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Dynamics Carts
#4-60501

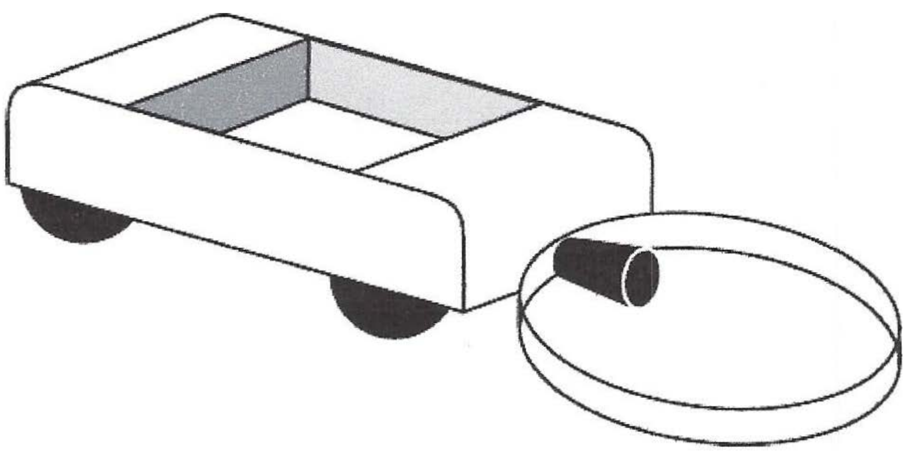
Warning:

- **Not a toy; use only in a laboratory or educational setting.**
- **Contains latex.**
- **California Proposition 65 Warning: This product can expose you to chemicals including nickel, styrene, and benzene, which are known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information go to www.P65Warnings.ca.gov.**

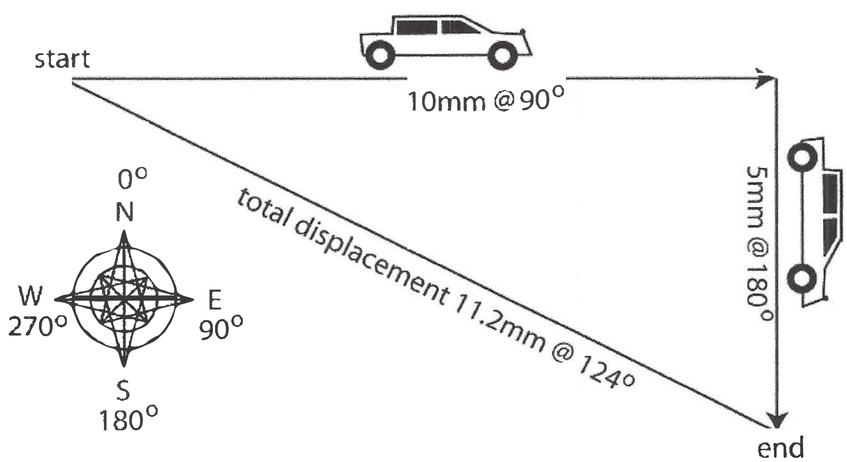
Introduction

The dynamics carts are used for the experimentation and study of elastic and inelastic collisions as well as for studying velocity and acceleration.

Measurement of Force: In analyzing force and motion, in particular, there are two distinct variables that are generally observed. One ofdirection and one of magnitude. In studying a variable that includes both, you are dealing with vector quantities. Drawing arrows whose direction is equivalent to the direction of force and whose length is proportional to the force applied can depict vector quantities such as velocity. A scalar quantity refers to a measurement of magnitude only and does not take into account direction.



A change in the position ofan object is called *displacement.* Displacement can be added together to calculate the total position movement even ifthe displacement is not in the same direction. Furthermore not only can direction but force and speed can be added to this calculation. For example, a car drives ten miles an hour east for one hour and then 5 miles an hour south for one hour. Draw lines representing the car's direction with the length ofthe line representing the distance traveled. In this case driving ten miles an hour would yield a distance often miles in one hour going east and then five miles an hour south would yield a distance offive miles south. Let one millimeter equal one mile. The results are a total displacement of11.2 millimeters at an angle of124 degrees. This was derived by using the Pythagorean theory (10^2 x $5^2 = 11.2^2$) and the angle was derived by using trigonometry. The solution can also be calculated graphically by drawing the lines to scale, measuring the displacement and using a protractor to figure the angle.



Usually, when experimenting with motion or collision we are primarily concerned with force, however, one can hardly study force without studying the direction to which it is applied, as the two are basically two sides of the same coin.

