Edible Rovers Activity – High School –
Edible Rover Worksheet – Algebra 1 – Answers

Instructions

You have just been notified that NASA is planning to launch another Mars Rover Mission and you are going to design the rover. NASA has given you a budget of $1,450,000 and provided you with several required parts for the rover; however, you must design a new body and select the instruments that will be mounted on the body. The body must weigh less than 16 kilograms and be able to support the instruments you plan on using. You have been given a list of four material types (Table 1), each with unique strengths, weights, and costs, to choose from for the body. Use your knowledge of Mars Rovers and mathematics to construct a rover that can effectively study Mars while meeting all of these requirements.

Material	Price ($/sqr. m)	Strength (kg/sqr. m)	Weight(kg/sqr. m)
Funky Carbon	52500	8	4
Honeycomb Core	45000	8	4.75
Old School Steel	35000	6	5
Outer Space Aluminum	30000	5	4.5

Table 1: Available Materials for Body Construction

1. Describe a Mars rover's instrumentation. What scientific instrumentation can be found on a Mars rover and what does each instrument do?

   Panoramic Camera, also known as the Pancam can rotate 360 degrees and is equipped with several types of cameras that take pictures at different wavelengths. The capabilities of the Pancam help scientists map out the areas the mars rover explores and determine if there was ever water on Mars. The Pancam is mounted on the neck of the rover.
   Hazard Avoidance Cameras or Hazcams are used to help the Rover avoid crashing into objects on the surface of Mars. They are black and white cameras that use visible light to map out the road ahead and work with software to avoid any impassable objects. Hazcams are mounted on the front and back of the body of the Rover.
   Navigation Cameras or Navcams are also used to help the rover navigate on the surface of Mars. These cameras are mounted on the neck of the rover and work with the Hazcams, providing a complimentary view of the terrain. Without the Navcams the rover's navigation capability would decrease greatly.
   Microscopic Imager is a camera used to take extreme close-up shots of rocks and soil on Mars. The information gathered from these pictures is used to determine how soil and rocks will impact rover mobility. This instrument is also used with the Rock Abrasion Tool to study the history of rocks. The Microscopic Imager is mounted on the arm of the rover.

Mössbauer Spectrometer is an instrument that was specially designed to measure and analyze iron-bearing minerals on Mars. It can accurately measure the abundance of these minerals in rocks, which among other things, gives scientists insight into the magnetic properties of the surface of Mars. The Mössbauer Spectrometer is mounted on the arm of the rover.
Rock Abrasion tool is a small drill used to drill holes in volcanic rocks on Mars. Then with the aid of the Microscopic Imager, it can be used to determine how rocks formed. This knowledge provides insight into the environmental conditions in which the rocks were formed. The Rock Abrasion Tool is mounted on the arm of the rover.
X-Ray Spectrometer uses x-rays to determine the chemical composition of rocks and soil on Mars. Knowledge of the composition of the rocks and soil will provide scientists with information about the formation of the Martian crust and any past weather patterns. The X-Ray Spectrometer is mounted on the arm of the rover.

If the students have not discussed the Mars instrumentation on this level of detail then the following would be more appropriate:
Visible Light Video Cameras help the rover maneuver around obstacles on Mars. They also allow scientists to map areas of Mars and study the geography for indications of Mars' past.
Scientific Cameras are used on the Mars rover to analyze the soil and rocks on Mars. Unlike the cameras used to map Martian geography, the scientific cameras are capable of seeing X-rays, ultraviolet light, and other forms of light besides visible light.
Drills are used to get a more extensive study of rocks and soil on Mars. By drilling holes in rocks and analyzing what's inside scientists can determine the environment in which the rock was created.
Antennas are used to relay information back to Earth. Since the rovers were created to eventually die on Mars all of the data they collect must be sent back to Earth via antennas.

2. Think about the Mars rover you are building. What will be the purpose of your rover? What capabilities should your rover have?

