Case Study III: **Optimizing Cargo Weight for a Lunar Mission**

This Case Study can be taught after or instead of Case Study II.

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 the students to think of the supplies and scientific instruments required for the mission. The students will compose a list of items needed for a successful mission and will research corresponding weights for each item.

Explore: The teacher will begin a class discussion on the topic of volume and weight optimization. Similarly to the class activity in Case Study II, the class will be divided into groups of four and each group will be asked to calculate how many matchboxes (5 cm x 1 cm x 8 cm, 30 g) would fit in a shoebox (25 cm x 20 cm x 30 cm) and what would be the total weight of all the matchboxes. The groups will be asked to justify their logic and present the findings to the class.

After reporting their findings to the class each group will be given a shoebox and a supply of matchboxes in order to validate their findings (alternatively, any larger box and a set of smaller boxes may be used). In this hands-on activity the students will be able to prove or disprove their earlier findings. Finally, the groups will construct the KWL chart in order to identify what the group has learned and what questions it may have.

Explain: After concluding the class discussion mentioned above and completing the KWL chart, the teacher will explain to the students that the volume of a three-dimensional rectangular shape can be computed by multiplying its three dimensions: $v = lwh$.

Most importantly, however, the teacher will explain to the class the best way to approximate the number of units that would fit in a larger space is to divide the volume of that space by the volume of each unit. Lastly, the teacher will explain to the students that in order to calculate the total units' weight the individual weight of each unit would have to be multiplied by the number of units calculated above.

Extend: To further students' understanding of how to optimize a cargo hold volume for different containers, the students will be asked to complete a case study worksheet (of appropriate difficulty level) where they will consider various scenarios of cargo hold volume and weight optimization.

Once the case studies are completed, the students will work in the computer lab where they will practice optimizing cargo volume holds using the WTD tool. By using the WTD tool, the students will be able to drag and drop containers of different sizes in the cargo hold of a spacecraft in order to optimize its capacity. The built-in calculator will provide total cargo weights in both regular and "moon" units of measure. 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.

Lunar Habitat II

Case Study III
Level A
Student Worksheet

Optimizing Cargo Weight for a Lunar Mission

You are the load manager for the next lunar mission. The cargo hold of the spacecraft is three meters tall, eight meters long, and five meters wide. There are two container types used for this mission. Type A container is a cube with each side being one meter long. It weighs three hundred and fifty kilograms. Type B container is three meters long, one meter tall, and one meter wide. It weighs eight hundred kilograms.

Your task is to determine how many Type A or Type B containers would fit in the cargo hold and to calculate corresponding weights in kilograms and "moon-kilograms".

Lunar Habitat II

Case Study III
Level B
Student Worksheet

Optimizing Cargo Weight for a Lunar Mission

You are the load manager for the next lunar mission. The cargo hold of the spacecraft is three meters tall, eight meters long, and five meters wide. There are two container types used for this mission. Type A container is a cube with each side being one meter long. It weighs three hundred and fifty kilograms. Type B container is three meters long, one meter tall, and one meter wide. It weighs eight hundred kilograms.

Your task is to determine how many Type A and Type B containers are required to fill 50% of the cargo hold with each container type and to calculate corresponding weights in kilograms and "moon-kilograms".

Lunar Habitat II

Case Study III
Level C
Student Worksheet

Optimizing Cargo Weight for a Lunar Mission

You are the load manager for the next lunar mission. The cargo hold of the spacecraft is three meters tall, eight meters long, and five meters wide. There are two container types used for this mission. Type A container is a cube with each side being one meter long. It weighs three hundred and fifty kilograms. Type B container is three meters long, one meter tall, and one meter wide. It weighs eight hundred kilograms.

Your task is to determine how many Type A and Type B containers are required to fill the cargo hold if the requirement is to have the equal amount of containers of each type and to calculate corresponding weights in kilograms and “moon-kilograms”.

Lunar Habitat II

Case Study III
Level A
Teacher Worksheet

Optimizing Cargo Weight for a Lunar Mission

You are the load manager for the next lunar mission. The cargo hold of the spacecraft is three meters tall, eight meters long, and five meters wide. There are two container types used for this mission. Type A container is a cube with each side being one meter long. It weighs three hundred and fifty kilograms. Type B container is three meters long, one meter tall, and one meter wide. It weighs eight hundred kilograms.

Your task is to determine how many Type A or Type B containers would fit in the cargo hold and to calculate corresponding weights in kilograms and "moon-kilograms".

