Lunar Habitat and What's The Difference (WTD)
Teacher's Guide to Case Study 1

Instructional Curriculum

Mathematics: Grades 6-9

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Moon Math Case Studies

Introduction: This unit of instruction will consist of three case studies. Each case study will address the concepts of lunar habitat design. All three case studies will utilize WTD application in order to offer the students a deeper understanding of different lunar habitat models.

Depending on mathematical competency of the students, these units can be utilized in upper middle grades or with high school freshmen. It is not required for students to complete all three units. While it is suggested that all students complete the third unit, students familiar with the area concepts do not need to complete the first unit. Similarly, the students familiar with the volume concepts do not need to complete the second unit.

The three cases all have three levels of difficulty: A, B, and C. Level A, the beginning level, will involve multiplying whole numbers (except for π). Level B, the intermediate level, will involve multiplying decimals. Level C, the advanced level, will involve multiplying fractions.

The first case study, Case Study I, will address the concept of area by having the students calculate areas of two different lunar habitat designs. The students will also calculate area of a one-bedroom apartment and compare it with the areas of both lunar habitat designs.

The second case study, Case Study II, will address the concept of volume by having the students calculate volumes of two different lunar habitat designs. The students will also calculate volume of a one-bedroom apartment and compare it with the volumes of both lunar habitat designs.

The third case study, Case Study III, will address the concept of proportions by having the students construct scale models of a lunar habitat. Three levels of difficulty will be offered in this case study: A, B, and C. Level A, the beginning level, will ask the students to create a scale model of a simple singe-building lunar habitat. Level B, the intermediate level, will ask the students to create a scale model of a lunar habitat consisting of two structures. Level C, the advanced level, will ask the students to create a scale model of a lunar habitat consisting of three structures.

Guiding Question: How can the area and volume of a lunar habitat be calculated easily and effectively?

Main Concept: Paper-and-pencil calculations can be used to problem-solve simple calculations of area and volume, but technology is required for speed and accuracy in more complicated cases.

The students will also master the following concepts: multiplying decimals, multiplying fractions, and converting units of measure.

Prerequisite Skills: To successfully complete Case Study I, the students needs to be able to compute the areas of basic cylinders.

To successfully complete Case Study II, the students need to be able to compute volumes of basic cylinders.

To successfully complete Case Study III, the students need to be able to construct proportionate scale models of three-dimensional shapes.

Objectives: By completing these case studies the students will gain an understanding of the design requirements for a lunar habitat. The students will also become proficient in calculating area and volume of various shapes, and in creating scale models of various shapes.

NCTM Standards: Represent and Analyze (Algebra): explore relationships between symbolic expressions and graphs of lines; model and solve contextualized problems using various representations, such as graphs, tables, and equations.

Analyze Characteristics (Geometry): precisely describe, classify, and understand relationships among types of two- and three-dimensional objects using their defining properties; understand relationships among the angles, side lengths, perimeters, areas, and volumes of similar objects; create and critique inductive and deductive arguments concerning geometric ideas and relationships, such as congruence, similarity, and the Pythagorean relationship.

Preparation: Before starting work on each unit, the teacher will discuss the appropriate mathematical concepts with the students. Depending on the case study they participate in, students will be exposed to the areas and volumes of cylinders and to the construction of scale models.

Materials: Each student is expected to have a pencil, ruler, sheet of paper, and an appropriate student worksheet. Calculators are optional. The

teacher should also secure access to the computer lab and WTD application.

Time for Activity: Each case study is expected to take between one and two academic hours depending on the skills of the students. A teacher may assign more than one case study per student.

Case Study I: Comparing Areas of Different Lunar Habitats

Engage: The lesson will begin with the teacher discussing the history of lunar exploration. The teacher will show the footage of Neil Armstrong walking on the moon. The teacher will discuss the Apollo mission. The teacher will ask students to think of five things regarding what it would be like to travel to the moon. The teacher will continue by asking the students to imagine what it would be like to live on the moon for an extended period of time.

Explore: The teacher will ask the students to consider the requirements needed for a building on the moon. The concept of the lunar habitat will be introduced and discussed. The teacher will break the class in two groups and will ask one group to consider the exterior design of the lunar habitat. The second group will be asked to consider the interior design of the lunar habitat.

