CO_2 Cars

Name _____

Math Period _____

Math Teacher _____

Science Period _____

Table of Contents

Essential Questions:

1. How does industry in the real world operate?

2. What factors should be considered when building a CO_2 car?

3. What is the best design for maximizing the speed of a car?

Car Designs: Drag, Mass, and Height of Toy Cars

Drag of Toy Cars

One factor that could affect how fast your toy racers go is **air resistance**, or **drag**. Air resistance is a force that is caused by air, the force acts in the opposite direction to an object moving through the air. We can measure drag, or air resistance, using a wind tunnel.

1. Define drag.

2. Choose three model cars. In the "Description," note which car will be Car #1, Car #2, etc... Use the wind tunnel to find the drag, in grams, a scale to measure the mass in grams and a ruler to measure the height in centimeters of the car (the height is measured at the highest point from the ground tot he car).

Table 1

Car	#1	#2	#3
Description			
Drag (g)			
Mass (g)			
Height (cm)			

Need Help Reading a ruler? bit.ly/2IlANTT

Car Designs: Toy Cars

When you think about your design for your CO_2 Car and your Soap Box Derby Car, do you wonder what design would make it go the fastest?

With this science lab, you will test various designs of toy cars to see which design goes the fastest.

I. Introduction

1) Question or Problem: What car design travels the fastest?
2) Background Information: In the VTAM lab, you will design a CO_2 Car that you will be racing. There are many factors that affect the speed of a car. Many of the factors have to do with the design of the car. All cars will use a CO_2 cartridge as an engine and will race down the same track. In this lab, we will experiment to explore how the shape of a car affects how fast it goes.

II. Experimental Procedures

1) Materials
    - Various model cars
    - One Ramp
    - One Stopwatch
    - One Tape Measure
2) Procedures

    Step 1: Sketch the top view and side view of the three cars you chose on the Car Sketches worksheet on pg. 5

    Step 2: Look table 1 on page 3. In the "Description," note which car will be Car #1, Car #2, and Car #3. Make sure these numbers match the car numbers in "**Car Designs: Drag, Mass, and Height of Toy Cars**."

    Step 3: Hold the car at the top of the ramp with the back wheels at the edge of the top of the ramp.

    Step 4: Release the car so it moves down the ramp. Do NOT push the car down the ramp.

    Step 5: Start your stopwatch when the front bumper of the toy car is in line with the bottom of the ramp. Stop your stopwatch when the toy car reaches the 5ft mark. Record the time, to the nearest second, in the table in the **Results** (table 2) section of your lab report. Repeat the test three times per car and calculate the average speed.

    Step 6: Continue steps 3 – 6 until your group has completed testing all three cars.

Car Sketches (Concept Sketches)

- Small, quick, thumbnail sketches.
- Details are NOT necessary!

Toy Car #1: Side View	**Toy Car #1:** Top View
Toy Car #2: Side View	**Toy Car #2:** Top View
Toy Car #3: Side View	**Toy Car #3:** Top View

III. Results

1) Table
    - Record your data in the table below.
2) Calculations
    - Calculate the speed of each of your three cars using the formula:

$$speed = \frac{distance}{time}$$

    - Record your calculations in the table below:

Table 2

Car	Time Trial #	Distance (in)	Time (sec)	Speed (in/sec)	Avg. Speed (in/sec)
Car 1	1				
	2				
	3				
Car 2	1				
	2				
	3				
Car 3	1				
	2				
	3				

3) Complete the tables below, compare your results, and make observations:

Table 3- Drag

Car	Drag (g)	Avg. Speed (in/sec)
Car 1		
Car 2		
Car 3		

Table 4 - Mass

Car	Mass (g)	Avg. Speed (in/sec)
Car 1		
Car 2		
Car 3		

Table 5 - Height

Car	Height (cm)	Avg. Speed (in/sec)
Car 1		
Car 2		
Car 3		

Answer the Questions:

1) What do you notice from your data?