   Allow the students to be creative here and have any kind of purpose they can think of, for example:

   a. To find water on Mars
      - The rover has to be able to navigate the Planet in order to find rock samples. Then it must be able to analyze the samples it finds. It also might need a powerful drill to drill deep down in the surface to try and find water below ground. There is no telling how long it could take collecting the data so the rover must be durable.
   b. To climb the highest mountain on Mars
      - In this case the rover will have to be heavy and have an advanced navigation system. It will need all possible cameras and perhaps a drill in case it comes to an obstacle it cannot maneuver around. In order to perform all of the necessary maneuvering it will have to be well powered.
   c. To study the weather patterns of Mars

- The rover will need to be able to measure temperature, humidity, and wind speed. It will also need to be able to withstand severe weather conditions. It must have good navigation capabilities to measure weather patterns on other parts of Mars.

d. To find traces of aliens on Mars
   - The rover will need all types of cameras to navigate and detect foot prints or any form of chemicals left behind. It will also have to have the capability to excavate anything it finds. In case of an alien attack it will have to be able to quickly send information back to Earth, which will require the best available antennas.

e. Map out an entire hemisphere of Mars
   - This will need to be a lightweight, high-speed rover with a very sophisticated navigation program. It will also have to quickly map out areas. Even with the ability to travel at high speeds it will take a very long time to map a hemisphere of Mars, therefore it must be durable.

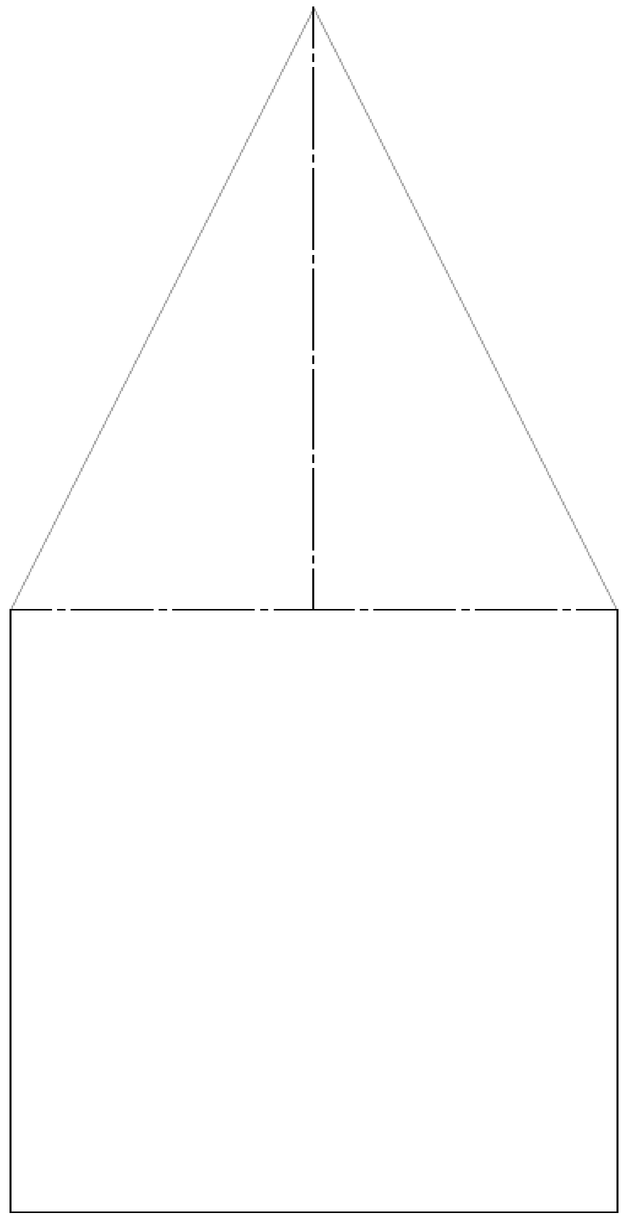
3. What instruments are you planning on using? Give a brief description of why for each one. How much will these instruments cost?

   If the goal of a student's rover is to climb the highest mountain, the following instruments might be appropriate.

   1. <u>Panoramic Camera</u> – The rover should have a Pancam to get a good view of what's ahead and map out the best course the rover can take.
   2. <u>Hazard Avoidance Cameras</u> – Hazcams are entirely necessary if the rover is to have the best navigation system possible, which it needs since the rover will have to do most of the driving.
   3. <u>Navigation Cameras</u> – The Nav cams will work with the Pan Cam to map out the optimal route for the rover.
   4. <u>Rock Abrasion tool</u> – Some sort of drill is a must to allow the rover to get past otherwise impassable obstacles.
   5. <u>X-Ray Spectrometer</u> – This tool will allow us to asses the composition of a rock, thereby determining how well the rock(s) can support the rover.
   6. <u>Mössbauer Spectrometer</u> – It is always nice to have backup equipment in the case of unforeseen events. The spectrometer could act as a replacement to the X-Ray spectrometer if it breaks and provide insights into the composition of rocks on a more thorough level.

