NAME____________________________________ DATE________________

Lab 2:
Essentials of Physics: PHYS 101

There are two experiments and one demonstration listed below. You will be doing/seeing all three of them in the lab today.

Experiment One

Introduction:

In today's lab we will be using car models built with K'nex building materials. Imagine you have been given the task of designing the fastest K'nex car—how would you systematically go about completing this task? The purpose of this part of the lab is to examine some of the variables that affect how fast a previously built car will go and to determine the relationship between those variables.

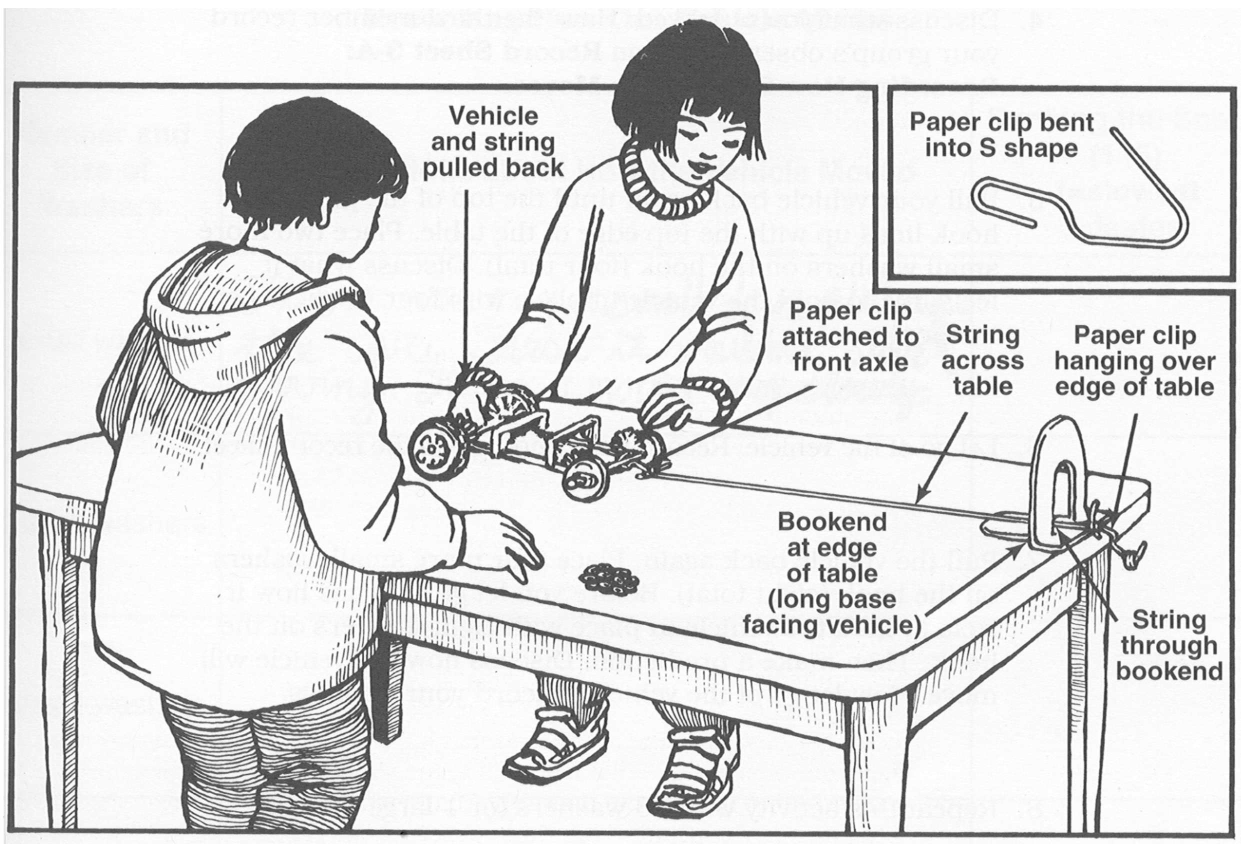


Figure 1: The setup for Experiment One.

