College- and Career-Readiness Standards for Mathematics

Exemplar Lesson Plan

"Discover the Volume of Right Rectangular Prisms"

5.MD.5a
5.MD.5b
5.MD.5c

MISSISSIPPI DEPARTMENT OF EDUCATION
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Mississippi College- and Career-Readiness Standards
Mathematics
Exemplar Lesson Plan

GRADE: 5	
Title: *Discover the Volume of Right Rectangular Prisms* **Estimated Duration:** *3 Days*	**Real World Purpose:** Have you ever wondered how many boxes can fit inside a container on the back of an 18-wheeler? Have you ever had to move and pack up all or some of your things? Have you had to figure out if all of your things will fit in the car? Knowing how to find the volume of rectangular prisms will allow you to answer these questions.

I Can:

- **5.MD.5:** Relate volume to the operations of multiplication and addition and solve real-world and mathematical problems involving volume.
- **5.MD.5a:** Find the volume of a right rectangular prism with whole-number side lengths by packing it with unit cubes, and show that the volume is the same as would be found by multiplying the edge lengths, equivalently by multiplying the height by the area of the base. Represent threefold whole-number products as volumes, e.g., to represent the associative property of multiplication. (SMP 2, 3, 4, and 8)
- **5.MD.5b:** Apply the formulas $V = l \times w \times h$ and $V = B \times h$ for rectangular prisms to find volumes of right rectangular prisms with whole-number edge lengths in the context of solving real-world and mathematical problems. (SMP 1, 2, 4, and 6)
- **5.MD.5c:** Recognize volume as additive. Find volumes of solid figures composed of two non-overlapping right rectangular prisms by adding the volumes of the non-overlapping parts, applying this technique to solve real-world problems. (SMP 1, 4, and 7)

Prerequisite Skills:

- Identify shapes as two-dimensional (lying in a plane, “flat”) or three-dimensional (“solid”). (K.G.3)

- Analyze and compare two- and three-dimensional shapes, in different sizes and orientations, using informal language to describe their similarities, differences, parts (e.g., number of sides and vertices/ "corners") and other attributes (e.g., having sides of equal length). (K.G.4)
- Compose two-dimensional shapes (rectangles, squares, trapezoids, triangles, half-circles, and quarter-circles) or three-dimensional shapes (cubes, right rectangular prisms, right circular cones, and right circular cylinders) to create a composite shape and compose new shapes from the composite shape. (1.G.2)
- Volume is the space in a three-dimensional figure. (4.MD.2)
- Volume can be "packed" or "filled." Packing with unit cubes vs. filling with liquid/gas. (4.MD.2)
- Recognize volume as an attribute of solid figures and understand concepts of volume measurement. (5.MD.3)
- Measure volumes by counting unit cubes, using cubic centimeters, cubic inches, cubic feet, and improvised units. (5.MD.4)
- Fluently multiply multi-digit whole numbers using the standard algorithm. (5.NBT.5)
- Find whole- number quotients of whole numbers with up to four-digit dividends and two-digit divisors, using strategies based on place value, the properties of operations, and/or the relationship between multiplication and division. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models. (5.NBT.6)

Materials/Resources:

- Unit cubes (cm cubes)
- Unifix cubes
- Dot paper/graph paper
- Scissors
- Cardstock/Cardboard
- Rulers
- Tape
- Chart paper
- Attachments (Total: 7)

Key Vocabulary:

- Length
- Width
- Height
- Volume
- Right rectangular prism
- Unit cubes
- Additive
- 2D figure
- 3D figure
- Solid figure
- Base
- Face
- Non-overlapping parts
- Area of the base (*B*)
- Repeated addition

Lesson Introduction

Student Exploration Activity:

Day 1:

Ms. Williams bought 48 tiles on sale at the hardware store. The area of each tile is one square foot. She would like to create a rectangular patio using all of the tiles.

- What are the possible dimensions of her patio? Explain to your neighbor why your answer is correct.
- What other dimensions would you need to know about these tiles if you were going to pack them into a box? Explain your answer.

Day 2:

The teacher will present the following problem to the students to determine their understanding of finding volume using unit cubes:

Josh and Jonah were finding the volume of the prism to the right. The boys agree that 4 layers can be added together to find the volume. Josh says that he can see on the end of the prism that each layer will have 16 cubes in it. Jonah says that each layer has 24 cubes in it. Who is right? Explain how you know using words, numbers, and/or pictures.

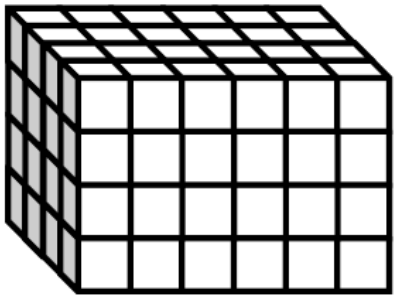
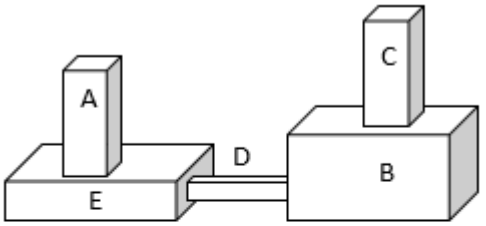


Figure 1

Students who are struggling with 5.MD.4 may be provided with a right rectangular prism created with Unifix cubes so they can manipulate the figure and answer the problem.