   Cost: $1,122,994

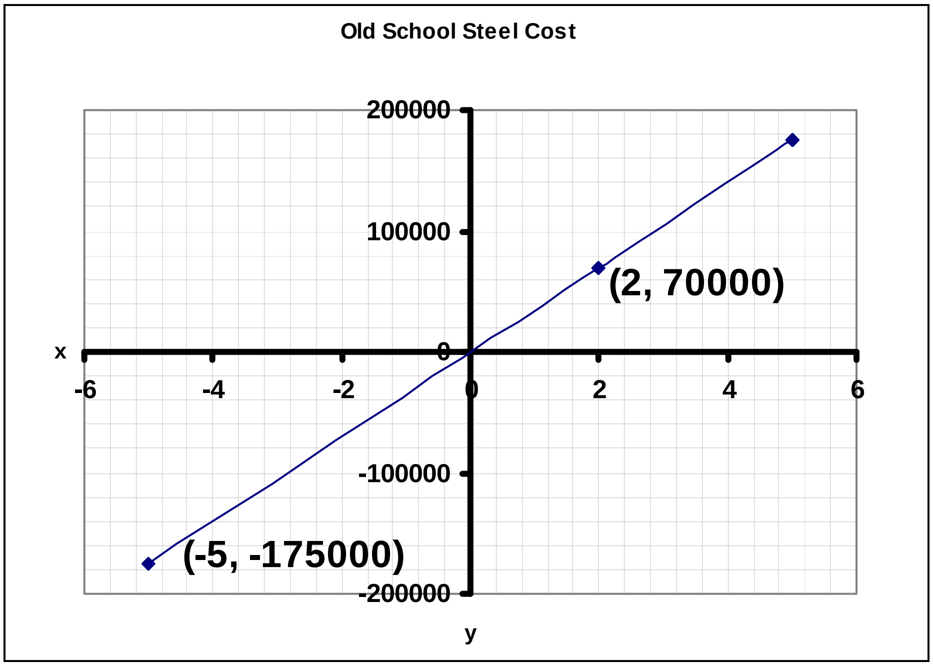
4. Draw the body of your rover in the space below. Be sure to include dimensions in your design. Also, keep in mind the mission constraints and the strength required to support the instruments you plan on using.



5. Based on the dimensions of your design, how much material will you need for the body of your rover?

   Area = (Area Square) + (Area Triangle) = (base * height) + (1/2 * base * height)
   = (1.5 * 1.5) + (1/2*1.25*1.5)
   = 3.1875 m^2

6. Study Graph 1 and Graph 2 and develop an equation in terms of y and x to represent the graphs. What do y and x represent?



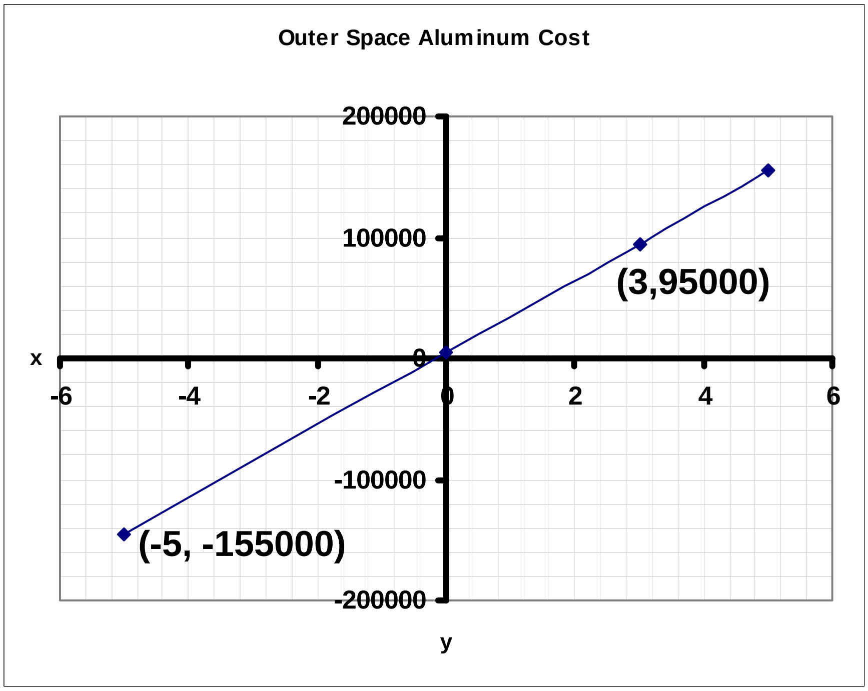
Graph 1: Old School Steel Cost representation