Question: In an experiment depicted in the figure, above, washers are used to propel a car. What is the relationship between the number of washers pulling a car and how fast it will accelerate? State your prediction in the form of a hypothesis below. Be specific.

Hypothesis: If I double the number of washers pulling a car….

Checkpoint: Have a laboratory instructor initial your hypothesis before proceeding .

Procedures:

1. Use the electronic balance to find the mass of your car alone. Find, also, the mass of one small washer and one large washer. Record the information in the spaces above the table below.
2. Set up your experiment as depicted in Figure 1, above . Make certain to thread the string through t the opening in the bookend. Have one member pull the vehicle back until the top of the paper clip hook lines up with the top edge of the table.
3. Mark the location of the front tires with a piece of tape. Mark a position 0.75 m closer to the bookend with another piece of tape.
4. In your group of three choose a timer, a holder, and a catcher. The timer will time how long it takes the car to travel 0.75 m; the holder will let the car go; and the catcher will catch the car before it goes off the edge.
5. While one member holds the vehicle in place, have another member put two small washers on the paper clip hook at edge of the table. Can the person who is holding the vehicle feel this weight?
6. Do three trials with each number of washers (small and large) indicated in the table below. Record your observations and the <u>average</u> amount of time it took the car to travel 0.75 m.

Observations:

Mass of car _____ (kg) mass of small washer _____ (kg) mass of large washer ______ (kg)

(note: 1 g x 1 kg/1000 g => kg, so divide mass in grams by 1000 to get kg!)

washers (#)	force (N)	Observations	Distance (m)	Average Time (s)	Velocity (m/s)	Acceleration (m/s/s)
4 small			0.75			
8 small						
16 small						
1 large						
2 large						
4 large						

Calculations/Questions:

1. You may remember from class that one definition of velocity is the change in position over time. Given the results from your experiment use this definition to calculate the velocity . Record your results in the table. Show a sample calculation below:

2. The force pulling the car is that of gravity pulling the washers downwards. You can calculate that force using the formula:

   $$\text{force (N)} = n \cdot m \cdot \text{g}$$

   Where n is the number of washers, m is the mass of each washer and g is the acceleration of gravity (magnitude is about 10 m/s/s) (g doesn't stand for grams here). Using the masses for the small and large washers (recorded above table) and this formula, fill in the force column of the above table. Use a spring scale to measure the pulling force of 2 and 4 large washers. Do the spring scale readings compare well with their respective calculated forces in the table? Explain.

3. In the experiment above the number of small washers and then large washers was doubled each time. Reviewing your measurements using the spring scale, did doubling the number of washers result in a doubling of the force? Give examples citing your data.

Experiment Two

Introduction:

In Experiment One you looked at the effect of changing the amount of pulling force on a car's motion. In a real car the pulling force is provided by a motor (in place of washers). Selecting a bigger motor would therefore increase the car's pulling force. However, increasing the size of the motor will also result in the car having greater mass. In Experiment Two you will look at the effect of increasing mass on how fast the car goes.

Question: Given a constant pulling force on a car, what is the relationship between the mass of a car and how fast it will accelerate? State your prediction in the form of a hypothesis below.