2) What variable (drag, mass, or height) affects speed the greatest based upon your results?

3) Was your test valid? (are you able to tell if the variables we choose to test, actually affect speed)

4) Was your data reliable? (are your results consistent and repeatable)

Qualities of a good graph

•

Graphing

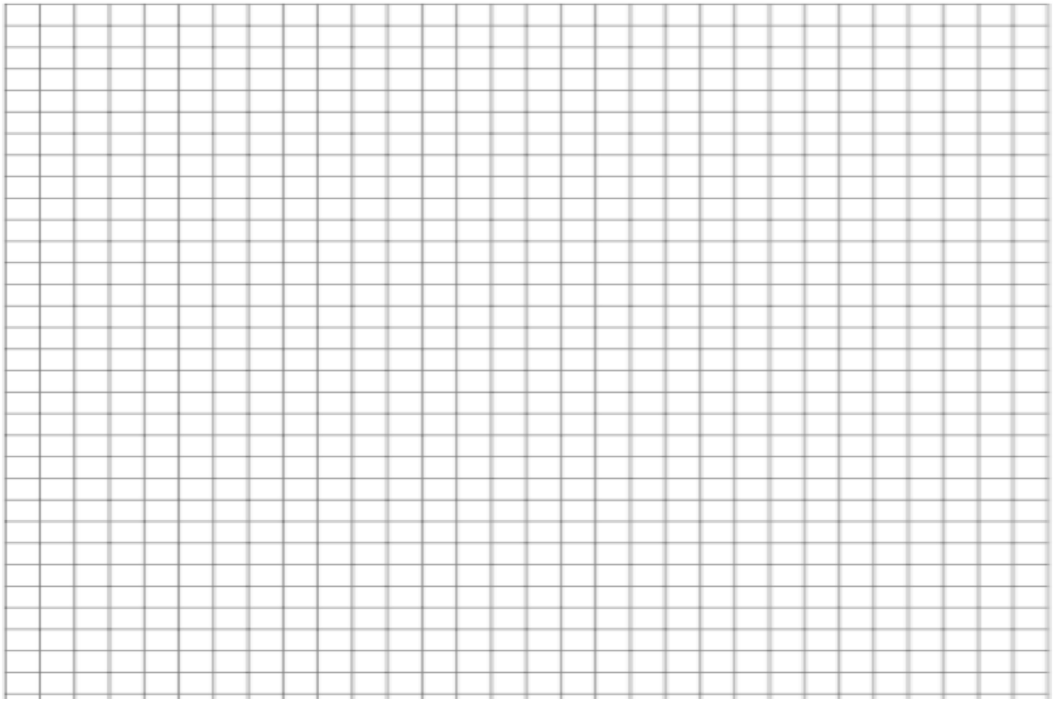
1) Analyze the table 3. Is there a relationship between the drag and the speed of your cars? If so, describe the relationship. If not, how do you know, based on the data, why there is no relationship?

2) Suppose that there is a relationship between the drag and the speed. Which variable, drag or speed, is the dependent variable? Which is the independent variable? To determine this, ask yourself the following question: Is the drag dependent on the speed or is the speed dependent on the drag?

   Need Help? bit.ly/2knGrAJ

3) Graph

   - Make a line graph on the grid paper below that shows the relationship between the **mass** and the speed. The dependent variable will go on the *y*-axis and the independent variable will go on the *x*-axis.
     Need Help? bit.ly/2knFAzQ