y = mx + b where m = slope and b = y-intercept

m = (rise)/(run) $m = \frac{y2 - y1}{x2 - x1}$ $m = \frac{70000 - -175000}{2 - -5}$ m = 35000

y = 35,000x + b use point (2, 70000)
70,000 = 35,000 * 2 + b
b = 0

The final answer is:
y = 35,000x



Graph 2: Outer Space Aluminum Cost representation
(note: the linear equation does not pass through the origin)

$y = mx + b$ where m = slope and b = y-intercept

m = (rise)/(run) $m = \frac{y2 - y1}{x2 - x1}$ $m = \frac{95000 - -155000}{3 - -5}$ $m = 31250$

$y = 31{,}250x + b$ use point (3, 95000)
$95{,}000 = 31{,}250 * 3 + b$
$b = 1250$

In both graphs, y represents the cost of the material in dollars, and x represents the amount of material purchased in m^2.

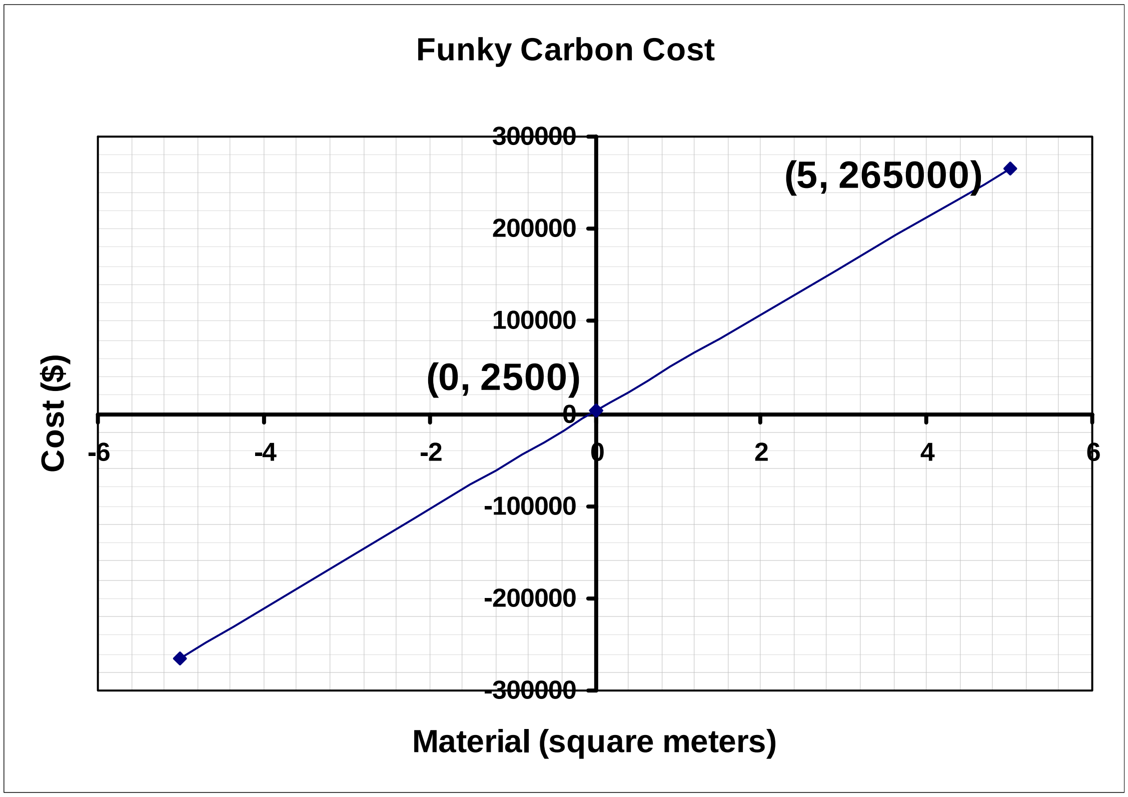
7. The company who provides Funky Carbon has requested that you pay a $2,500 surcharge for their services. Create a graph and corresponding equation of the price of Funky Carbon. Use the information from Table 1 and take into account the $2,500 fee.

