



MND Physics

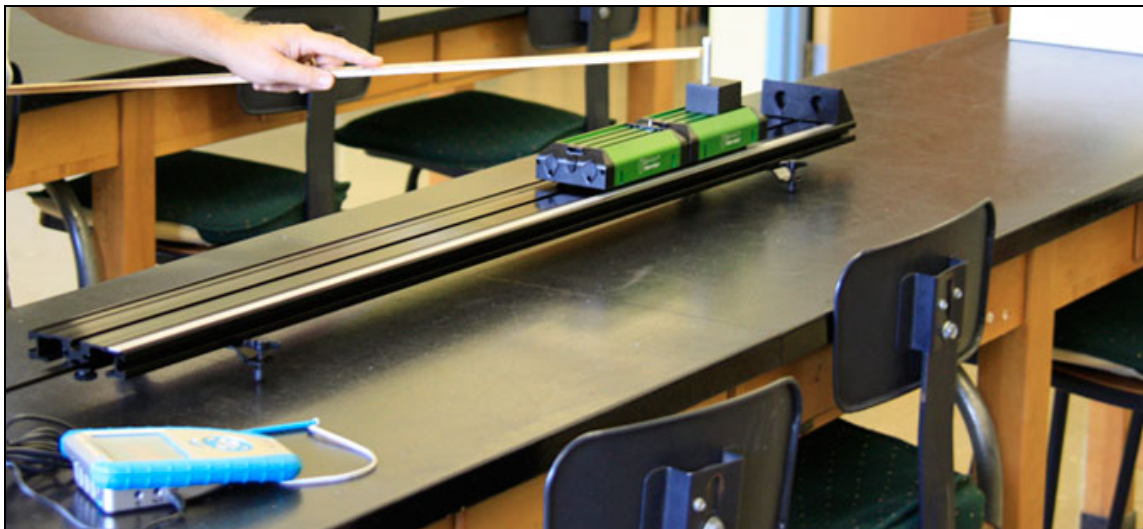
Conservation of Momentum

The momentum of any closed, isolated system does not change. This law is true regardless of the number of objects in the system. In this lab, two carts will push away from each other. We call this type of "collision" an explosion. The momentum of one cart will be equal and opposite of the other cart because momentum must be conserved in an explosion.

The experimental explosion is caused by a release of a spring located in one of the carts (Cart A). By setting the spring, you store elastic potential energy that will be utilized during the experiment, causing both carts to move in opposing directions (elastic potential energy is converted to kinetic energy).

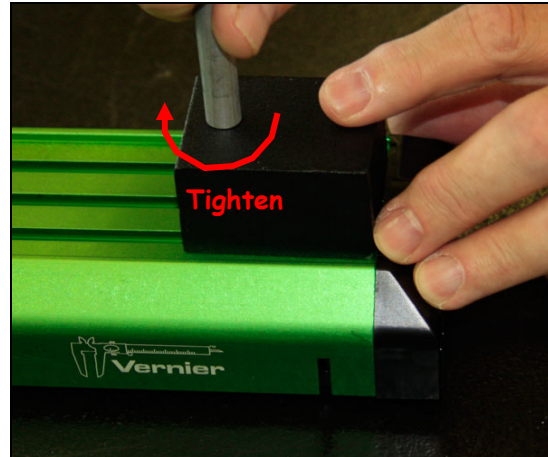
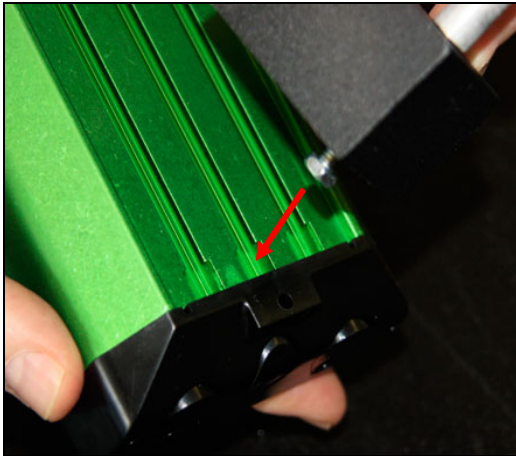
EQUIPMENT:

VERNIER momentum track, frictionless Cart "A" with a spring mechanism, frictionless Cart "B" with an attached added mass, Vernier motion detector, LabQuest with link cable, meter stick and a triple-beam balance.