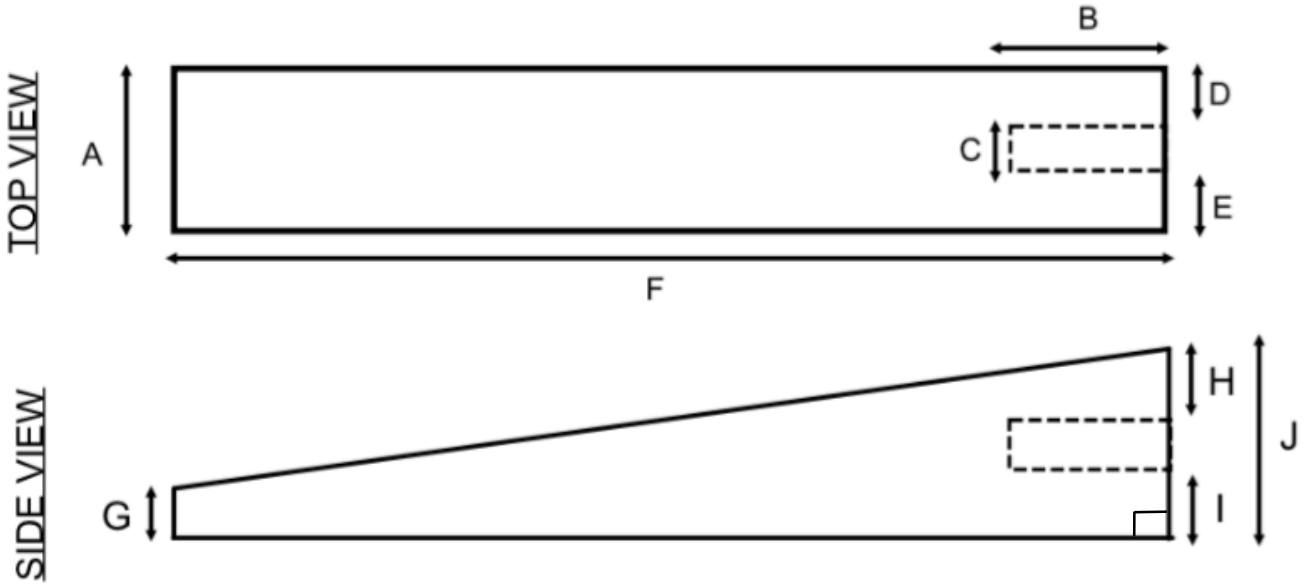
4) Graph

- Make a line graph on the grid paper below that shows the relationship between the drag or height and the speed. Copy the data table from page 7 that you are using to create your graph. Remember the qualities of a good graph. The dependent variable will go on the *y*-axis and the independent variable will go on the *x*-axis. **Need Help?** bit.ly/2knFAzQ

Car	Drag (g) Or Height (cm)	Avg. Speed (in/sec)
Car 1		
Car 2		
Car 3		

Measurement (length)

The following measurements for most parts of your wood blank have been given in the table below. Fill in the blanks.



Dimension	Measurement (mm)	Measurement (cm)
A		
B		
C	19 mm	
D		1.2 cm
E	12 mm	
F		31.3 cm
G	21 mm	
H		
I	24 mm	
J		

Need Help? bit.ly/2llANTT ***and*** bit.ly/1rodKAj

Measurement (mass)

Using the scale, record the mass of each of the following dragster components in grams (g). Convert each mass in grams to its equivalent mass in kilograms. Then, find the sum as indicated.

Component	Mass (g)	Mass (kg)
Wood Blank		
Two Rear Wheels		
Two Front Wheels		
Two Axles		
Plastic Straw		
Unspent CO_2 Cartridge		
Four Copper Washers		
Sum of Masses (Σ)		

Need Help? bit.ly/1rodKAj ***and*** http://bit.ly/1N2LcGZ

Bell Work/Notes #1

Concept Sketches

- Small, quick, thumbnail sketches.
- Purpose is to get several ideas down on paper to visualize & think about.
- Details are NOT necessary!
- Draw a minimum of 5 sketches