For material purchased = 1 m^2, the cost is $52,500
For material purchased = 2 m^2, the cost is 2*$52,500 = $105,000
In the equation $y = mx + b$, the value of b will equal the surcharge

m = (rise)/(run) $m = \frac{y2 - y1}{x2 - x1}$ $m = \frac{105000 - 52500}{2 - 1}$ $m = 52500$

$y = 52{,}500x + 2500$

For x = 0, y = 0 + 2500 = 2500 x = 5, y = 52,500*5 + 2500 = 265,000
With these two points we can create a linear graph. We could have also used the first two points and then continued using the slope for reference.



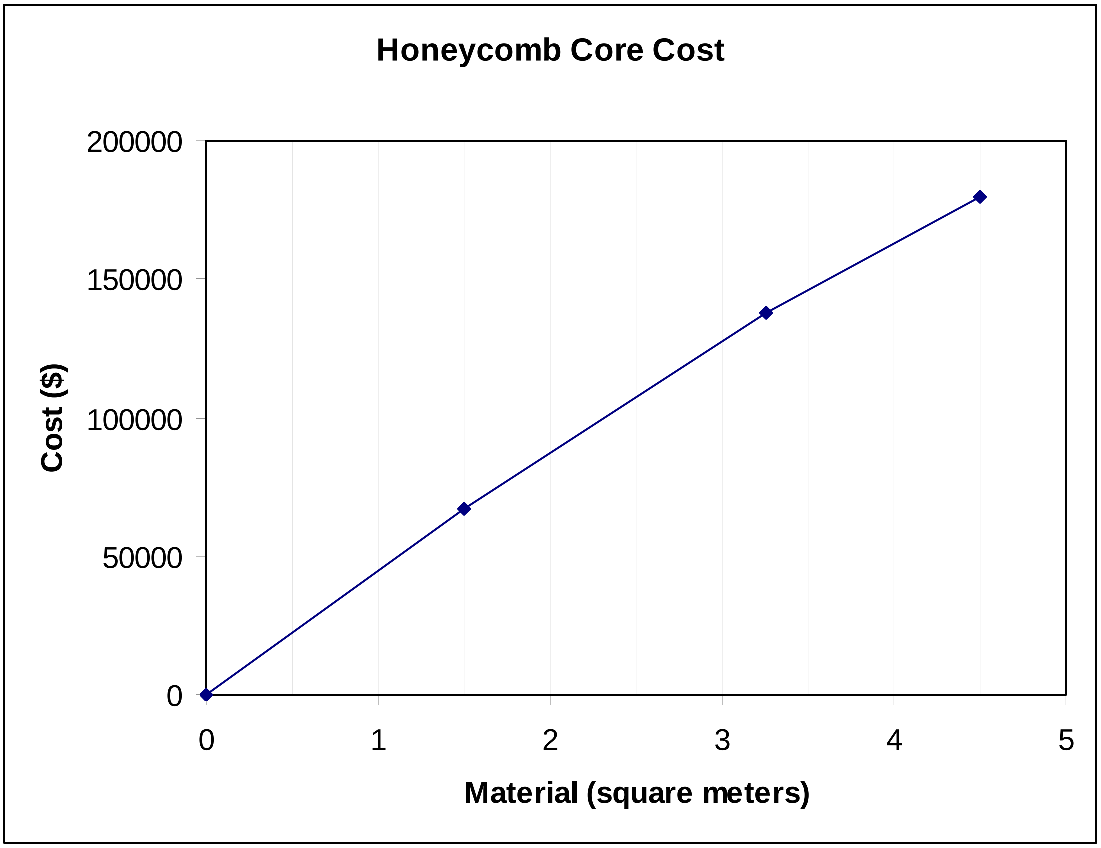
8. The company who provides Honeycomb Core has offered decreased cost rates with an increase in purchase quantity. Using the information from Table 2, create a graph and corresponding equation to represent the cost of Honeycomb Core.

