THE FUTURES CHANNEL
MECHANICAL ENGINEERING - LESSONS

Subject:
Math

Grade Level: 7th Grade, 8th Grade, 9th Grade, 10th grade, 11th Grade, 12th Grade
(CCSS 7.G.4, 7.G.6, 8.G.5, HS.G-GMD.3)

Topics: Mathematics, Geometry

Concepts:
- Geometric shapes and their formulas

Knowledge and Skills Needed for the Project:
- 2-dimensional shapes formulas
- 3-dimensional shapes formulas
- exterior angle sum theorem

Materials:
Paper and pencil

Lesson:

Procedure: This project should be done by students individually or in teams of two or three.

After watching The Futures Channel Mechanical Engineering video, tell students they will be using their knowledge of geometry to solve real world problems.

Invite students to imagine they work at Jet Propulsion Laboratories (JPL) alongside Sergio Valdez. Sergio and his team have started a new project. The parts for a new satellite have arrived at JPL and must be brought into the Spacecraft Assembly Facility (SAF). The JPL SAF High Bay 1 (known as a cleanroom) is approximately 80 ft by 120 ft and 44 ft high. SAF High Bay 1 has a 20 ft wide by 15 ft high set of hanger doors, which lead to the lot the satellite is in. The first assembly station is inside the SAF at the midpoint of the left-hand shorter wall.

BEFORE they do the work on the handout, have each student make a drawing of the dimensions of SAF High Bay 1. Draw the walls, the bay doors and station one in the correct locations.

Now give the students the handout. Have them use their knowledge of geometry to answer the questions. **NOTE: for 7th graders, do ONLY Part one. For 8th graders and above, do BOTH part A and part B.**

STUDENT HANDOUT

Imagine you work at Jet Propulsion Laboratories (JPL) alongside Sergio Valdez. Sergio and his team have started a new project. The parts for a new satellite have arrived at JPL and must be brought into the Spacecraft Assembly Facility (SAF). The JPL SAF High Bay 1 (known as a cleanroom) is approximately 80 ft by 120 ft and 44 ft high. In the center of the longer walls there is a 20 ft wide by 15 ft high set of hanger doors leading to the lot the satellite is in. The first assembly station is inside the SAF at the midpoint of the left-hand shorter wall.

Using the facts above, help Sergio's team design the route and plan to get the satellite and its parts safely inside the JPL cleanroom and to the first assembly station. Remember that this satellite is a multi-million dollar piece of equipment and can't be dinged, dented, dropped or rolled at any point.

Satellite dimensions: The satellite main body is a cylinder with a height of 27 ft and a radius of 4.5 ft.

Answer the following questions:

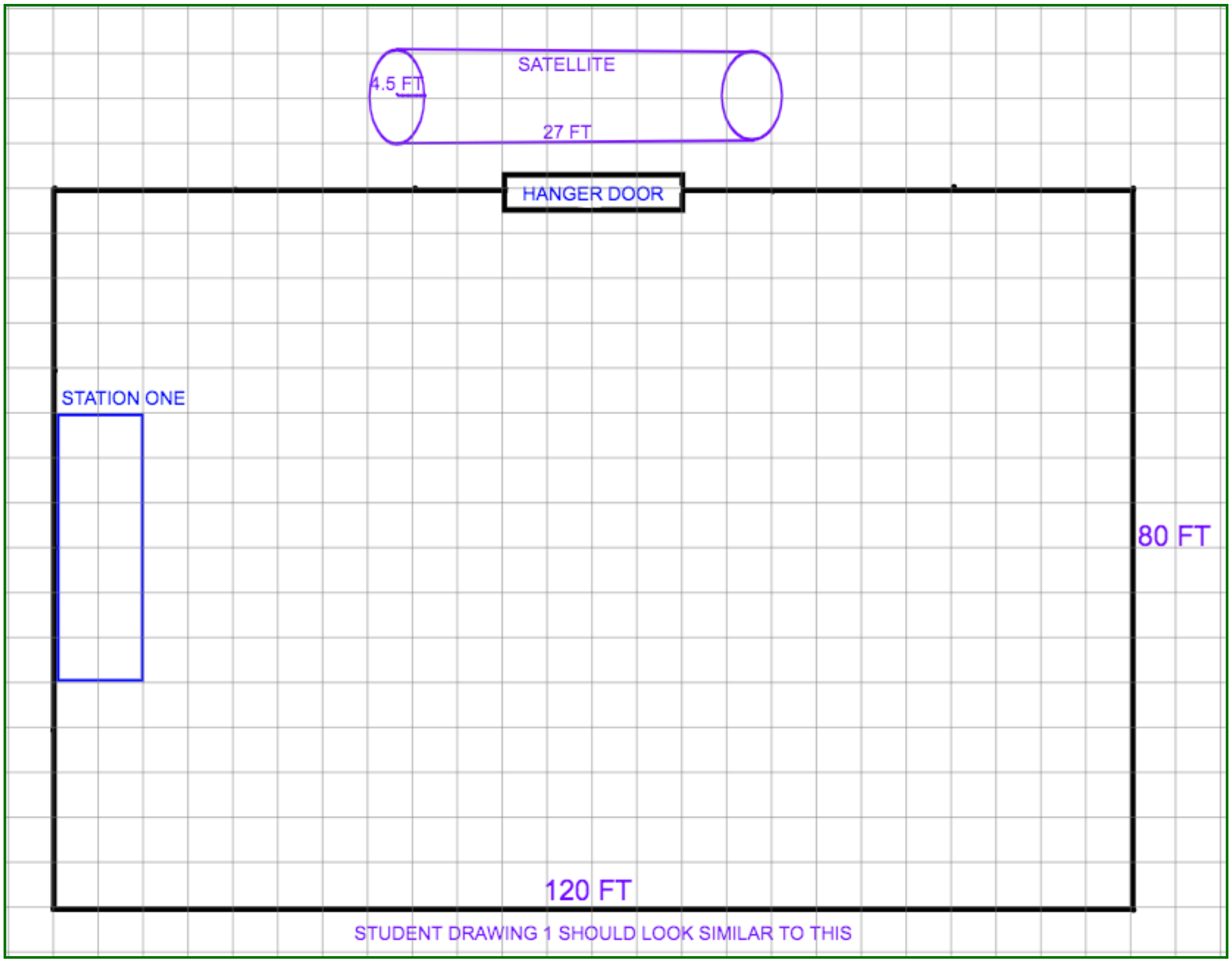
1. What is the total volume of the satellite? (Hint: what is the formula for the volume of a cylinder?)
2. What is the area of the opening for the hanger doors? Will the satellite fit through the doors?
3. What is the total square footage of SAF High Bay 1 (cleanroom)? What is its volume?
4. Design a plan to get the satellite from outside SAF High Bay 1, and into position at station one.

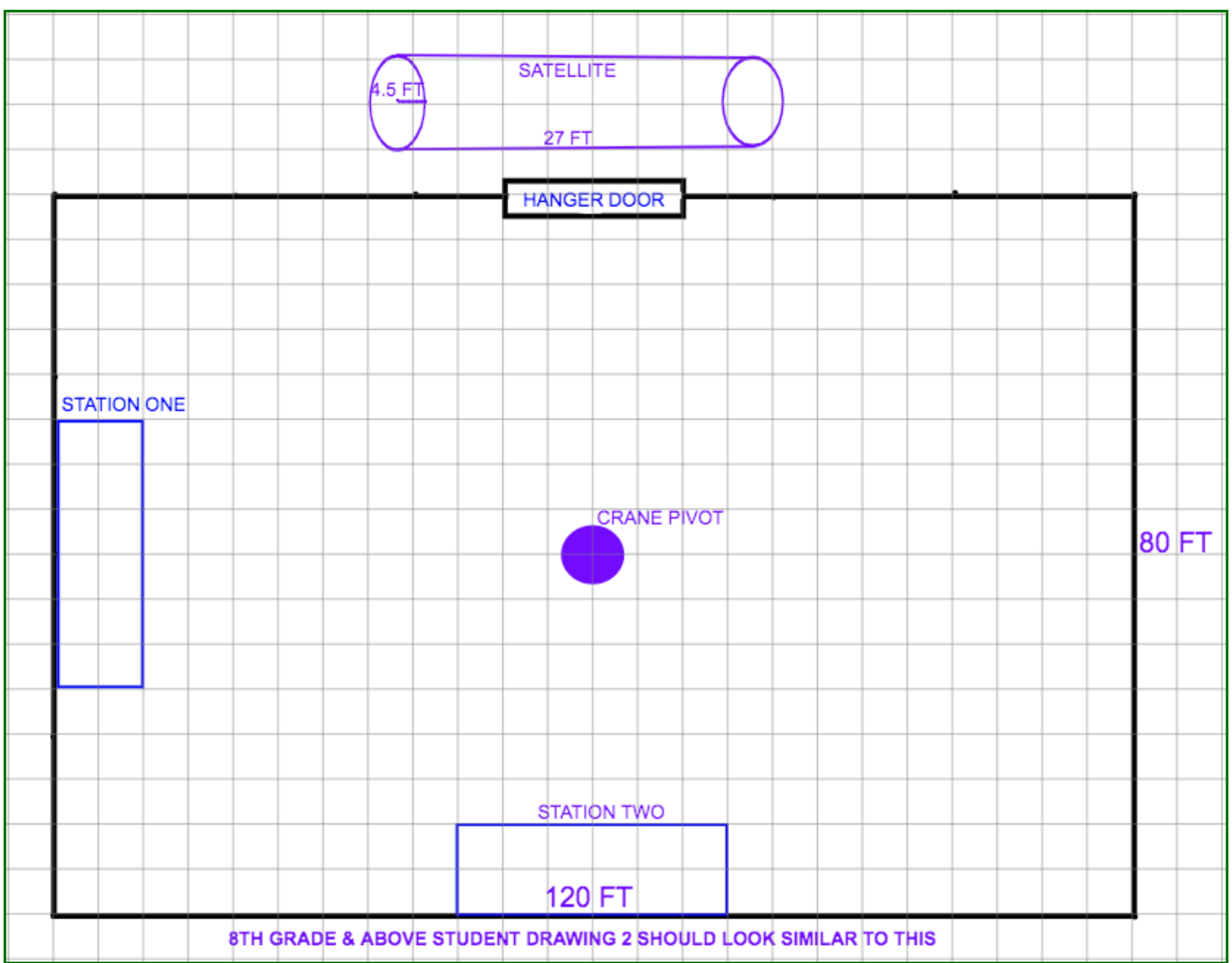
For 8th Graders and High Schoolers: Add the following.