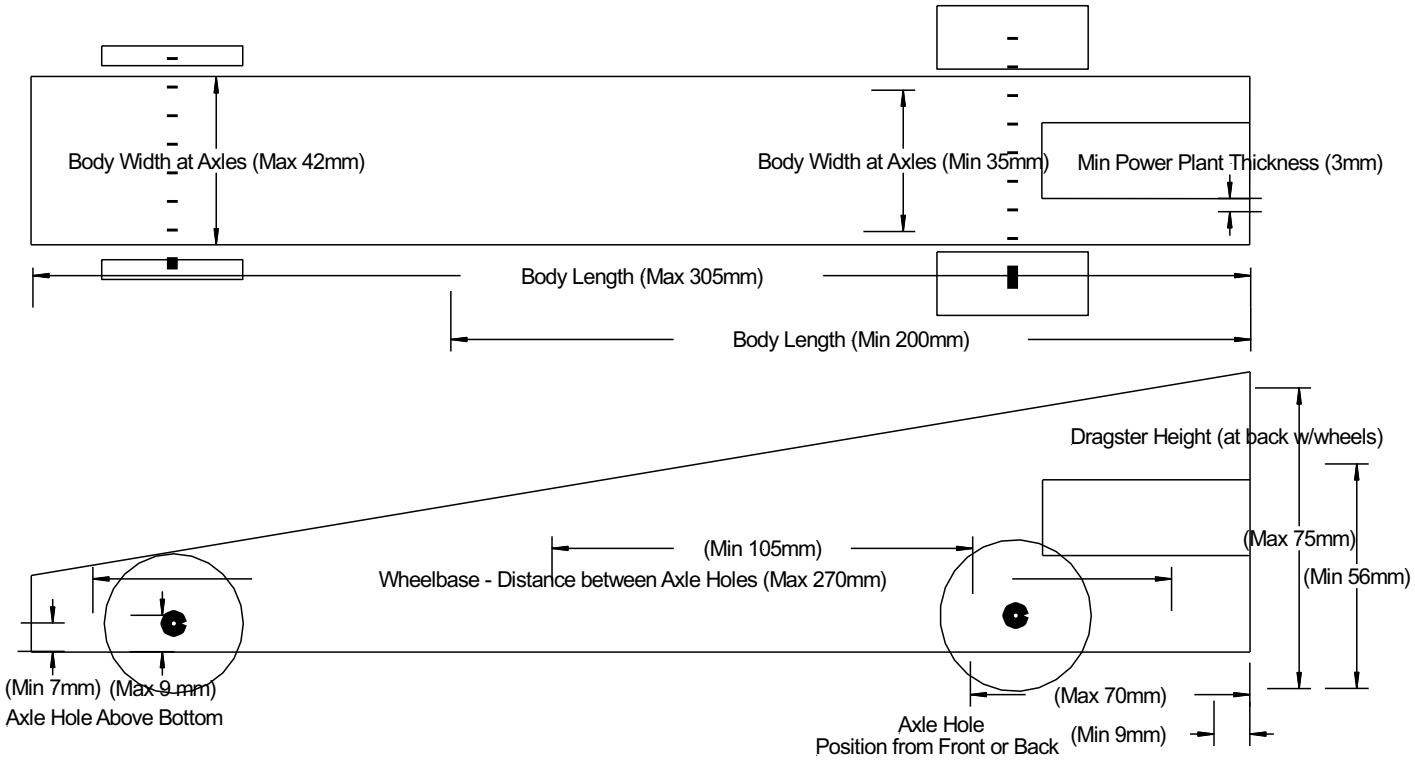
Design Sketch

- Re-draw top & side views of your favorite idea from your Concept Sketches.
- Drawing is larger and has more detail than Concept Sketches.
- Show location of holes, axles/wheels, color, etc.
- Exact size & shape NOT necessary!

Side View

Top View

Dragster Specifications



Recommended Design Specifications

Record all measurements in millimeters.