Day 3:

1. The teacher will project a composite figure (Figure 1) on the board and Attachment #7, ***Project Critique***, on chart paper to be filled out as a class.
2. "Today you will be creating your own sculpture using rectangular prisms. Here is a project that was created by (me, students from last year, as an example, etc.). We are going to critique it following the rubric on the chart paper so you have an idea of what is expected of you when you start to make your own. The first thing we need to do is check the volumes of each prism that have been recorded. Work with your partner to calculate the volumes of each of the right rectangular prisms." (All the volumes are correct.)
3. The teacher will then lead the students through the rubric using the example project. [MP 1, MP 2, MP 3, MP 4, MP 5, MP 6]



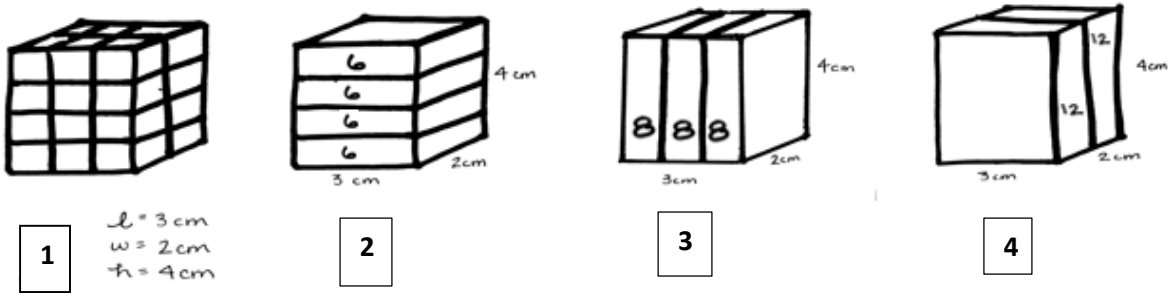
Prism A: 6 cm × 3 cm × 2 cm = 36 cm^3
Prism B: 10 cm × 7 cm × 6 cm = 420 cm^3
Prism C: 6 cm × 3 cm × 2 cm = 36 cm^3
Prism D: 6 cm × 3 cm × 1 cm = 18 cm^3
Prism E: 10 cm × 7 cm × 2 cm = 140 cm^3

Lesson Activities

Day 1

Part 1: Find the volume of multi-layer prisms using multiplication.

1. The teacher will distribute Attachment #1, ***Discovering Volume Problem Set***, to the students. The teacher will then project a 3 x 2 x 4 rectangular prism (Figure 1 below) on the board and the students will record the length, width, and height on their recording sheet. The students will decompose the prism into layers three different ways to find the volume.



The teacher will ask questions to help the students record the correct information in their tables, starting with Figure 2: "Look at the top layer of this figure. How many cubes are in the top layer? How do you know?" (There are 6 cubes, because it's 3 cubes by 2 cubes and 3 x 2 equals 6. I counted the cubes. It's like an array.) The teacher will follow a similar method for the other two decompositions and the students will fill out the first column of their recording sheet.

2. The teacher will ask the students how this information can be used to find the volume for the rectangular prism. (Figure 2: There are 4 layers, and 6 cubes in each layer. Therefore there are 24 cubes in all.) The teacher will lead the students through each figure and complete the remaining two columns of their recording sheet.

Think-Pair-Share: The teacher will ask the students to take 30 seconds to note any patterns they see in the table below. The students will then share their observations with their partner. The teacher will select pairs to report out to the class. Possible observations: The volume is the same every time. → We are multiplying all the sides together, but they are in a different order. → When we multiply the length of the sides together, we get the same volume as when we counted the layers. Question: "So, centimeters times centimeters times centimeters gives us centimeters cubed? True? Why or why not? Turn and talk." [MP 1, MP 2, MP 3, MP 4, MP 5, MP 6, MP 7, MP 8]

Cubes in Each Layer	Number of Layers	Volume
(3×2)	4	$24cm^3$
(2×4)	3	$24\ cm^3$
(3×4)	2	$24\ cm^3$

<u>Part 2</u>: Calculate the volume when the area of one face is given.

3. The teacher will project a 2 cm x 2 cm square (Figure 1) on the board. "This square shows the top face of a right rectangular prism. If the prism is made of 1 cm cubes, what is the area of this face?" (4 square centimeters)

Figure 1

4. The teacher will write A = 4 cm^2 on the board and project the image of the prism with a height of 4 cm (Figure 2). "If the rectangular prism that sits below this face is also built of 1 cm cubes, and has a height of 4 cm, how many layers of centimeter cubes are in the prism?" (4 layers) "How can we use the layers to find the volume of the prism? Turn and talk." (I can see that the length is 2 cm and the width is also 2 cm, so if the height is 4 cm, I can multiply 2 by 2 by the number of layers, which is 4, to get the volume. → Since the area of the top is 2 cm times 2 cm, which is 4 cm^2, we can just multiply the area times the height to find the volume.) "What multiplication sentence can be used to find the volume of the prism?" (V= 2 cm x 2 cm x 4 cm = 16 cubic cm → V = 4 cm^2 x 4 cm = 16 cm^2)

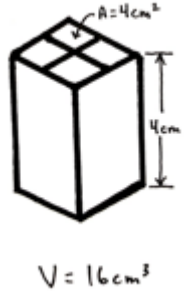


Figure 2

5. The teacher will write 16cm^2 on the board and then project a third rectangular prism (Figure 3) on the board. "How is this prism different from the others?" (We can't see the individual cubes in the faces. → We don't know the dimensions of the top face, only the area.) "Do we need the dimensions of the top face in order to find the volume of the right rectangular prism? Why or why not?" (No, we can use the area. → We don't want to know how many cubes are in each layer. We just want the total volume. The area and the height are enough to find the volume.) "Find the volume of the right rectangular prism. Work with a neighbor." (V = 12 in^3)