In fifteen-twenty minutes, the teacher will re-unite the class and the groups will report their findings to the whole class. The teacher will construct a KWL chart with sub-sections for exterior and interior design.

Explain: After concluding the class discussion mentioned above and completing the KWL chart, the teacher will address the key issues of exterior and interior lunar habitat design. If not already addressed by the students, the teacher will explain that most models of lunar habitats appear to be cylindrical due to various considerations, such as the ease of construction, transportation, and assembly; shielding from radiation; etc. Two models of lunar habitats will be

demonstrated to the class: model A consisting of three wide cylinders (r > h) stacked on top of each other and model B consisting of a single large horizontally aligned cylinder (r < l).

The teacher will address the interior design requirements of each model as well. The teacher will mention that each model should include the following: living quarters, hygiene area, galley, central eating / recreation area. There should also be enough space left to add laboratories, workshops, and crew health and exercise stations in the future (see http://www.astrobio.net/news/modules.php?op=modload&name=News&file=article&sid=1904&mode=thread&order=0&thold=0 for reference).

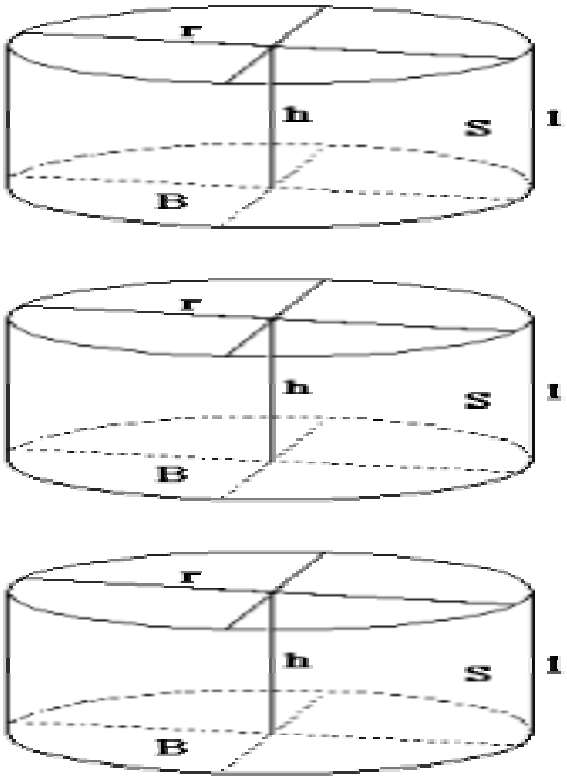
Extend: To further students' understanding of various lunar habitat designs and to reinforce students' mastery with computing areas, the students will be asked to complete a case study worksheet (of appropriate difficulty level) where they will compute areas of two different lunar habitat designs and compare it with the area of a typical one-bedroom apartment.

Once the case studies are completed, the students will work in the computer lab where they practice comparing different lunar habitat shapes using the WTD tool. The teacher will circulate and offer individual help as needed.

Evaluate: As students complete the case studies, their finding shall be presented to the class. The students will submit their Findings Sheets and they will be posted on the classroom walls. The teacher will proceed with re-teaching or enrichment as needed after analyzing students' work.

Case Study I: Level A Teacher Worksheet

Figure A:



Part A: Consider figure A on the left. In this case, the lunar habitat consists of three cylindrical shapes that are arranged vertically with a stair case connecting each cylinder. Each cylinder represents one floor of the habitat. All three cylinders are congruent which means that they have identical dimensions.

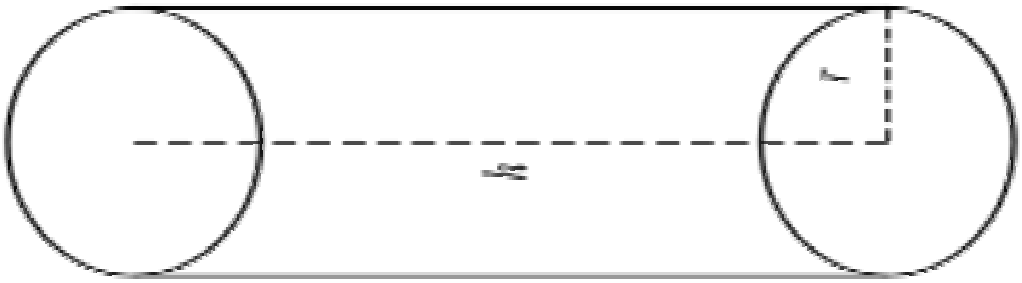
Given that the radius of each cylinder (r) is 10 meters and its height (h) is 3 meters, compute the surface area of this lunar habitat. Do not include the areas of each staircase in your computations.