Description	Minimum Measurement	Symbol	Your Measurement	Symbol	Maximum Measurement
Example		≤		≤	
Front Axle Hole Position (distance from front of car)	9 mm	≤		≤	70 mm
Rear Axle Hole Position (distance from rear of car)	9mm	≤		≤	70mm
Front Axle Hole Position (above bottom of body)	7 mm	≤		≤	9mm
Rear Axle Hole Position (above bottom of body)	7mm	≤		≤	9 mm
Dragster Body Length	200mm	≤		≤	305 mm
Dragster Body Mass (record in grams)	45 g	≤		≤	170g
Front Body Width (at axle holes)	35 mm	≤		≤	42mm
Rear Body Width (at axle holes)	35 mm	≤		≤	42mm
Distance between Screw Eyes	155mm	≤		≤	270 mm
Wheel Base	105 mm	≤		≤	270 mm

Lab Goals

Bell Work/Notes #2

Drag of Finished CO_2 Car

One factor that could affect how fast your car goes down the track is **air resistance**, or **drag**. Air resistance is a force that is caused by air, the force acts in the opposite direction to an object moving through the air. We can measure drag, or air resistance, using a wind tunnel.

1. Use what you have learned about drag and the definition above to define drag in your own words.

2. Use the wind tunnel to find the drag, in grams, of your finished CO_2 Car.

   Drag of Finished Car: _____ grams

The formula for approximating the drag of a car is:

$D = 0.245A$, **where** D **is the drag and** A **is the area of the front face of the car**

3.

Example:	Do:
Find the drag, D, of a car whose front face has an area, A, of 0.002 m^2.	Find the drag, D, of a car whose front face has an area, A, of 0.108 m^2.

Need Help? bit.ly/2lpiRng ***and*** bit.ly/2kPrISG

4.

Example:	Do:
Find the front face area, *A*, of a car with a drag, *D*, of 0.000735.	Find the front face area, *A*, of a car with a drag, *D*, of 0.005635.

5. Find the area of the front face, *A*, for each of your three toy cars and your finished CO_2 Car.

Car #1	Car #2	Car #3	CO_2 Car

6. In order for a car to make the list of the "10 of the Sleekest Cars on the Road," the car had to have a drag coefficient of less than 0.27. Write this inequality, using the symbols, < or >, to represent this constraint.
   Need Help? bit.ly/2lJtPbd

Mass of Finished CO_2 Car

Another factor that could affect how fast your car goes down the track is the mass of your finished car.

1. Use a scale to measure the mass, in grams, of your finished CO_2 Car.

   Mass of Finished Car: _____ grams

2. At the beginning of the project, Keha weighs her wood blank and gets 203 g. At the end of the project, she weighs her finished dragster and gets 97 grams. She writes the following equation that will allow her to figure out how much mass she removed:

   $203 = m + 97$, where m is the mass she removed

   a. Explain why this formula works.
   Need Help? http://bit.ly/2ksXaVE

   b. Solve the formula for m.
   Need Help? bit.ly/2kPrISG

   c. Substitute your answer to **b** into the equation to see if your answer is correct.
   Need Help? bit.ly/2lpiRng

3.

Example:	Do:
When Luke weighs his wood blank, he gets 195 g. At the end of the project, Luke weighs his finished dragster and gets 78 g. Write an equation to figure out how much mass Luke removed from his wood blank. Use your equation to figure out how much mass Luke removed.	Write a problem for Luke and his wood blank for the equation, $g - 81 = 103$. Then solve the equation.

Height of Finished CO_2 Car

Another factor that could affect how fast your car goes down the track is the height of your finished car.