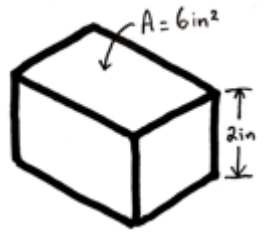


Figure 3

6. The students will complete the problems on Attachment #1 on their own.

Day 2

1. The teacher will pair students. [This can be done a variety of ways: Two struggling students together and two advanced students together or an advanced student and a struggling student together.] Partner A will have use one color to build a structure that is 3cm by 2cm by 2cm. Partner B will use a different color to build a cube that is 2cm on every side. Record the volume of your structures. (A: $12cm^3$ B: $8cm^3$) [MP 1, MP 2, MP 3, MP 4, MP 5, MP 6]
2. Keeping the original dimensions of your structures, how could you combine the two structures you've built? Turn and talk then find the volume of your new structure. (We could put the cube on top of the rectangular prism. → We could put them beside each other on the end. → We could make an L. → The volume is 20 cubic units.) [MP 1, MP 2, MP 3, MP 4, MP 5, MP 6, MP 7, MP 8]
3. Now build a different structure using your original prisms and find the volume. (20 cubic units) When you built the second structure, did the volume change? Why or why not? (It did not change the volume. There were still 20 cubic units. → It doesn't matter how we stacked the two prisms together. The volume of each one is the same every time, and the volume of the whole thing is still 20 cubic units. → The total volume is always going to be the volume of A plus the volume of B, no matter how we stack them.) [MP 1, MP 2, MP 3, MP 4, MP 5, MP 6, MP 7, MP 8]
4. The teacher will draw or project Figure 1 on the board. "What is the volume of this rectangular prism?" (42 cubic meters) Imagine another right rectangular prism identical to this one. If we glued them together to make a bigger prism, how could we find the volume? Turn and talk, then find the volume. (We already know that the volume of the first one is $42m^3$. We could just add another 42 m^3 to it. That would be 84 m^3. → We could multiply 42 by 2 since they are just alike. That's 84 m^3.)
5. The teacher will project Figure 2 on the board or draw it. "How is this figure different from the last one?" (There are two different size boxes this time. → The little box on top only has measurements on the length and the height.) Find the volume of the bottom rectangular prism. (V = 6 in x 5 in x 4 in = 120 in^3) Find the volume of the top rectangular prism. (V = 3 in x 5 in x 2 in = 30 in^3) "How could we find the volume of the entire figure?" (Add the two volumes together. → 150 in^3)

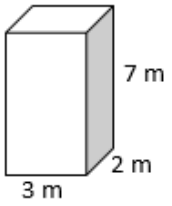


Figure 1

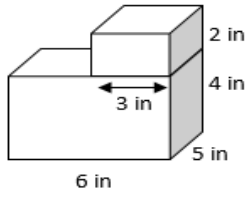


Figure 2

6. The teacher will project Figure 3 on the board or draw it. "How is this figure different from the last one?" (Instead of two separate heights, it has a bracket that shows the entire height of both rectangular prisms is 4 m.) If there are no measurements for the top box, how might we still calculate the volume? Turn and talk. (We can decompose the figures. If the total height is 4 m, and the height of the bottom figure is 2 m, 4 m – 2 m = 2m, then the height of the top figure is 2 m. We can do the same for the length 6 m – 4 m = 2 m, and we know the width is 2 m.) What is the volume of the top prism? (V = 2 m x 2 m x 2 m = 8 cubic meters) What is the volume of the bottom figure? (V = 6 m x 2 m x 2 m = 24 cubic meters) What is the total volume of both prisms? (V = 32 cubic meters)

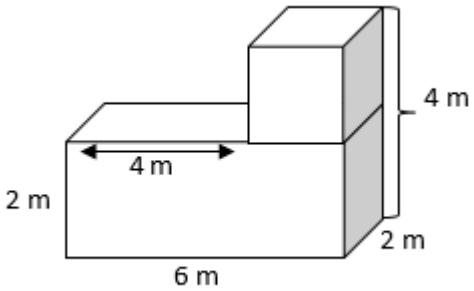


Figure 3

7. The teacher will distribute Attachment #2, ***Combining Prisms Problem Set***, to the students, and they will work individually to complete.

Day 3

1. The teacher will pair off the students and distribute: Attachment #3, ***Sculpture Recording Sheet***, Attachment #4, ***Project Requirements***, Attachment #5 ***Evaluation Rubric***, Attachment #6 ***Box and Lid Patterns*** (at least three of each per group copied onto cardstock), scissors, tape, rulers, and glue to pairs. Teacher's Note: Students will cut the templates to form boxes of a certain volume by adjusting the height of the sides. They should construct the boxes by taping edges together. Students will use between three and five rectangular prisms to construct their sculptures. The teacher will allow the students enough time to read through the rubric, project requirements, and problem set.
2. The teacher will demonstrate how to cut the boxes and lids for the students and answer questions while the students complete their sculptures.
3. Once the sculptures are completed, the teacher will distribute Attachment #7, ***Project Critique***, to the students. Each pair of students will be assigned another pair's sculpture to review using the worksheet provided, following the steps demonstrated in the lesson opening.

Lesson Closure	
1. The teacher will ask the students: Explain why the prisms in Problems 1(d) and 3(b) have the same volume but different dimensions. How is that possible? The students will write their response on a slip of paper, notecard, etc. and turn in as class ends: Identify the dimensions of a third prism that would have an equivalent volume. 2. **3-2-1:** The students will write 3 things they learned, 2 things they have a question about, and 1 thing they want the teacher to know on an index card, post-it-note, slip of paper, etc. and hand it in as they leave the classroom. 3. The teacher will lead a discussion: What was your thought process as you designed your sculpture? Were you inspired by something you have seen or own? **Write it Down:** The students will write down two challenges they faced and how they overcame them while creating their sculptures.	**Essential Questions:** • How can I measure capacity? • How can I find area? • What is the relationship between linear measurement, area, and volume? • How can models be used to determine volume? • What is the difference between mass and capacity?