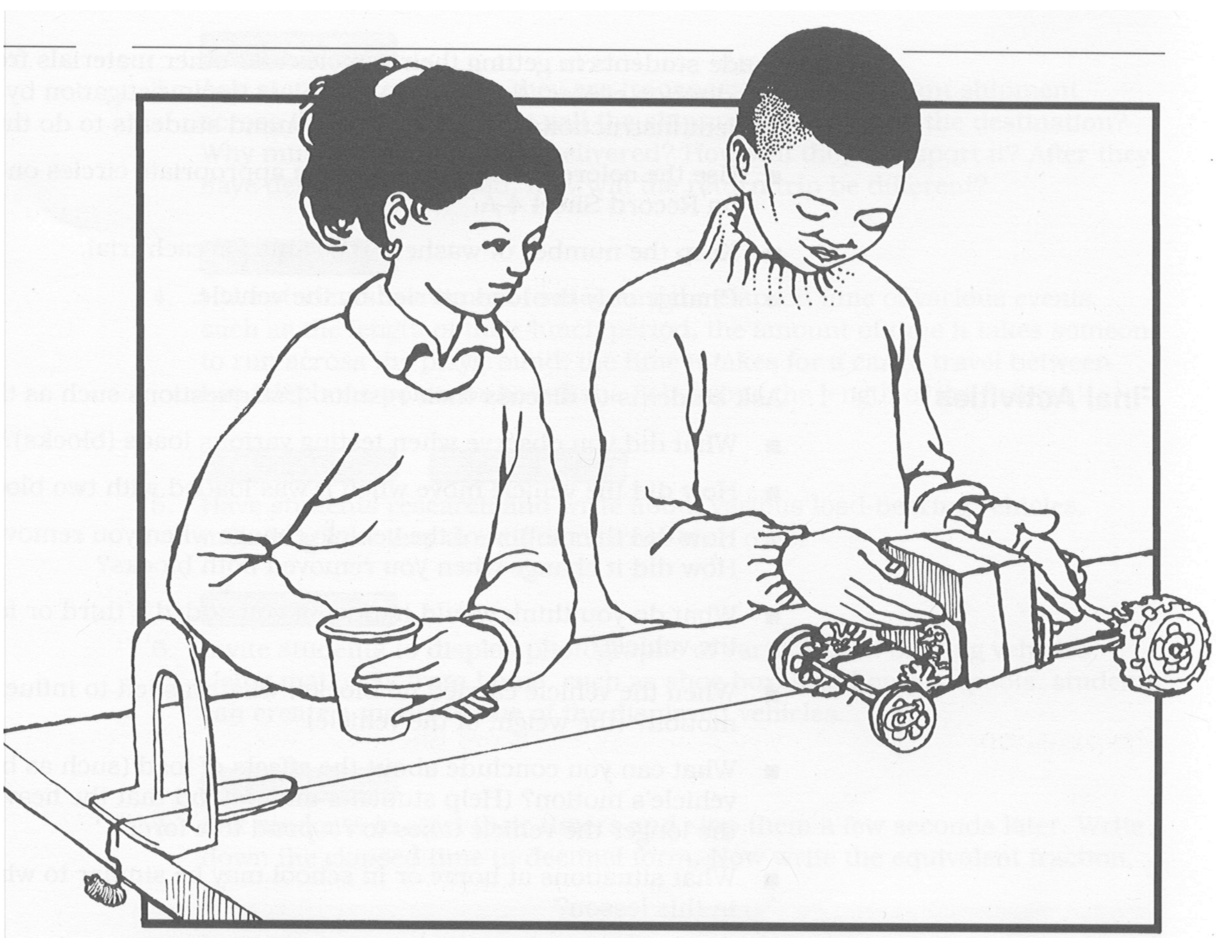
Hypothesis:

If I double the mass of a car while keeping the pulling force constant….

Checkpoint: Have a laboratory instructor initial your hypothesis before proceeding .

Procedures:

1. Record the pulling force of 4 large washers in the space by the table below.
2. Set up your experiment as depicted in the figure for Experiment One above. The figure below illustrates how mass can be added to the car by adding wooden blocks between the brackets. Start with two blocks on your car.



3. Mark the location of the front tires with a piece of tape. Mark a position .75 m closer to the bookend with another piece of tape.
4. In your group of three choose a timer, a holder, and a catcher. The timer will time how long it takes the car to travel 0.75 m; the holder will let the car go; and the catcher will catch the car before it goes off the edge.
5. Do three trials with each number of blocks indicated in the table below. Record your observations and the average amount of time it took the car to travel 0.75 m.