1. Use a ruler to measure the height, in cm, of your finished CO_2 Car.

   Height of Finished Car: _____ cm = _____ mm

2. Before putting on her axles and tires, Max measured the height of his car and gets 6.3 cm. After putting on her axles and tires, Max again measures the height of her car. This time, she gets a height of 8.1 cm. She writes the following equation that will allow her to figure out how much higher the tire made her car:

   $8.1 = t + 6.3$, where t is the height of the tire

   a. Explain why this formula works. As part of your explanation, sketch a picture of the situation.
   Need Help? http://bit.ly/2ksXaVE

   b. Solve the formula for t.
   Need Help? bit.ly/2kPrISG

   c. Substitute your answer to **b** into the equation to see if your answer is correct.
   Need Help? bit.ly/2lpiRng

3. The height of Kaipo's car without the axles and wheels is 4.1 cm. On his design template, he saw that he removed 1.7 cm from the height of the wood blank. He writes the following equation that will allow him to figure out the height of the wood blank:

$$4.1 = h - 1.7 \text{ where } h \text{ is the height of the wood blank}$$

   a. Explain why this formula works. As part of your explanation, sketch a picture of the situation.
   Need Help? http://bit.ly/2ksXaVE

   b. Solve the formula for h.
   Need Help? bit.ly/2kPrISG

   c. Substitute your answer to **b** into the equation to see if your answer is correct.
   Need Help? bit.ly/2lpiRng

Using Your CO_2 Car Data

You have seen or will see the formula,

$d = rt$, where d = distance, r = rate or speed, and t = time

many times in your science and math classes.

1. Use the formula and your distance and time data from your "CO_2 Car Data Sheet" to find the speed of your and 5 other classmates' dragsters. The data is provided on your Science Google Classroom site.

Your speed: _____ Classmate #1's speed: _____

Classmate #2's speed: _____ Classmate #3's speed: _____

Classmate #4's speed: _____ Classmate #5's speed: _____

2. Find the average speed of you and your five classmates' dragsters.

Relationship Between Speed & Mass

One of the factors that could possibly affect the speed of your car is the mass of your finished CO_2 car. We can use math to determine if this factor does or does not affect the speed of your car.

There are two variables: the speed **and** the mass of your finished CO_2 car.

1. Which variable, speed or the mass of your finished CO_2 car, is the independent variable? Which is the dependent variable? To help you answer this question, ask the question:
   - Does the speed depend on the mass of my finished CO_2 car or does the mass depend on the speed?