$$A = 2\pi r^2 + 2\pi rh = 2\pi r(r + h)$$

A = 3 * 2 * 3.14 * 10 * (10+3) = 2,449.20 (m^2)

Please remember to multiply the quantity by 3 because there are 3 congruent cylinders.

Figure B:



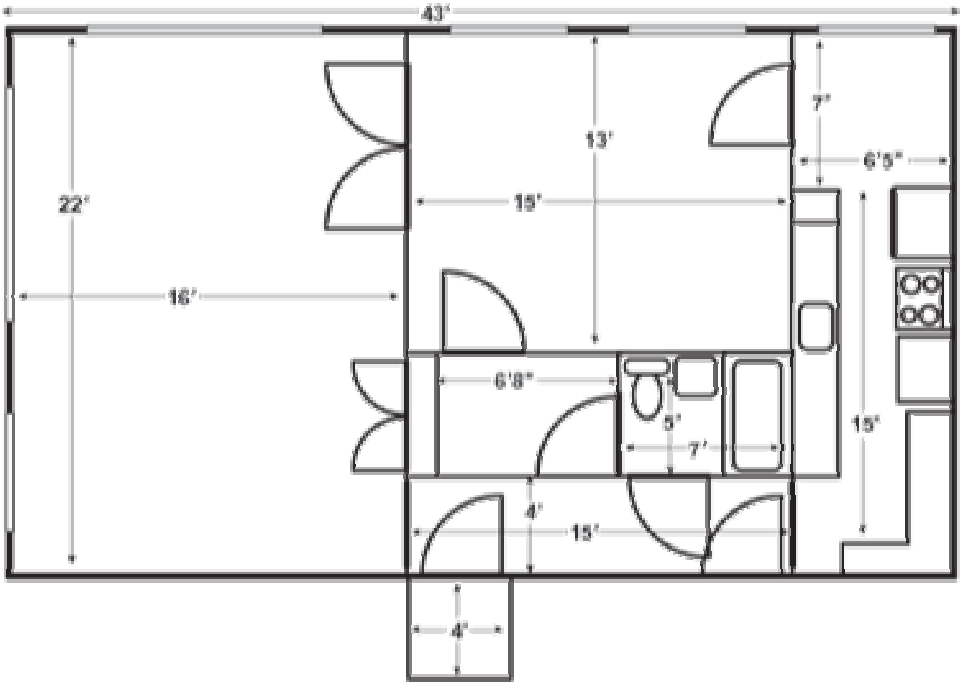
Part B: Consider figure B above. In this case, a typical elongated cylinder is tilted on its side to create a lunar habitat model. Given that the cylinder has a radius (r) of 4 meters and height (h) of 25 meters, compute the surface area of this lunar habitat.

$$A = 2\pi r^2 + 2\pi rh = 2\pi r(r + h)$$

A = 2 * 3.14 * 4 * (4 + 25) = 728.48 (m^2)

Case Study I: Level A Teacher Worksheet

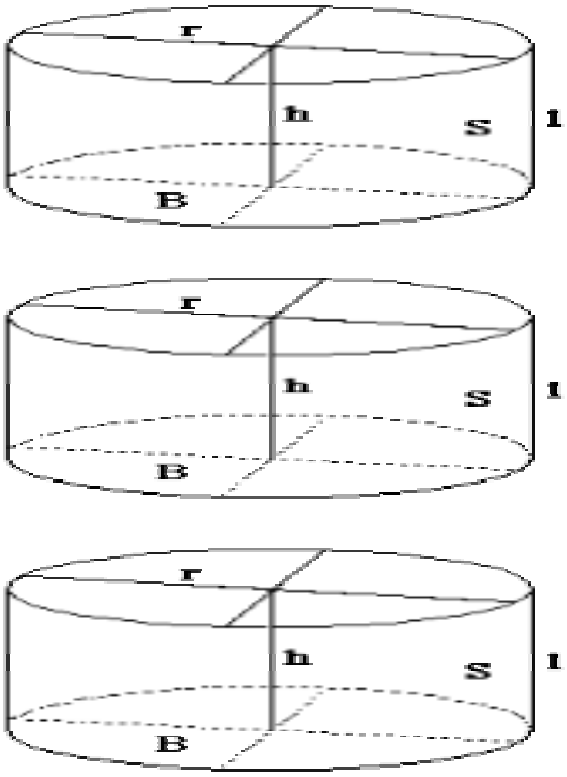
Figure C:



Part C:	Consider figure C above. You are seeing a typical floor plan of a one-bedroom apartment. For comparison purposes, compute the total area of this apartment. Make sure to convert all units of measure to the metric system. A = L * W A = [(.3 * 43) * (.3*22)] + [(.3 * 4)] * (.3*4)] = 87.06 (m^2) Remember to convert feet to meters and to add the foyer area.

Case Study I: Level B Teacher Worksheet

Figure A:



Part A: Consider figure A on the left. In this case, the lunar habitat consists of three cylindrical shapes that are arranged vertically with a stair case connecting each cylinder. Each cylinder represents one floor of the habitat. All three cylinders are congruent which means that they have identical dimensions.

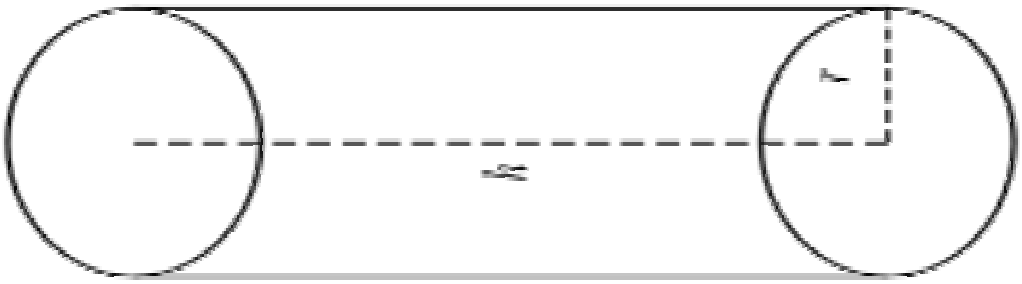
Given that the radius of each cylinder (r) is 10.3 meters and its height (h) is 2.4 meters, compute the surface area of this lunar habitat. Do not include the areas of each staircase in your computations.

$$A = 2\pi r^2 + 2\pi rh = 2\pi r(r + h)$$

A = 3 * 2 * 3.14 * 10.3 * (10.3 + 2.4) = 2,464.46 (m^2)

Please remember to multiply the quantity by 3 because there are 3 congruent cylinders.

Figure B:



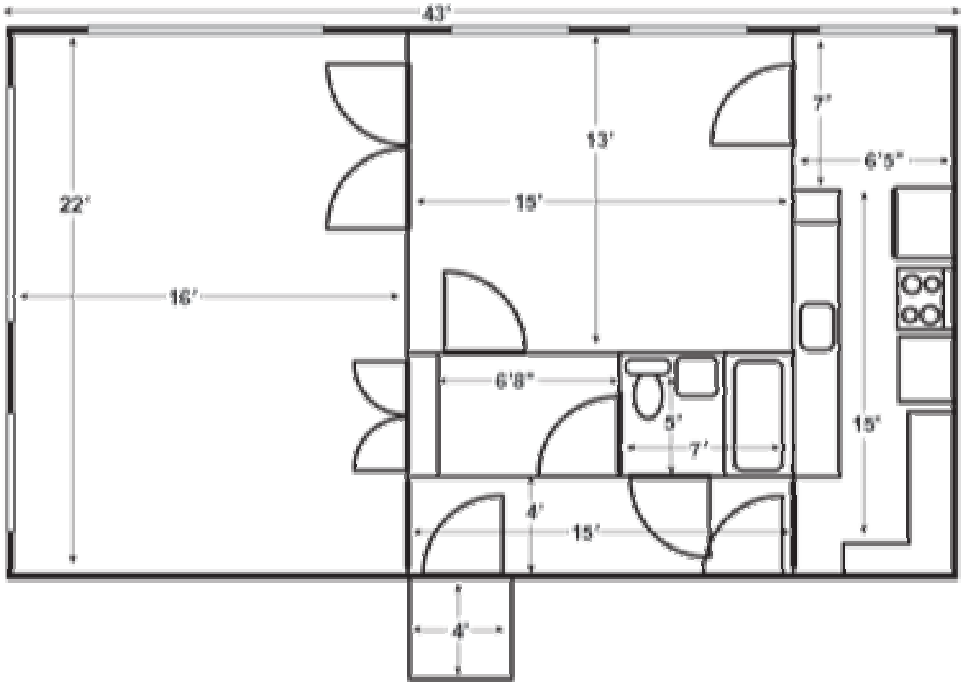
Part B: Consider figure B above. In this case, a typical elongated cylinder is tilted on its side to create a lunar habitat model. Given that the cylinder has a radius (r) of 3.5 meters and height (h) of 26.18 meters, compute the surface area of this lunar habitat.