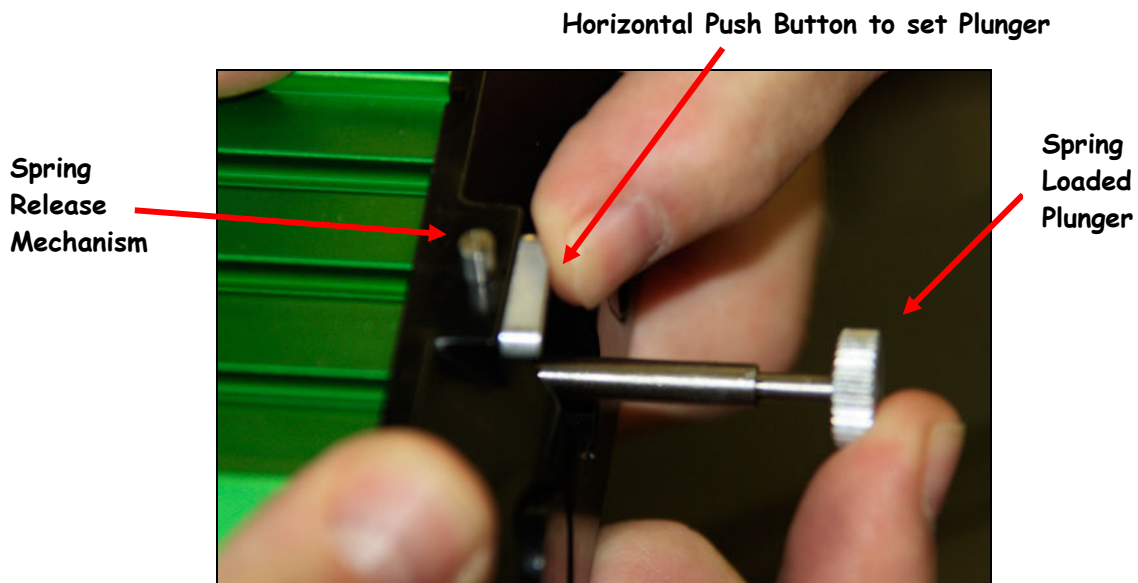


PROCEDURE:

- The cart with the spring mechanism will be designated Cart A. Cart B will be the cart without the spring. Cart B will carry the extra mass.
- Measure the mass of each of the carts with the balance provided.
- Weigh the extra mass (including the aluminum screw fastener), then attach to cart B.



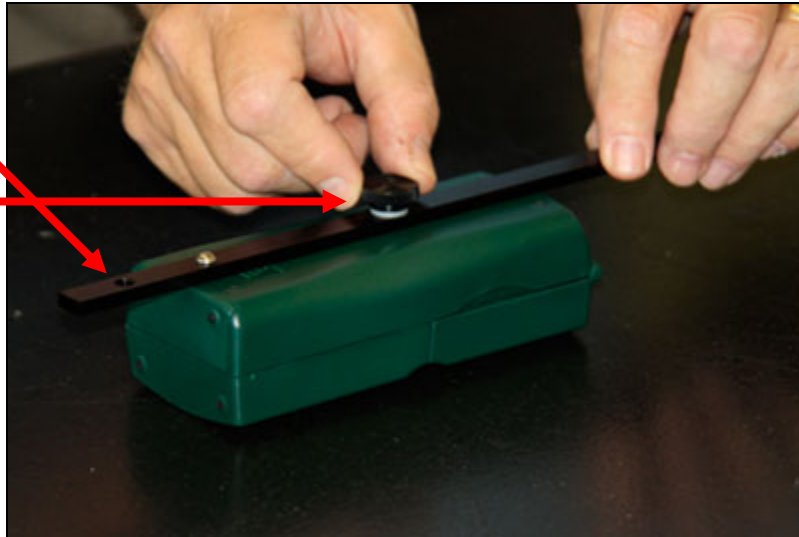
- Set up the equipment as shown in the photograph on page 1.
- Compress the spring in cart A. Set the spring by pushing the plunger while setting the horizontal push button; you should hear a click when the plunger is set.