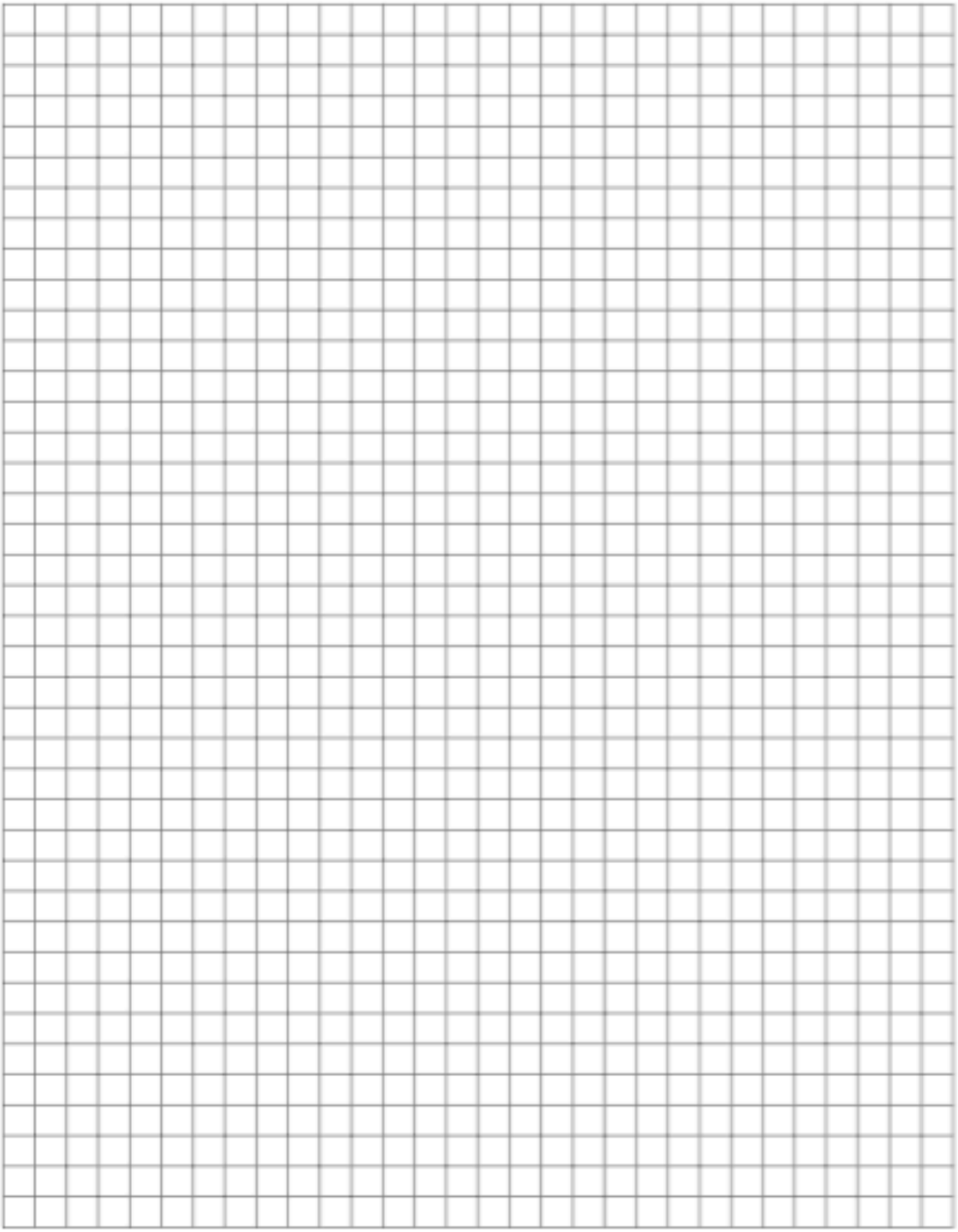
2. Choose 15 cars from your "CO_2 Car Data Sheet" and make a table of the following data: speed and mass of your finished CO_2 car. Fill in the blank below the *x* with the independent variable from question **1**. Fill in the blank below the *y* with the independent variable from question **1**.

x (_____)															
y (_____)															

3. Use your table to graph the data on the grid paper on page 27.

4. Is there a relationship between speed and weight? Use your table and graph to justify your answer.

Grid Paper



Relationship Between Speed & Height
&
Relationship between Speed & Drag

One of the factors that could possibly affect the speed of your car is the drag or height of your finished CO_2 car. We can use math to determine if this factor does or does not affect the speed of your car. Create two graphs on your computer using Google Sheets.

1. Is there a relationship between speed and height? Use your table and graph to justify your answer.

2. Is there a relationship between speed and drag? Use your table and graph to justify your answer.

Reflection

Using a prompt provided in class write a **6** sentence response reflecting on your experience & learning.

Aloha Parents and Guardians,

This school year the 6th grade will be working in the VTAM lab to complete their CO_2 Dragster unit. During this process the students will have the opportunity to use the tools listed below to complete their dragster. Prior to tool use in the lab, students will review tool safety and pass tool tests. If for any reason there is a tool **you do not want your child to use**, simply *draw a line through the tool.* Tool authorization is not required to successfully complete the class. Please sign below.

Tools to be used:

- ☐ Drill Press
- ☐ Band saw
- ☐ Scroll saw
- ☐ Belt sander
- ☐ Drum Sander

Sincerely,

Kumu Brendan Courtot
Kamehameha Schools Hawai'i Campus
Phone: 982-0443
Email: brcourto@ksbe.edu

Student Name: _____

Parent/Guardian Name: _____

Parent/Guardian Signature _____