$$A = 2\pi r^2 + 2\pi rh = 2\pi r(r + h)$$

A = 2 * 3.14 * 3.5 * (3.5 + 26.18) = 652.37(m^2)

Case Study I: Level B Teacher Worksheet

Figure C:

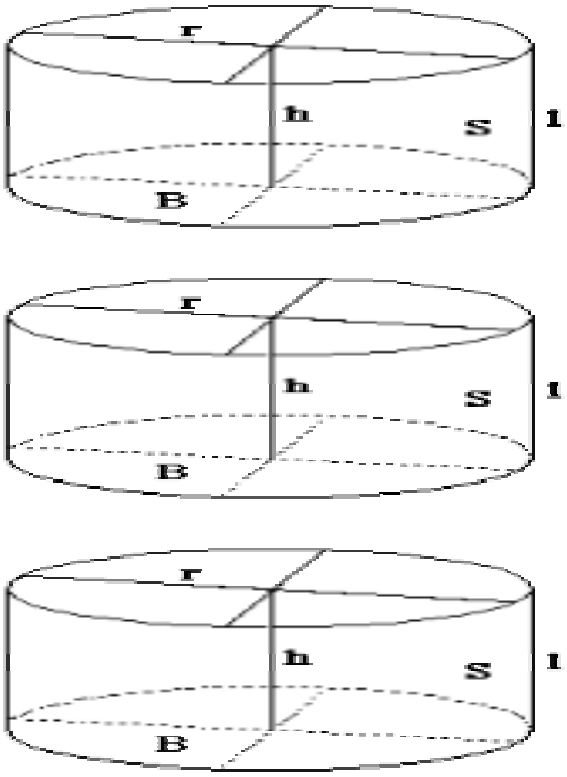


Part C:	Consider figure C above. You are seeing a typical floor plan of a one-bedroom apartment. For comparison purposes, compute the total area of this apartment. Present your answer in both square feet and square meters units of measure.

A = L * W
A = [43 * 22] + [4 * 4] = 962 (ft^2)
A = [(.3 * 43)] * (.3 * 22)] + [(.3 * 4)] * (.3*4)] = 87.06 (m^2)

Case Study I: Level C Teacher Worksheet

Figure A:



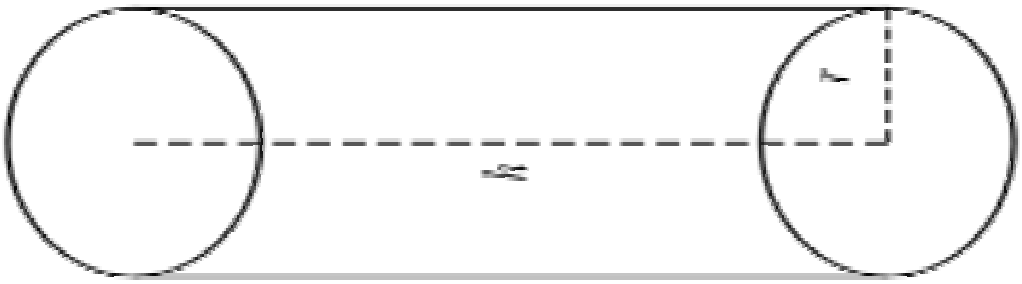
Part A: Consider figure A on the left. In this case, the lunar habitat consists of three cylindrical shapes that are arranged vertically with a stair case connecting each cylinder. Each cylinder represents one floor of the habitat. All three cylinders are congruent which means that they have identical dimensions.