Acceleration & Velocity: It is important in the understanding of physics and to the study offorce and motion to understand the concept of *acceleration.* Many think that acceleration is the act ofan object speeding up. In actuality, acceleration can be positive when the object is increasing in speed and the acceleration is negative ifthe speed is decreasing, however both are considered acceleration. The definition ofacceleration is "the change ofa bodies velocity during any interval oftime divided by the duration ofthat interval".

Another misconception is that of *velocity.* Many people are under the false assumption that the word velocity and speed are interchangeable.

Uniform Acceleration: A body thrown forward as opposed to falling downward travels at a relatively uniformed rate. Without a force continuing to accelerate it and excluding friction, there is nothing to slow it down. The formula for calculating the distance covered is s = vt. In this case (s), once again being the distance, is determined by multiplying the (v) velocity times the (t) time of flight. So, in this case, an object traveling horizontally at a constant acceleration of 50 ft per sec will travel 50 ft in I sec, I 00 ft in two sec and 150 ft. in 3 sec.

It has been discovered, by Isaac Newton nonetheless, that the horizontal acceleration of an object is independent of the vertical acceleration. Thus, as indicated in the chart below, if a rock was thrown forward off of a cliff at a speed of 50 ft per sec. it would still continue to follow the preceding formula of gravitational acceleration downward.

Time in Seconds

	1	**2**	**3**	**4**	**5**
Horz. Travel ft.	50	100	150	200	250
Vert. Drop ft.	16	64	144	256	400

The laws of momentum state that, except for energy lost to heat in a collision, the total energy before the collision should be equal to the total energy after the collision. If we look at a simple situation, where two objects of equal mass and speed are moving across a frictionless surface, and strike each other at 180 degrees to each other (i.e.head on), they should rebound in the opposite direction, and with the same speed. If one of the objects has a greater mass, or is moving at a higher speed, the object which has the greater momentum (greater mass or speed) will not rebound as much, but will continue in the original direction but with a lower speed. The object with lower momentum (smaller mass or speed) will rebound, with a speed equal to or greater than the original speed. The formula for such a collision is: **MlUli + M2U2i = MlUlf+ M2U2f**

The mass of the first object times its initial velocity plus the mass of the second object times its initial velocity is equal to the mass of the first object times its final velocity plus the mass of the second object times its final velocity.

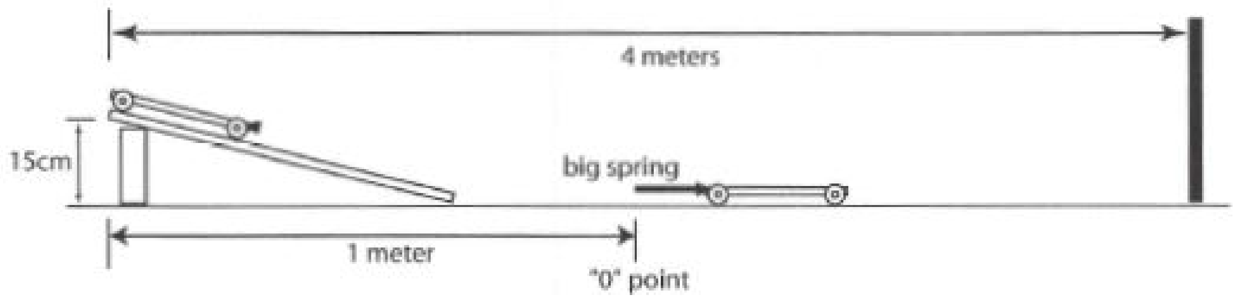
Momentum:

Momentum is basically the quantity of motion. It is derived by multiplying the amount of mass and velocity. Mass is rather easy to determine by simply weighing the object. (We will disregard the fact that advanced theories of momentum indicate that an object's mass changes with speed. In this case it is too small for consideration). Velocity on the other hand is a little more difficult to calculate accurately without a little more sophisticated equipment such as a photogate timer. It is important that students understand that momentum is derived from a combination of the two variables, mass and velocity. However as an introduction to the concept we will only be primarily interested in the changing mass part of the equation at this time.

Experiment:

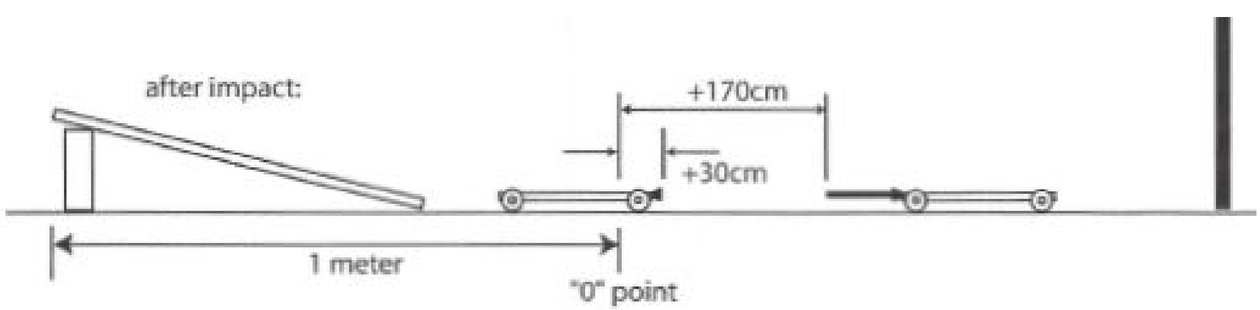
Two carts have been included with this kit. Each cart consists of a recession for mass to rest, a rubber stopper bumper and mounting screws for a spring bumper. Although you can experiment with these cars using nothing else except some mass, it is best if you use some sort of incline plane. This will help to keep the force applied more constant.

Begin by tilting a board or incline plane up so that the top edge rests 15cm above the table. This incline should be positioned 4 to 5 meters from a wall (see illustration).

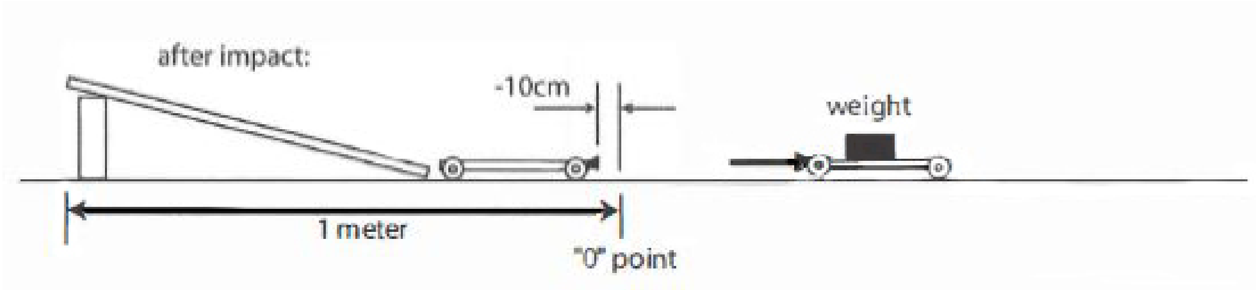


All measurements will be taken from a zero point located one meter from the top edge of the ramp. This point is the point of initial contact between the two carts. Cart "B" will be the cart at rest and will be located so that the front edge of the spring is even with this mark. Cart "A" is the cart that will be placed at the top of the ramp. For consistency, always try to place the cart with the back edge even with the top edge of the ramp.

We will be using cart "B" as a gauge or meter for taking measurements of impact force. Cart "A" will be the "applied" force of the experiments. Please note from the illustrations below that measurement of distance moved can be both positive and negative in relationship to the "zero" point. It is also a good idea to perform each experiment three times and take the average reading to place in the experiment chart.



Begin by placing the big spring on cart "B" and setting it down in position so that the front edge of the spring is even with the zero point. Cart "A" has no spring but only a rubber bumper attached. The first experiment uses no mass. Release cart "A" and allow it to roll down the incline and strike cart "B". Now measure both carts from the zero point and place this information into the chart. Repeat for every variable in the chart.



CART	SPRING	WEIGHT (grams)	FINAL POSITION
Experiment 1			
A	N	N	
B	S	N	
A	N	200	
B	S	N	
A	N	500	
B	S	N	
A	N	N	
B	S	200	
A	N	N	
B	S	500	
Experiment 2			
A	S	N	
B	N	N	
A	S	200	
B	N	N	
A	S	500	
B	N	N	
A	S	N	
B	N	200	
A	S	N	
B	N	500	

N = None

S = Spring

After filling out the chart you should be able to get a good idea of what to expect during the collisions. By examining your data you will probably be able to see that both mass and speed are major factors in determining force.

Below are some observations that you may make during these experiments. The reasons for these occurrences should be discussed among the class.

* When mass was added to cart "A" and it struck the second cart the weight may have slid forward. Why does this happen and what affect does it have on the experiment?

* One might think that regardless of which cart the mass is placed on, the total amount of displacement of the carts should be equal, but this is not the case, why? What factor is not being considered here? (Hint: momentum)

* Why does the size of the spring matter and how does it change the results of the cart's movement? What happens to the energy that the spring absorbs?

* What would happen if a spring bumper were placed on both carts? Try it and see.

* Try measuring the amount of impact cart "B" receives and then repeat the experiment only this time with cart "B" setting at a 30 degree angle to cart "A". Why did the distance that the cart was pushed back change and where did the extra force go?