$V_{CargoHold} = 3 \times 8 \times 5 = 120\ (m^3)$

$V_{TypeA} = 1 \times 1 \times 1 = 1\ (m^3)$

$V_{TypeB} = 3 \times 1 \times 1 = 3\ (m^3)$

Therefore, the cargo hold would have a capacity of 120 Type A containers ($V_{CargoHold}$ / V_{TypeA}) or 40 Type B containers ($V_{CargoHold}$ / V_{TypeB}).

To calculate corresponding weights for Type A containers: 120 x 350 = 42,000 (kg). To convert this weigh to "moon-kilograms" or to calculate its corresponding weight on the moon: 42,000 x 0.17 = 7,140 (kg).

To calculate corresponding weights for Type B containers: 40 x 800 = 32,000 (kg). To convert this weigh to "moon-kilograms" or to calculate its corresponding weight on the moon: 32,000 x 0.17 = 5,440 (kg).

Lunar Habitat II

Case Study III
Level B
Teacher Worksheet

Optimizing Cargo Weight for a Lunar Mission

You are the load manager for the next lunar mission. The cargo hold of the spacecraft is three meters tall, eight meters long, and five meters wide. There are two container types used for this mission. Type A container is a cube with each side being one meter long. It weighs three hundred and fifty kilograms. Type B container is three meters long, one meter tall, and one meter wide. It weighs eight hundred kilograms.

Your task is to determine how many Type A and Type B containers are required to fill 50% of the cargo hold with each container type and to calculate corresponding weights in kilograms and "moon-kilograms".

$V_{CargoHold} = 3 \times 8 \times 5 = 120\ (m^3)$

$V_{TypeA} = 1 \times 1 \times 1 = 1\ (m^3)$

$V_{TypeB} = 3 \times 1 \times 1 = 3\ (m^3)$

Therefore, the cargo hold would have a capacity of 60 Type A containers ($0.5V_{CargoHold} / V_{TypeA}$) or 20 Type B containers ($0.5V_{CargoHold} / V_{TypeB}$). Remember to multiply the volume of the cargo hold by 0.5.

To calculate corresponding weights for Type A containers: 60 x 350 = 21,000 (kg). To convert this weigh to "moon-kilograms" or to calculate its corresponding weight on the moon: 21,000 x 0.17 = 3,570 (kg).

To calculate corresponding weights for Type B containers: 20 x 800 = 16,000 (kg). To convert this weigh to "moon-kilograms" or to calculate its corresponding weight on the moon: 16,000 x 0.17 = 2,720 (kg).

Lunar Habitat II

Case Study III
Level C
Teacher Worksheet

Optimizing Cargo Weight for a Lunar Mission

You are the load manager for the next lunar mission. The cargo hold of the spacecraft is three meters tall, eight meters long, and five meters wide. There are two container types used for this mission. Type A container is a cube with each side being one meter long. It weighs three hundred and fifty kilograms. Type B container is three meters long, one meter tall, and one meter wide. It weighs eight hundred kilograms.

Your task is to determine how many Type A and Type B containers are required to fill the cargo hold if the requirement is to have the equal amount of containers of each type and to calculate corresponding weights in kilograms and "moon-kilograms".

$V_{CargoHold} = 3 \text{ x } 8 \text{ x } 5 = 120 \text{ (m}^3\text{)}$

$V_{TypeA} = 1 \text{ x } 1 \text{ x } 1 = 1 \text{ (m}^3\text{)}$

$V_{TypeB} = 3 \text{ x } 1 \text{ x } 1 = 3 \text{ (m}^3\text{)}$

Let N be the number of Type A containers and Type B containers required to fill the cargo hold. Therefore, $N\ V_{TypeA} + N\ V_{TypeB} = V_{CargoHold}$ or $1N + 3N = 120$ ($4N = 120$; $N = 30$). Therefore, 30 containers of each type would be required to fill the cargo hold.

To calculate corresponding weights for Type A containers: 30 x 350 = 10,500 (kg). To convert this weigh to "moon-kilograms" or to calculate its corresponding weight on the moon: 10,500 x 0.17 = 1,785 (kg).

To calculate corresponding weights for Type B containers: 30 x 800 = 24,000 (kg). To convert this weigh to "moon-kilograms" or to calculate its corresponding weight on the moon: 24,000 x 0.17 = 4,080 (kg).

Lunar Habitat II
Case Study III
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(level A): How many Type A or Type B containers would fit in the cargo hold? Calculate corresponding weights in kilograms and "moon-kilograms".		
Question 2 (level B): How many Type A and Type B containers are required to fill 50% of the cargo hold with each container type? Calculate corresponding weights in kilograms and "moon-kilograms".		
Question C (level C): How many Type A and Type B containers are required to fill the cargo hold if the requirement is to have the equal amount of containers of each type? Calculate corresponding weights in kilograms and "moon-kilograms".		