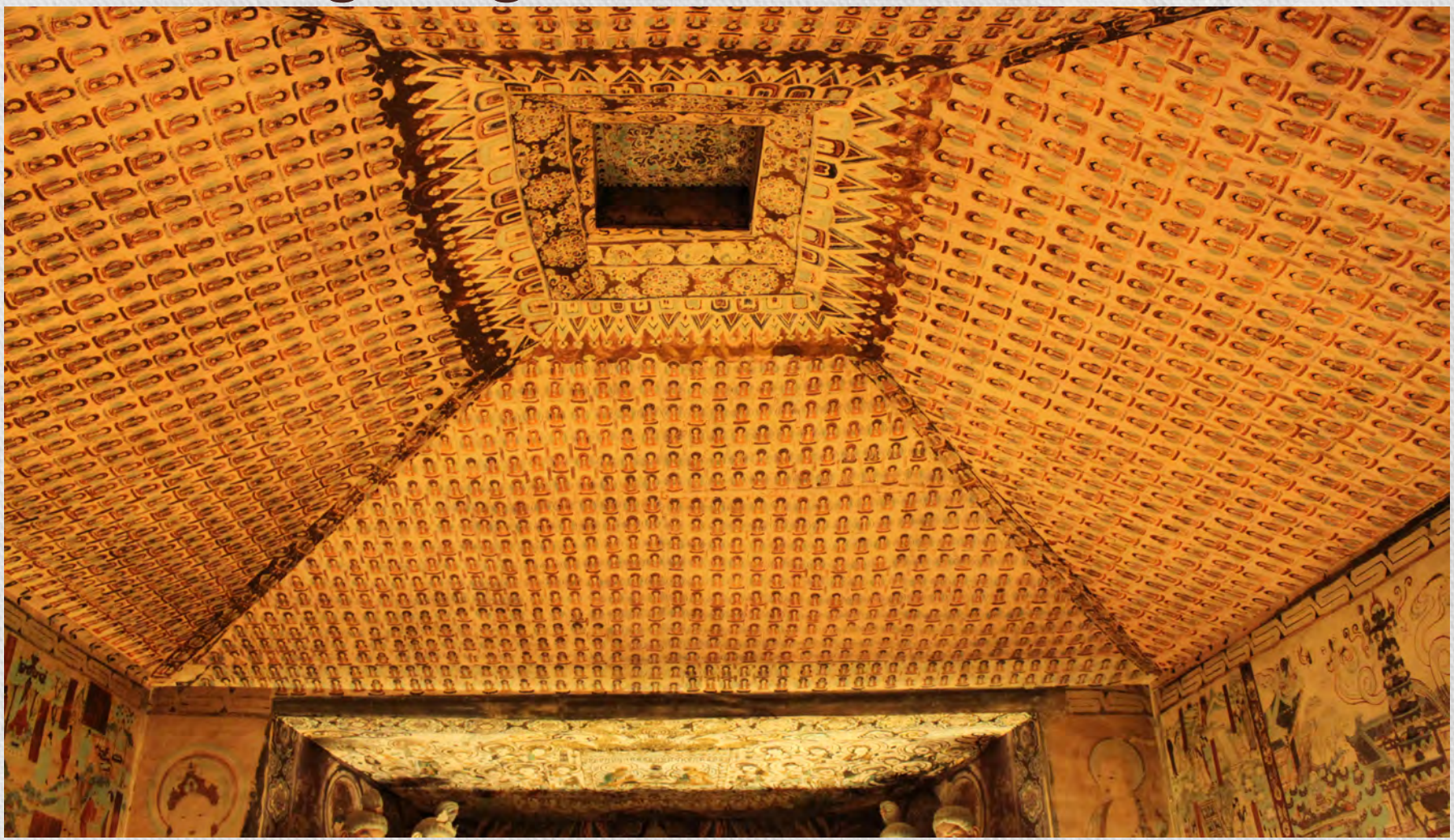
Sloped Ceiling of Cave 285

Release pressure in case of an earthquake

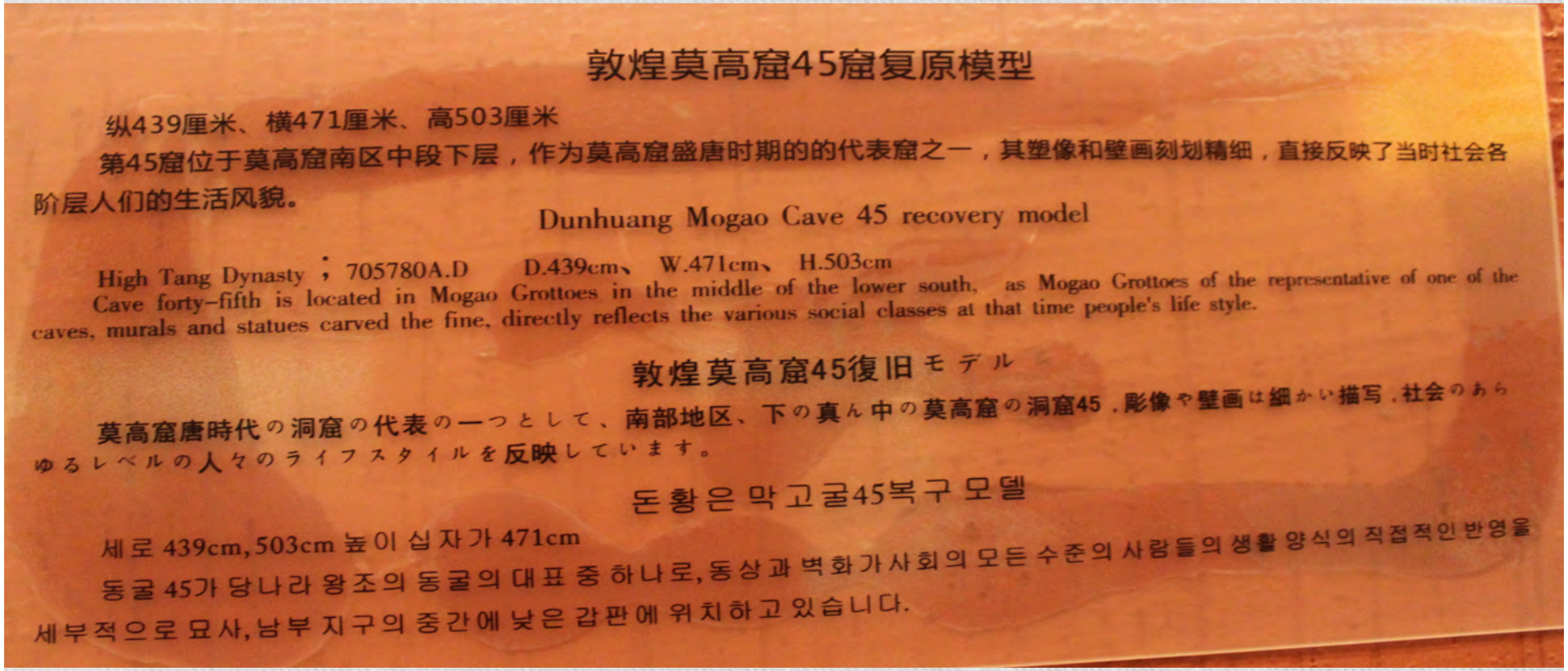
Estimating Width of Cave 45

Estimating Depth of Cave 45

Estimating Height of Cave 45



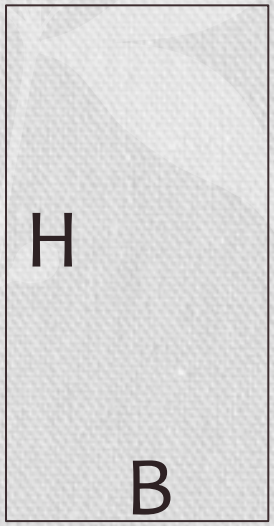
Actual Dimensions of Cave 45



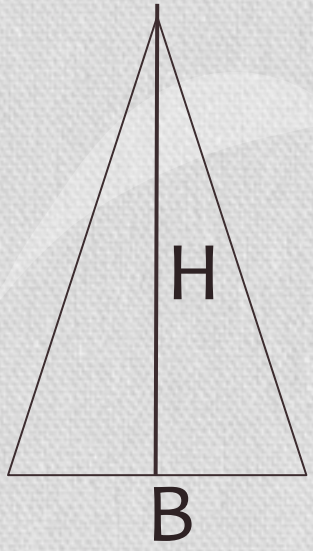
Depth 439 cm Width 471 cm Height 503cm

Surface Area Calculations

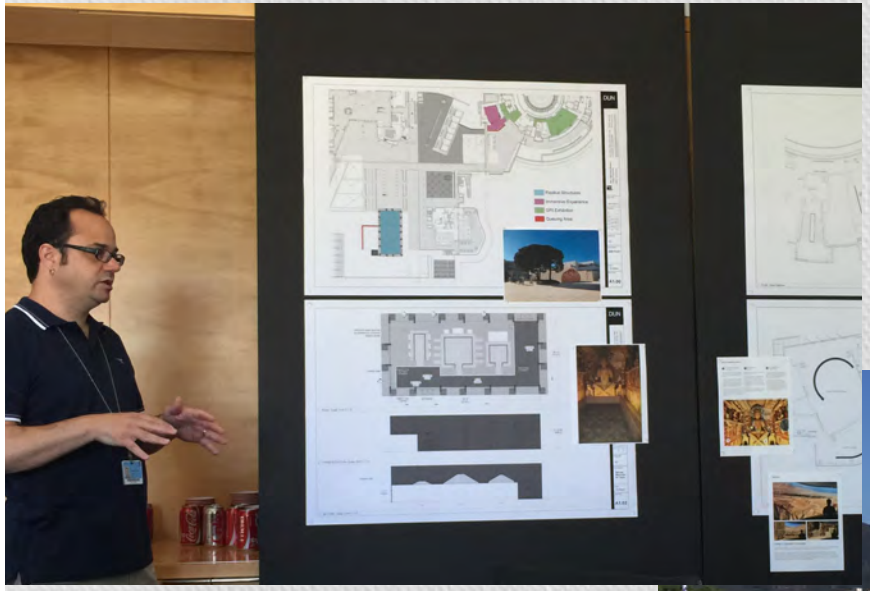
Area of a rectangle is A = B•H,
Where B is the base of the rectangle,
and H is the height of the rectangle



Area of a triangle is A = ½ B•H,
Where B is the base of the triangle,
and H is the height of the triangle



Getty Center Exhibition



Caves 275, 285, and 320

May 7 – September 4, 2016

Creating a Replica of Mogao Grottoes

Scale Factor

Replicating a Mural from Cave 285

Estimating the Area

- Estimate the area of your drawing
- Compare with the the surface area calculated
- Estimate how much time it would take to create a replica of the whole cave
- Using 40 hour work week, convert your time to reasonable units.

The Actual Time

3 years