Standards for Mathematical Practice
✓ Make sense of problems and persevere in solving them. ✓ Reason abstractly and quantitatively. ✓ Construct viable arguments and critique the reasoning of others. ✓ Model with mathematics. ✓ Use appropriate tools strategically. ✓ Attend to precision. ✓ Look for and make use of structure. ✓ Look for and express regularity in repeated reasoning.

Supplemental Activities	
Intervention • Students who struggle with visualizing the right rectangular prisms on paper can be provided with Unifix cubes to create the prisms. • **Day 3:** Some students may be overwhelmed by the amount of reading and interpretation of directions required for the project. Reading the requirements as a class and having discussion after each one can be helpful. Or, place accomplished readers with those who struggle. Some students may benefit from having cubes to actually construct a model of their structure first. Struggling students may be encouraged to use only three rectangular prisms to construct their sculpture.	**Enrichment** • **Day 2:** Challenge students whose spatial skills allow them to see these figures easily by having them draw a figure consisting of three different non-overlapping prisms on dot paper with just enough information given to calculate the volume of the figure. They should calculate the volume of their own figure and then exchange figures with a partner.

Performance Based Assessment Task

Math Task

Name_____

Planter Box Designer

You have a small backyard, but you want to plant a garden. You have 120 cubic centimeters of soil to make a planter box. You are going to design **three different box options** that will hold all of the soil. The soil will need to be 10 or 20 centimeters lower than the top of the box in order to keep the soil contained. .

Design 1	Design 2	Design 3

Extension: The students will select one of their designs to build using cardboard and tape. Using centimeter cubes, the students will verify their constructed design will hold 120 cubic centimeters of soil.

Rubric/ Plausible Student Response(s)

Name: _____ Teacher:

Date Submitted: _____ Title of Work: _____

	Criteria				Points
	4	**3**	**2**	**1**	
Explanation	A complete response with a detailed explanation.	Good solid response with clear explanation.	Explanation is unclear.	Misses key points.	___
Use Of Visuals	Clear diagram or sketch with some detail.	Clear diagram or sketch.	Inappropriate or unclear diagram.	No diagram or sketch.	___
Mechanics	No math errors.	No major math errors or serious flaws in reasoning.	May be some serious math errors or flaws in reasoning.	Major math errors or serious flaws in reasoning.	___
Demonstrated Knowledge	Shows complete understanding of the questions, mathematical ideas, and processes.	Shows substantial understanding of the problem, ideas, and processes.	Response shows some understanding of the problem.	Response shows a complete lack of understanding for the problem.	___
Requirements	Goes beyond the requirements of the problem.	Meets the requirements of the problem.	Hardly meets the requirements of the problem.	Does not meet the requirements of the problem.	___
Counter Examples	Includes counter examples.		Does not include counter examples.		___
				Total---->	___

Teacher Comments:

Possible Solutions (numbers can be in different orders)

- *1 x 2 x 60*
- *1 x 3 x 40*
- *1 x 4 x 30*
- *1 x 5 x 24*

	• *1 x 6 x 20* • *1 x 8 x 15* • *1 x 10 x 12* • *6 x 5 x 4* • *12 x 5 x 2* • *30 x 2 x 2* • *15 x 2 x 4* • *20 x 2 x 3*

Lesson Plan Attachments

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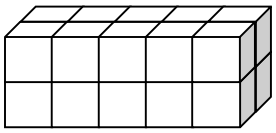
Name: _____ Date: _____

Discovering Volume Problem Set

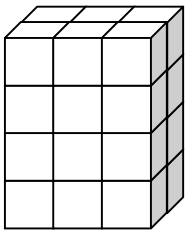
1.

Cubes in Each Layer	Number of Layers	Volume

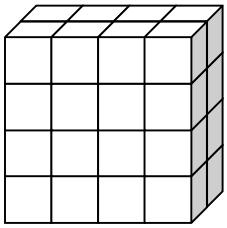
2. Each rectangular prism is built from centimeter cubes. State the dimensions and find the volume.

a. 

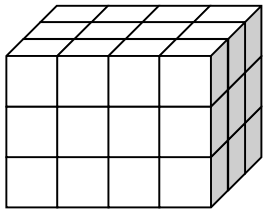
Length: _____ cm
Width: _____ cm
Height: _____ cm
Volume: _____ cm^3

b. 

Length: _____ cm
Width: _____ cm
Height: _____ cm
Volume: _____ cm^3

c. 

Length: _____ cm
Width: _____ cm
Height: _____ cm
Volume: _____ cm^3

d. 

Length: _____ cm

Width: _____ cm

Height: _____ cm

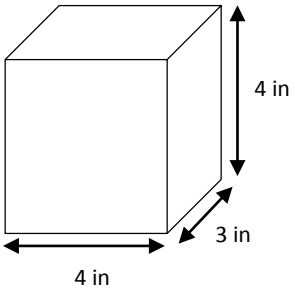
Volume: _____ cm^3

3. Write a multiplication sentence that you could use to calculate the volume for each rectangular prism in Problem 1. Include the units in your sentences.

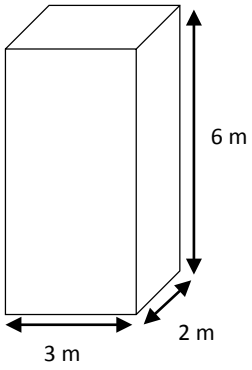
a. _____ b. _____

c. _____ d. _____

4. Calculate the volume of each rectangular prism. Include the units in your number sentences.

a. 

V = _____

b. 

V = _____

5. Tyron is constructing a box in the shape of a rectangular prism to store his baseball cards. It has a length of 10 centimeters, a width of 7 centimeters, and a height of 8 centimeters. What is the volume of the box?