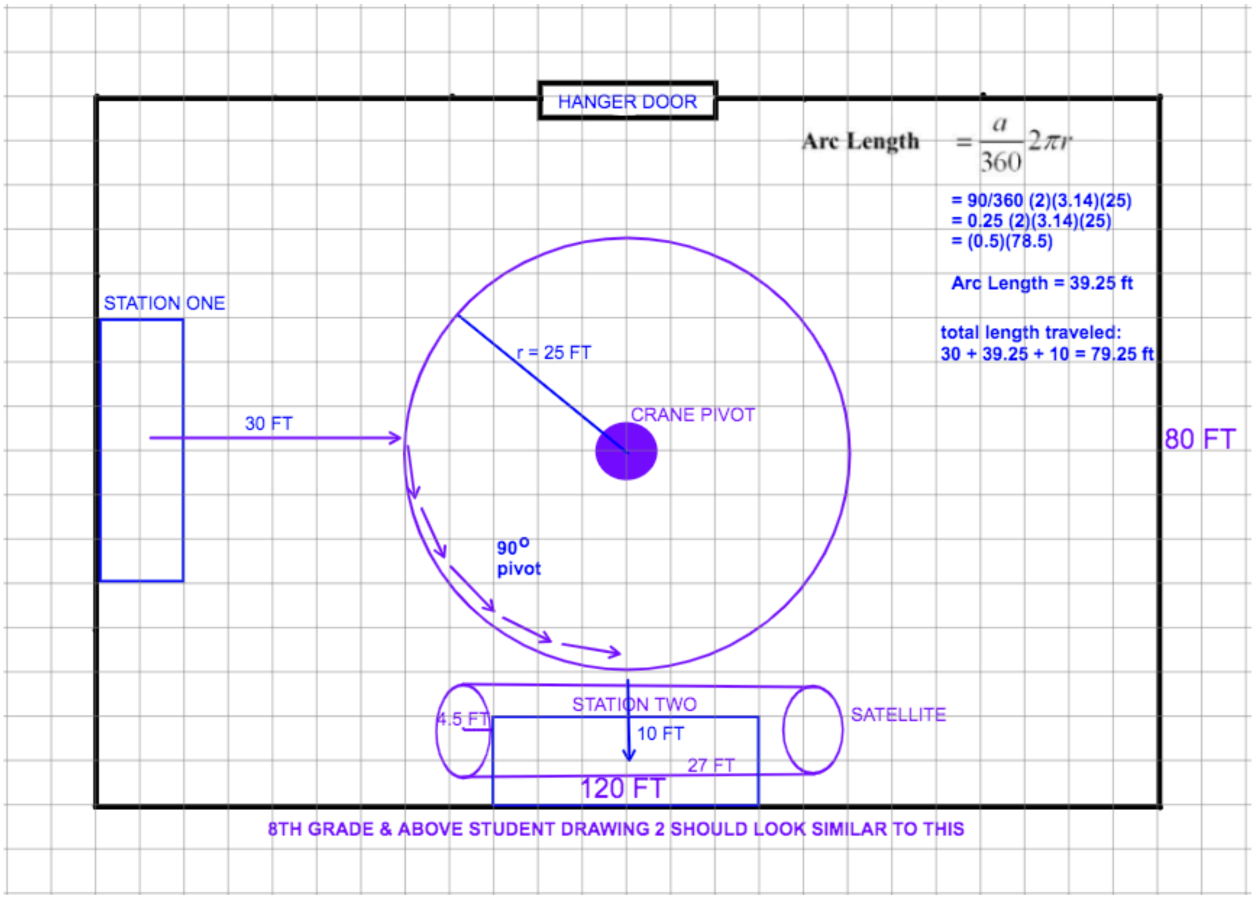
PART B - The first station is now done with their part of assembling the new satellite. It is ready to be moved to the next station. However, it can't just be wheeled over to the next station. At this point in assembly, moving the satellite on and off a wheeled cart risks too much possible damage. Once the satellite is on the 1st work station, it must be moved by crane from station to station. The crane pivot is in the center of SAF High Bay 1. The crane can reach anywhere in the room. Luckily, geometry can solve the problem! The crane can move laterally, vertically and in a circular motion. It will not move objects diagonally. The crane arm moves at a rate of one foot every 8 seconds. Based on the dimensions of the satellite and room, how do you get the satellite safely to station two?