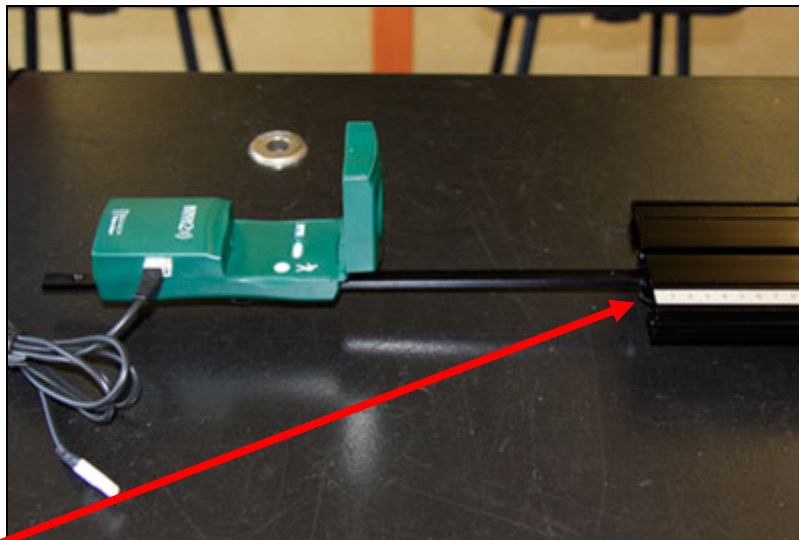
- Connect the mounting rail to the motion detector:

Remove mounting screw
from this position...

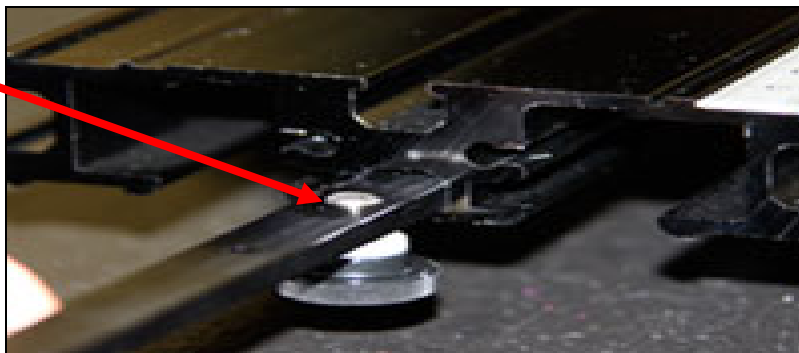
and place here



- Attach the motion detector to the track as shown:



Install the
thumb screw
upside down to
secure the rail
to the
underside of
the track



- Place the two carts on the track about 10 centimeters away from the track end opposite the motion detector. The plunger from Cart A should be in contact with Cart B.

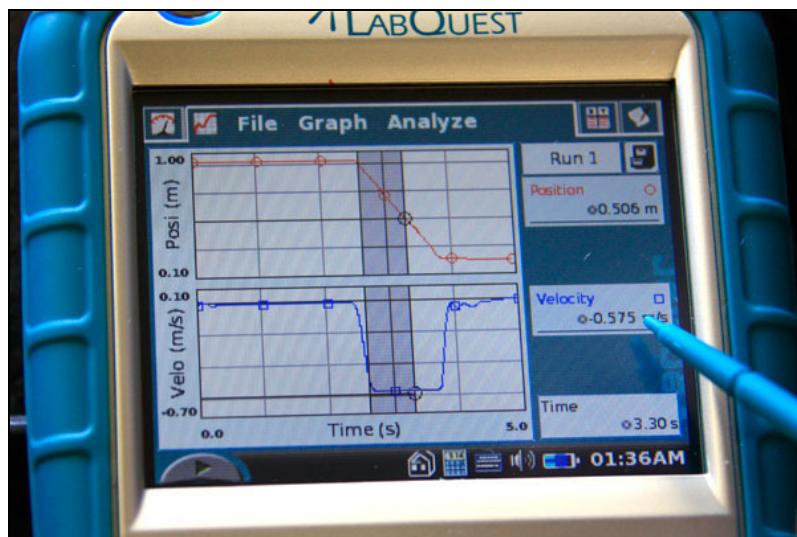
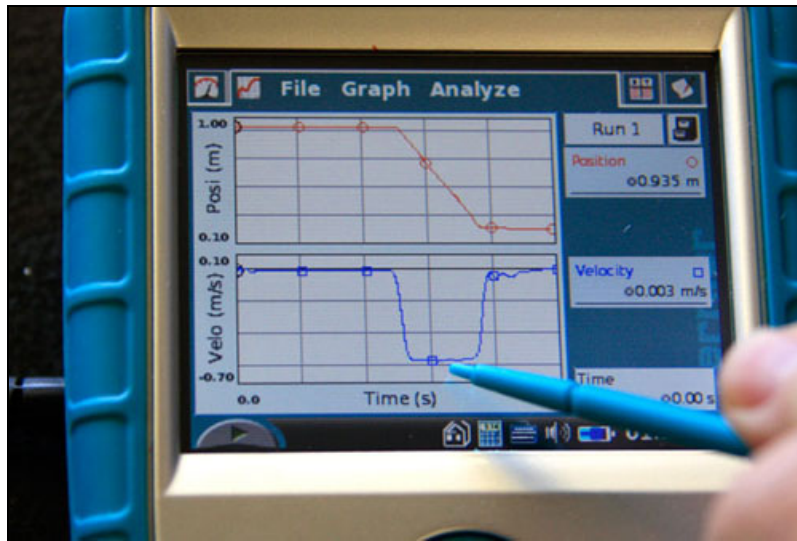