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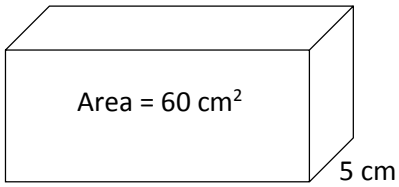
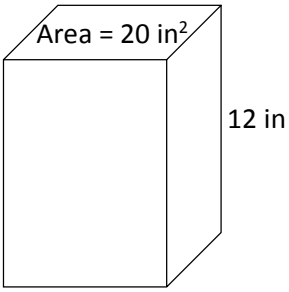
6. Aaron says more information is needed to find the volume of the prisms. Explain why Aaron is mistaken and calculate the volume of the prisms.

a.



b.



Attachment #2

Mississippi College- and Career-Readiness Standards
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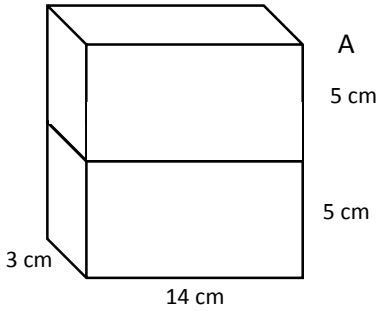
Name _____ Date _____

Combining Prisms Problem Set

1. Find the total volume of the figures and record your solution strategy.

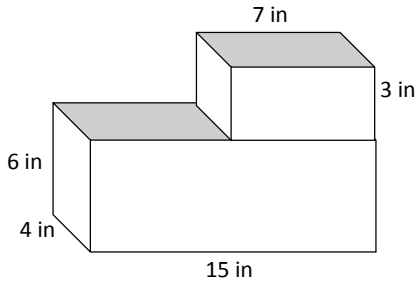
a.



Volume: _____

Solution Strategy:

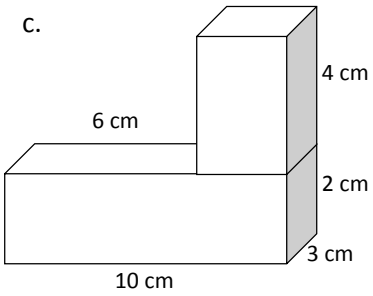
b.



Volume: _____

Solution Strategy:

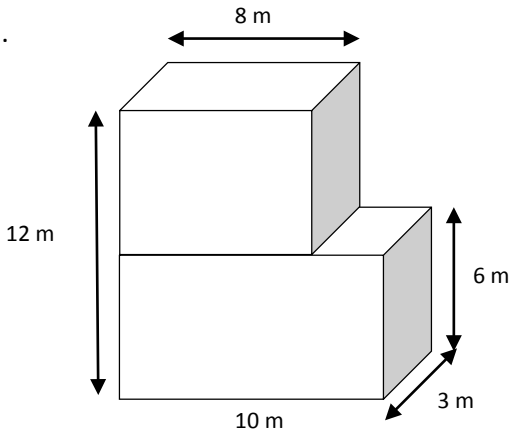
c.



Volume: _____

Solution Strategy:

d.



Volume: _____

Solution Strategy:

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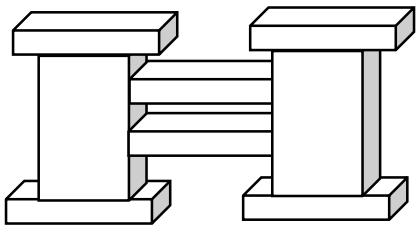
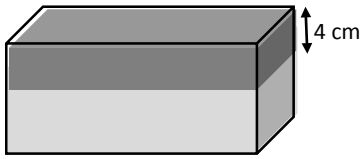
2. A sculpture (pictured below) is made of two sizes of rectangular prisms. One size measures 13 in by 8 in by 2 in. The other size measures 9 in by 8 in by 18 in. What is the total volume of the sculpture?



3. The combined volume of two identical cubes is 128 cubic centimeters. What is the side length of each cube?

4. A rectangular tank with a base area of 24 cm^2 is filled with water and oil to a depth of 9 cm. The oil and water separate into two layers when the oil rises to the top. If the thickness of the oil layer is 4 cm, what is the volume of the water?



Attachment #3

Mississippi College- and Career-Readiness Standards
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Name _____ Date _____

Sculpture Recording Sheet

Directions: Using the box patterns, construct a sculpture containing at least 5 but not more than 7 rectangular prisms that meets the following requirements in the table below.

1.	My sculpture has 5 to 7 rectangular prisms. Number of prisms: _____
2.	Each prism is labeled with a letter, dimensions, and volume.
	Prism A _____ by _____ by _____ Volume _____ Prism B _____ by _____ by _____ Volume _____ Prism C _____ by _____ by _____ Volume _____ Prism D _____ by _____ by _____ Volume _____ Prism E _____ by _____ by _____ Volume _____ Prism __ _____ by _____ by _____ Volume _____ Prism __ _____ by _____ by _____ Volume _____

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3.	Prism D has $\frac{1}{2}$ the volume of prism __.	Prism D Volume = _____ Prism __ Volume = _____
4.	Prism E has $\frac{1}{3}$ the volume of prism __.	Prism E Volume = _____ Prism __ Volume = _____
5.	The total volume of all the prisms is 1,000 cubic centimeters or less.	Total volume: _____ Show calculations:

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Project Requirements

1. Each project must include 5 to 7 rectangular prisms.
2. All prisms must be labeled with a letter (beginning with A), dimensions, and volume.
3. Prism D must be $\frac{1}{2}$ the volume of another prism.
4. Prism E must be $\frac{1}{3}$ the volume of another prism.
5. The total volume of all of the prisms must be 1,000 cubic centimeters or less.