Quantity of Purchased Honeycomb Core (m^2)	Price (dollar/m^2)
0 - 1.499	45000
1.5 – 3.2499	42500
3.25 - 4.5	40000

Table 2: Fixed Rates of Honeycomb Core based on quantity purchased

x = Quantity of material purchased
y = Cost
For x = 0 to x = 1.499 m = 45000 b = 0 because there is no surcharge
y = 45000x 0 < x < 1.5
For x = 1.5 to x = 3.2499 m = 42500 b = 0
y = 42500x 1.5 <= x < 3.25

For x = 3.25 to x = 4.5 m = 40000 b = 0
y = 40000x 3.25 <= x <4.5



9. Which type of material will you use for the body of your rover (see Table 1)? Why? What is the total cost and weight of the body? How much weight can it hold?

   Material: Honeycomb Core

   Cost: 3.1875 m^2 * 45000$/$m^2$ = $143,437.50

   Weight: 3.1875 m^2 * 4.75 kg/m^2 = 15.14 kg

   Strength: 3.1875 m^2 * 8 kg/m^2 = 25.5 kg (Note: this is the amount of weight that the rover can hold)

   Why: I choose to use the Honeycomb Core because it was the least expensive material that could still hold five instruments. The Funky Carbon was over $40,000 more expensive and the only advantage would be that it is a little lighter, but the sleight weight difference was not important because the Honeycomb Core is under the required 16 kg. The other two materials were cheaper but could only hold three or four instruments, which is not enough if the rover is to have the necessary instrumentation to climb the highest mountain on Mars.

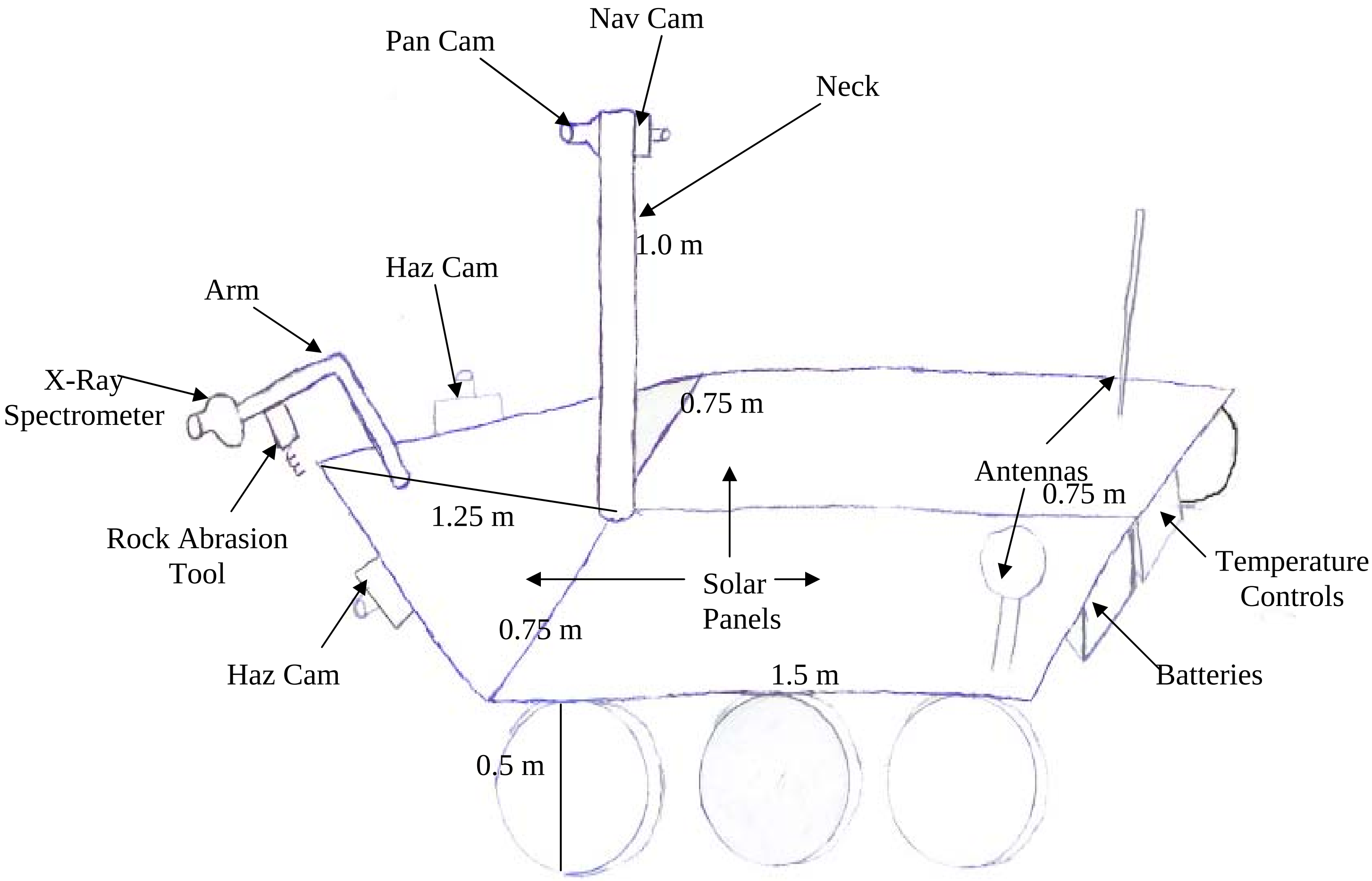
10. What is the total cost of your rover?