- Adjust the head of the motion detector until the LabQuest readout shows the actual distance from the cart to the detector (approx .9 m)



- One lab team member starts the LabQuest Data Collector by pressing the **ENTER** button. Another lab team member hits the release spring mechanism on Cart A with a meter stick within a couple seconds of hearing the detector start (practice this procedure before collecting data). The spring is best released by tapping the release mechanism with the stick using a single bounce motion.

- CAUTION: do not let the Cart traveling towards the motion detector fly off the end of the track... stop the cart with your hand just as it arrives at the end of the track using caution not to "block" the detector collecting motion data until the final moment.
- After the carts have finished moving and after the LabQuest receives the transferred data from the motion detector, results will appear something like the example below:



- Using the LabQuest stylus, highlight the data indicating constant velocity motion (drag to the right, stop and lift... you will create the gray shaded area shown above). The average velocity will appear in the "velocity" window on the right hand column. Record this constant velocity data in the appropriate data table.

- Repeat the trial and collect another set of data for Cart A (two separate trials should be run for Cart A).
- Reverse the direction of the carts (turn the carts around so that Cart A now faces the opposite direction). Repeat the experiment collecting data for Cart B. Run two separate trials for Cart B.

NOTE: When you turn the carts around, you should arbitrarily change the sign of the velocity for cart B to a positive value. The LabQuest always reports the velocity as a negative value because the motion of the cart will always be TOWARDS the detector. However, in our "explosion", one cart moves one direction and the other cart always reacts by moving in the opposite direction (so one velocity is positive and the other one negative). To facilitate data collection, we opted to reverse the carts instead of completely reconfiguring the track by re-mounting the motion detector on the other end of the track. Reversing the carts while keeping the motion detector mounted on one side of the track achieves the same result while avoiding a lot of unnecessary busy work. But we must remember to change the velocity sign of cart B due to our cart reversal.

DATA TABLE 1

	CART MASS (kg)	EXTRA MASS (kg) Cart B only	TOTAL MASS (kg) Cart plus any added mass
CART A			
CART B			

DATA TABLE 2

Trial 1		
	Average Velocity (m/s)	Average Momentum (kg m/s)
CART A		
CART B		
Trial 2		
	Average Velocity (m/s)	Average Momentum (kg m/s)
CART A		
CART B		

DATA TABLE 3

	Average Momentum Trial 1 (kg m/s)	Average Momentum Trial 2 (kg m/s)	Final Accepted Momentum (kg m/s)
CART A			
CART B			

ANALYSIS:

- Calculate the final average momentum for Cart A and Cart B.
- Subtract the final average momentum of Cart A from Cart B (it should be zero!).
- Discuss all possible causes of error.
- Calculate % error:

$$\% \text{ error} = \frac{|\text{ave. momentum cart A} - \text{ave. momentum cart B}|}{\text{ave. momentum cart A}} \times 100$$

QUESTION:

A real application of the type of conservation of momentum studied in this lab deals with an astronaut floating in space with a thruster as the only means of propulsion. A thruster is basically a container of compressed gas that can be fired in any direction. Conservation of momentum will provide the astronaut with motion; proper use of a thruster enables astronauts to maneuver in space.

Assume an astronaut is 10 m away from the space shuttle floating in free space. She wants to return to the shuttle. She fires a thruster that expels 35 g of hot gas at 875 m/s. The combined mass of the astronaut and thruster is 84 kg.

1. How fast does she move after firing the thruster?
2. In what direction should she aim the thruster to return to her spacecraft, away from the shuttle or directly towards the shuttle?
3. How long does it take her to reach the shuttle? (assume a direct straight path is taken)