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Project Requirements

1. Each project must include 5 to 7 rectangular prisms.
2. All prisms must be labeled with a letter (beginning with A), dimensions, and volume.
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Project Requirements

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Attachment #5

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Evaluation Rubric

CATEGORY	4	3	2	1	Subtotal
Completeness of Personal Project and Classmate Evaluation	All components of the project are present and correct, and a detailed evaluation of a classmate's project has been completed.	Project is missing 1 component, and a detailed evaluation of a classmate's project has been completed.	Project is missing 2 components, and an evaluation of a classmate's project has been completed.	Project is missing 3 or more components, and an evaluation of a classmate's project has been completed.	(× 4) _____/16
Accuracy of Calculations	Volume calculations for all prisms are correct.	Volume calculations include 1 error.	Volume calculations include 2–3 errors.	Volume calculations include 4 or more errors.	(× 5) _____/20
Neatness and Use of Color			All elements of the project are carefully and colorfully constructed.	Some elements of the project are carefully and colorfully constructed.	(× 2) _____/4
					TOTAL: _____ /40

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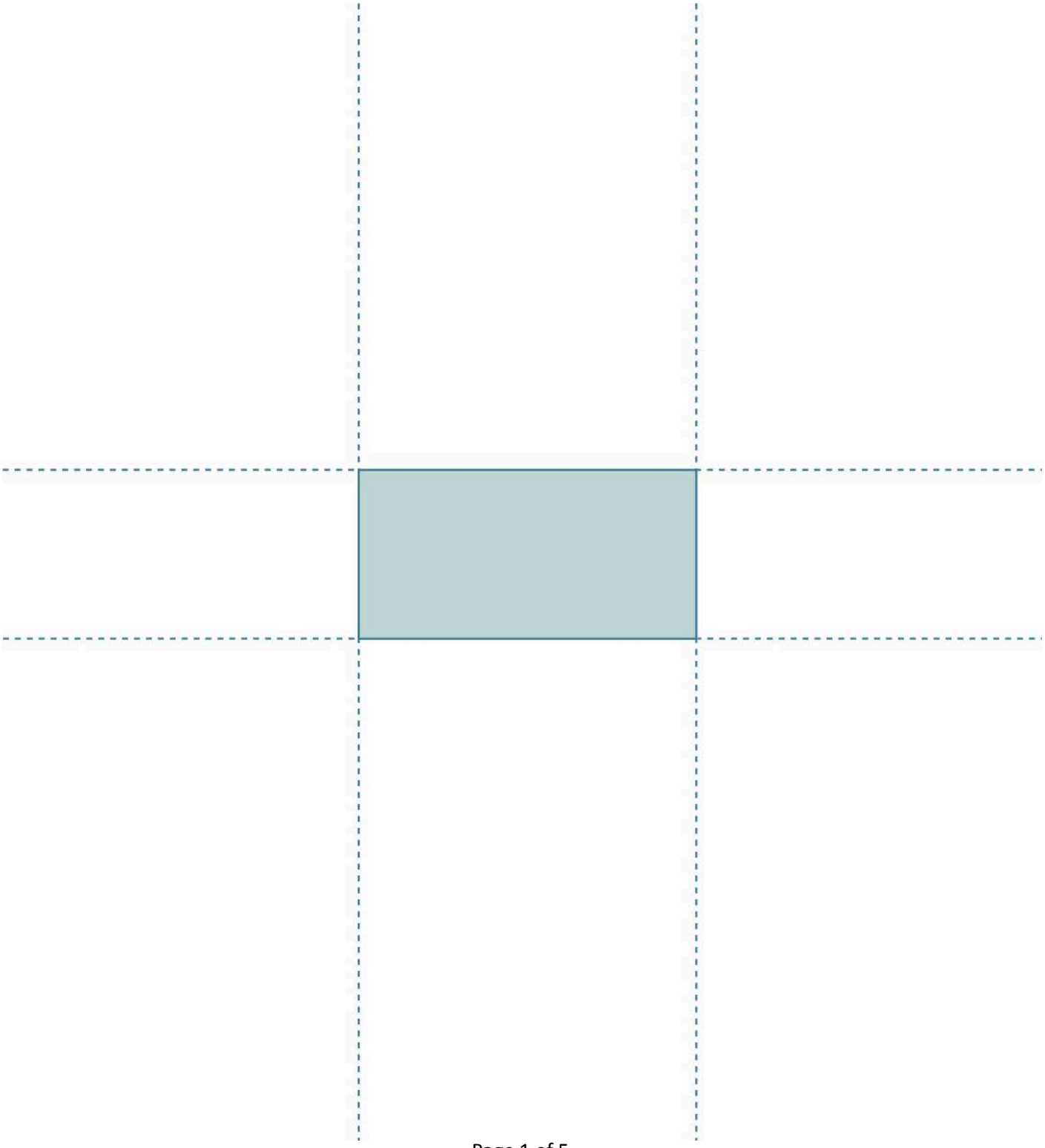
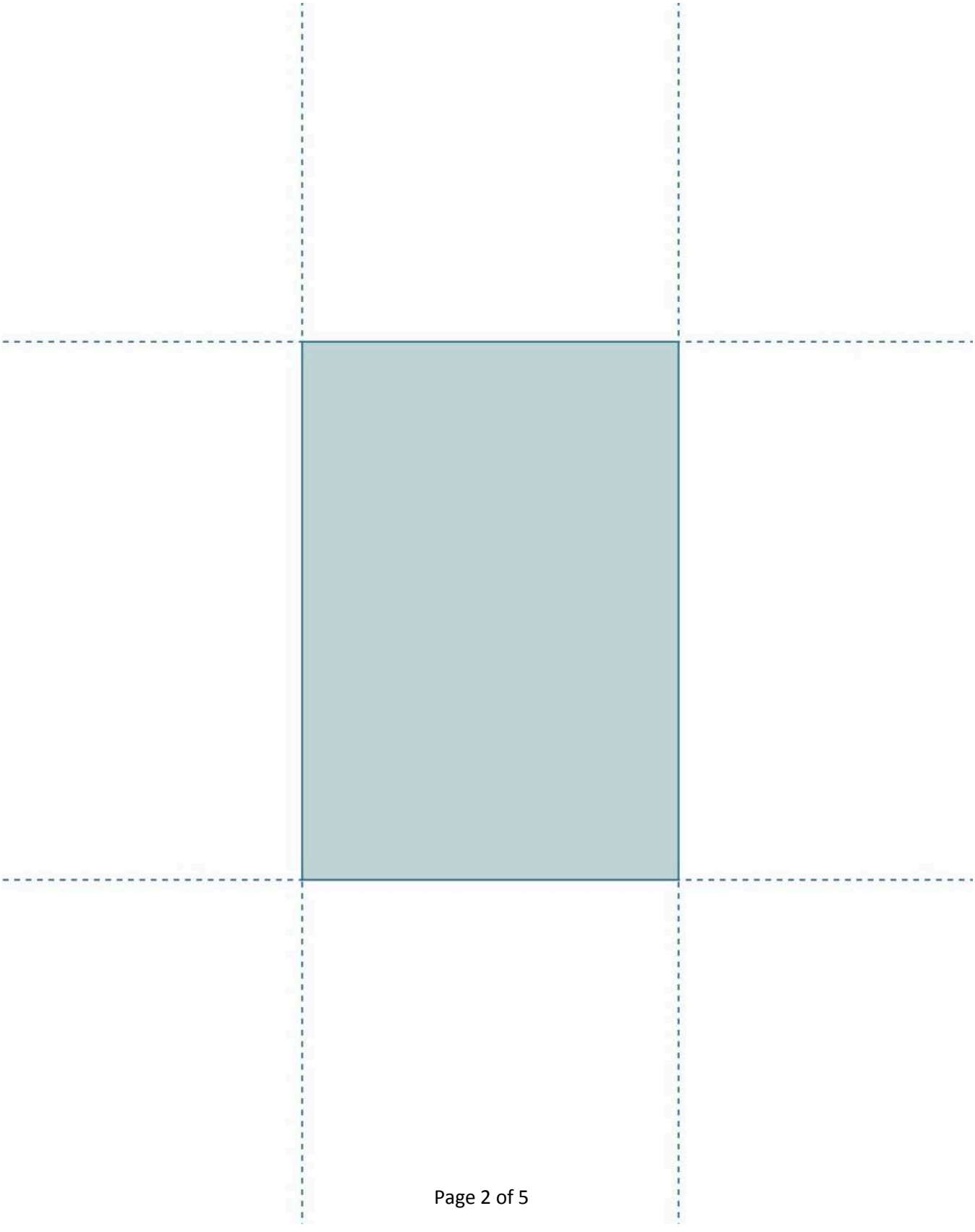
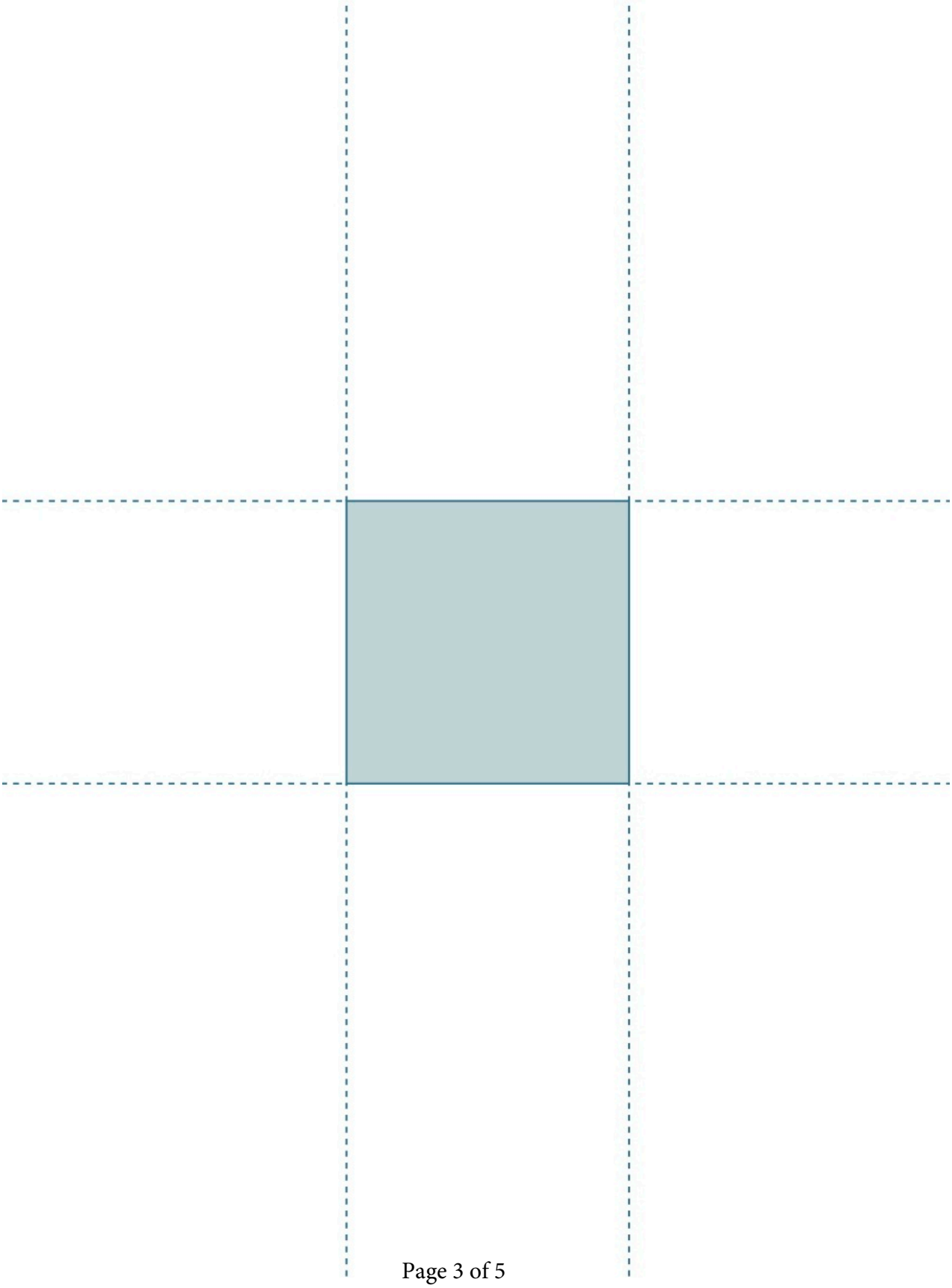
Box and Lid Patterns