Given that the radius of each cylinder (r) is 9 3/4 meters and its height (h) is 3 4/5 meters, compute the surface area of this lunar habitat. Do not include the areas of each staircase in your computations.

$$A = 2\pi r^2 + 2\pi rh = 2\pi r(r + h)$$

A = 3 * 2 * 3.14 * 9 3/4 * (10+3 4/5) =
= 2534.92(m^2)
Please remember to multiply the quantity by 3 because there are 3 congruent cylinders.

Figure B:



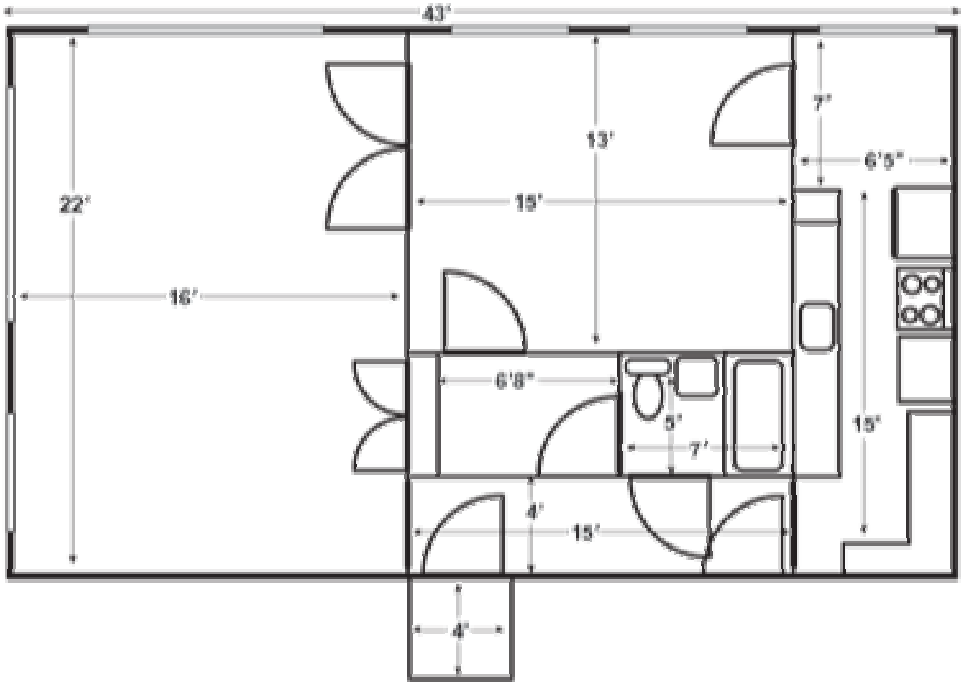
Part B: Consider figure B above. In this case, a typical elongated cylinder is tilted on its side to create a lunar habitat model. Given that the cylinder has a radius (r) of 3 1/5 meters and height (h) of 27 9/10 meters, compute the surface area of this lunar habitat.

$$A = 2\pi r^2 + 2\pi rh = 2\pi r(r + h)$$

A = 2 * 3.14 * 3 1/5 * (3 1/5 + 27 9/10) = 624.99 (m^2)

Case Study I: Level C Teacher Worksheet

Figure C:



Part C:	Consider figure C above. You are seeing a typical floor plan of a one-bedroom apartment. For comparison purposes, compute the total area of this apartment. Present your answer in both square feet and square meters units of measure.

A = L * W
A = [43 * 22] + [4 * 4] = 962 (ft^2)
A = [(.3 * 43)] * (.3 * 22)] + [(.3 * 4)] * (.3*4)] = 87.06 (m^2)

Case Study I: Findings Sheet

Name(s): _____
Level: _____
Period: _____
Date: _____

Directions: Fill out this sheet completely and turn it in with all work to your teacher.

Question	Answer	Reasoning
Question 1: What was the area of figure A?		
Question 2: What was the area of figure B?		
Question 3: Which was the area of figure C?		