Observations:

Force pulling car ___4___ (# of large washers) => __________ Newtons

Data Table: Experiment One

blocks (#)	Mass of Car (kg)	Observations	Distance (m)	Average Time (s)	Velocity (m/s)	Acceleration (m/s/s)
0			0.75			
1						
2						
3						

Calculations/Questions:

1. As you did in experiment one calculate the average velocity for each number of blocks. Show a sample calculation below:
2. Use an electronic balance to determine the mass of the car with each of number of blocks. Record the information in the table above.
3. In this experiment which variable did you manipulate? Force pulling the car, mass of car or acceleration?
4. Which variable was manipulated in Experiment One? Which variable was kept constant? How does this differ from what was manipulated and held constant for Experiment Two?

Demonstration

Introduction:

In experiments one and two we used average velocity as a way of describing a car's motion. Over the 0.75 m the car traveled was the car's velocity the same or changing? Did you calculate the average velocity?, the final velocity?, the initial velocity? What is the relationship between these? In this demonstration we will use a motion detector and a computer to more precisely observe the car's velocity over time.

Observations:

Time (s)	Position (m)	Velocity (m/s)	Acceleration (m/s/s)

Questions:

1. Looking at the results from the demonstration, does velocity stay constant over the 0.75 meters the car traveled? Give a specific example.

2. Average acceleration is defined as the change in velocity divided by the change in time:

$$a = \Delta v / \Delta t = (v_f - v_i) / (t_f - t_i)$$

Use this formula to fill in the acceleration column in the above table. Note that the acceleration you find using the first and second velocities, for example, is the average acceleration over that time interval, and can be assigned to the time half way between t_f and t_i.

3. Using the formula:

$$\text{acceleration} = 2\, v_{avg} / \text{time}$$

calculate the acceleration values for experiments one and two. Record your answers in the tables for each experiment. Show a sample calculation below:

4. Looking back at your original hypotheses and your results, describe whether your results supported or did not support your hypotheses. Explain.

   Experiment One:

   Experiment Two:

5. Given the rule: force = mass x acceleration, are your observations from experiments one and two consistent with the rule? Hint: How does what the rule predicts compare with what you observed for each experiment. (NOTE: the mass of the washers should be added to the mass of the cart for use in the above rule).

Definitions: (NB, *x* stands for position, *Δx* means a change in position)

Name	**Symbol**	**Definition in words**	**Formula**
Velocity:	v	Change in position divided by elapsed time.	$v = \Delta x / \Delta t$
Force:	F	Something that causes an object's motion to change.	$F = m \cdot a$
Mass	m	An objects resistance to change in motion.	$m = F / a$
Acceleration		Change in velocity divided by unit time.	$a = \Delta v / \Delta t$

Units:

In the rest of the civilized world position (*x*) is always measured in meters ("m").

Velocity, then is measured in meters per seconds ("m/s").

Acceleration, being a change in velocity, is measured in meters per second per second ("m/s/s," or m/s^2 (note that both "s"s are under the "/").

Mass is measured in kilograms (1000 grams, denoted by "kg"). In Britain or Canada, or anywhere else except here, one buys kilograms of cheese. You could take your "kilo" of blue cheese to the moon (to compare to green cheese?) and it would still be one kilogram. In the U.S., cheese is purchased in pounds (lbs.), which are a unit of force. A pound of cheese purchased in the U.S. would weigh much less than a pound on the moon (but, of course, its mass would be the same).

Force is measured in "kg m/s/s" (kilograms times meters divided by seconds divided by seconds). We name this unit after Sir Isaac, called the Newton ("N").

Speed versus velocity.

Speed is a measure of velocity (change in position divided by elapsed time) without concern about direction. Velocity is both a measure of speed and specification of direction. To get to Portland in a certain amount of time, I would specify velocity (go North at 100 km/hr)… speed alone would be inadequate. Interestingly, acceleration can involve a change in direction without changing speed. More on that later.