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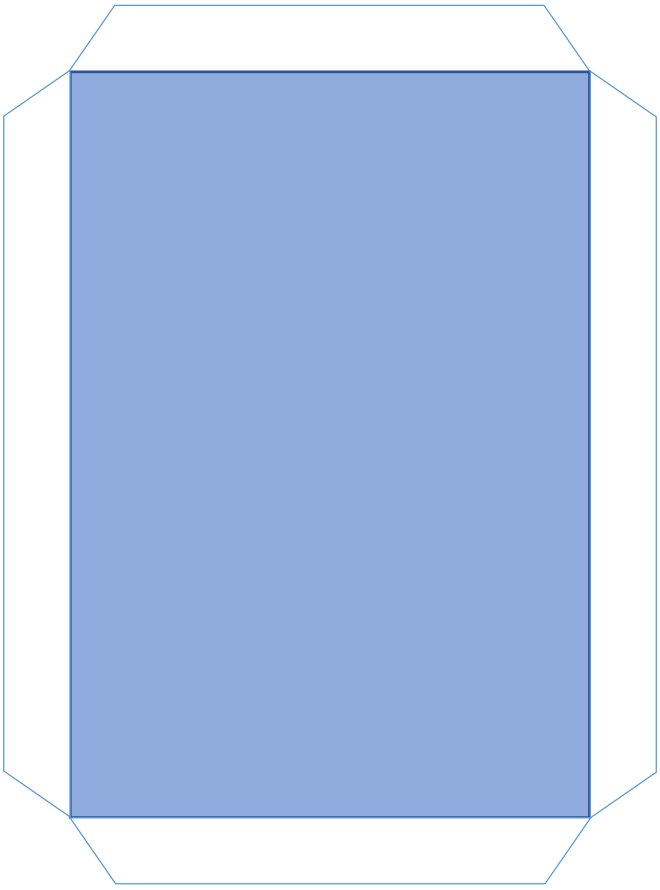

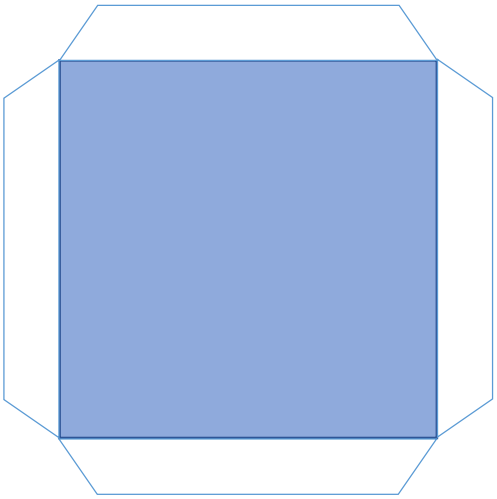

Attachment #7

Mississippi College- and Career-Readiness Standards
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Name _____ Date _____

Project Critique

I reviewed project number _____.

Directions: Use the rubric below to evaluate your classmates' project. Ask questions and measure the required parts to determine whether he or she has all the required elements. Respond to the prompt in italics in the third column. The final column may be used to write something you find interesting about that element if you desire.

Space is provided beneath the rubric for your calculations.

	Requirement	Element present? (✓)	Specifics of Element	Notes
1	Sculpture has 5 to 7 prisms.		*# of prisms:*	
2	All prisms are labeled with a letter.		*Write letters used:*	
3	All prisms have correct dimensions with units written on the top.		*List any prisms with incorrect dimensions or units:*	
4	All prisms have correct volume with units written on top.		*List any prism with incorrect dimensions or units:*	
5	Prism D has $\frac{1}{2}$ the volume of another prism.		*Record on next page:*	
6	Prism E has $\frac{1}{3}$ the volume of another prism.		*Record on next page:*	
7	The total volume of all the parts together is 1,000 cubic units or less.		*Total volume:*	

Calculations:

8. Measure the dimensions of each prism. Calculate the volume of each prism and the total volume. Record that information in the table below. If your measurements or volume differ from those listed on the project, put a star by the prism label in the table below and record on the rubric.

Prism	Dimensions	Volume
A	by by	
B	by by	
C	by by	
D	by by	
E	by by	
	by by	
	by by	

9. Prism D's volume is $\frac{1}{2}$ that of Prism _____.
   Show calculations below.

10. Prism E's volume is $\frac{1}{3}$ that of Prism _____.
    Show calculations below.

11. Total volume of sculpture: _____.
    Show calculations below.