In determining the path the satellite must take, answer the following:

1. On your original drawing of SAF High Bay 1, add station two at the center of the long wall, across the room from the hanger doors.
2. Based on the room's dimensions, the satellite's current location (station one) and destination (station two), would a simple circular path directly from station one to station two be the best route? Why, or any not?
3. If another path is needed, map it out on the drawing of SAF High Bay 1 you made earlier.
4. What is the total length of the satellite's path from station one to station two?
5. What is the total time it will take to get the satellite from station one to station two?


SATELLITE
4.5 FT
27 FT
HANGER DOOR
STATION ONE
80 FT
120 FT
STUDENT DRAWING 1 SHOULD LOOK SIMILAR TO THIS


SATELLITE
4.5 FT
27 FT
HANGER DOOR
STATION ONE
CRANE PIVOT
80 FT
STATION TWO
120 FT
8TH GRADE & ABOVE STUDENT DRAWING 2 SHOULD LOOK SIMILAR TO THIS



COMPLETED WORK - DRAWING

ANSWERS

PART 1

1. **What is the total volume of the satellite? (hint: what is the formula for the volume of a cylinder?)**

Formula for the volume of a cylinder $(3.14)(r^2)(h)$
$= (3.14)(4.5^2)(27)$
$= (3.14)(20.25)(27)$
$=1{,}716.795\ ft^2$

2. **What is the area of the opening for the hanger doors? Will the satellite fit through the doors?**

Area = Length x width. = (20)(15) = 300 Ft^2

The satellite will fit through the hanger doors if it is laid on its side and wheeled in longways.

3. **What is the total square footage of SAF High Bay 1? What is its volume?**

Area = Length x width. = (120)(80) = 9,600 Ft^2

Volume = length x width x height = (120)(80)(44) = 422,400 ft^2

4. **Design a plan to get the satellite from outside SAF High Bay 1, and into position at station one.**

Students should realize the satellite must be laid on its side, and turned longways in order to get it through the bay doors. Then once in the room, it must be wheeled to the center of the room (40 ft) and then to station one (60 ft).

PART 2

1. **On your original drawing of SAF High Bay 1, add station two at the center of the long wall, across the room from the hanger door.**

Students should add the crane pivot to the center of their original drawings, and add station two to the center of the wall opposite the hanger bay doors.

2. **Based on the room's dimensions, the satellite's current location (station one) and destination (station two), would a simple circular path directly from station one to station two be the best route? Why, or any not?**

No, the room is longer than it is wide, so moving in a circle from the middle of the short wall will result in the satellite knocking into the long wall before it reaches the second station.

3. If another path is needed, map it out on the drawing of SAF High Bay 1 you made earlier.

A sample of a workable path has been provided in the final drawing above. This is not the only path the satellite could take to the second station, but it provides a standard to work off where the satellite will not be damaged as it is moved.

4. What is the total length of the satellite's path from station one to station two?

See above sample, answer in final drawing.

5. What is the total time it will take to get the satellite from station one to station two?

Possible answer: Total path length of satellite = 79.25 ft.

Multiply by 8 seconds per foot (79.25)(8) = 634 seconds (or 10 minutes 34 seconds)

If the student has arrived at a workable plan for moving the satellite, then whatever total path length the student has come up with should be multiplied by 8 seconds, then divided by 60 (with remainders in whole numbers, not decimals) to get total minutes and seconds.