Cost Before Adjustments: $1,649,183.50

In order to meet my budget constraints I will take out the Mössbauer Spectrometer. By removing this camera the detail in the study of Martian rocks will decrease and therefore I will have to be more cautious when interpreting the readings of rocks from the X-Ray spectrometer. Also, I won't be able to have a back-up camera so I need to make sure that the X-Ray spectrometer doesn't break. After removing the Mössbauer Spectrometer the cost for all the instruments is $904,738.

Cost After Adjustments: $1,430,927.5

11. Draw a complete design of your Mars Rover in the space provided. Use the body you designed as the base and determine where the instruments will attach, how the body will sit on the wheels, where the required components will go, etc. Label the parts of your Rover and the dimensions of the major parts



Note: The number of components that are required to have dimensions is at the discretion of the Teacher.

Construction Phase:

12. What materials (candy) are you planning on using for your wheels, body, and instruments?

Component	Material (Candy type)
Body	Graham Crackers
Wheels	Oreos
Neck	Kit Kat
Panoramic Camera	Marshmallow
Hazard Avoidance Cameras	Jelly Beans
Navigation Cameras	M&Ms
Rock Abrasion tool	A piece of fruit roll up
X-Ray Spectrometer	Gumdrops
Robotic Arm	Toothpicks
Solar Panels	Hershey's chocolate bar
Batteries	Tootsie Rolls
Antennas	Straws
Temperature Controls	Licorice

13. What steps will you follow to build your rover?

First of all, I plan on laying down a heavy coat of frosting for the Rover to stand on. Then I will place the wheels on the frosting and connect the body to the wheels with frosting. Next, I will secure the arm on the body by laying a solar panel (chocolate bar) over the back end and using icing. I will then proceed to connect the spectrometer and rock abrasion tool to the arm by sticking them on the end of the toothpick. I will attach the neck using frosting and more solar panels and place the Pan Cam and Nav Cam on top. I will connect the batteries and temperature controls to the bottom of the body using frosting. Finally, I will place the solar panels on top with the antennas in between and attach both with frosting.

14. What was the most difficult part of the construction process and how would you do it differently next time?

The most difficult part of the construction process was attaching the arm. The weight at the end of the arm was a lot for it to support and so it kept falling off. Next time I think I would try to build the body with two layers and choose a stronger material for the arm. That way I could put the arm in between the two layers of graham crackers for more support.

15. Describe any changes you would make to the design process if you were to build another rover.

If I were to build another rover I would try to get a better idea of the general design I was going for before going through the details. I would also choose and design the material first and then pick which instruments I want to use.