

## Newton's Laws I



**Objective:** To investigate, qualitatively and quantitatively, the motion of an object when acted upon by external forces.

**Apparatus:** Motion sensor, force sensor (2), Pasco track, Pasco cart, hanging masses w/built-in hooks (2), short looped string for one motion sensor, meter stick, wooden blocks (for elevation)

### Introduction

You are already familiar with **Kinematics**, the study of motion that does not take forces and masses into consideration. In this lab you will find relationships between forces, masses and the resulting motion; this branch of mechanics is called **Dynamics**. For these series of experiments, do not take what you have learned from your lecture or textbook for granted - do the experiment and form your own conclusions

### Procedure

#### Activity 1

Use the cart, track and a pen to determine a *qualitative* relationship between an object's direction of motion (define one direction as (+), the other (-)). Examine the cart while it is at rest (not hitting or tapping cart), in motion, in motion but being tapped constantly on one side with a pen. Fill in the table below with either 0, + or -, depending on whether the quantity listed is zero, to the right, to the left. "Change in motion" is slowing down or speeding up. For instance, if the cart was moving to the right (+) but slowing down, the Change in Motion would be (-). If the net force was to the left, put a (-) in that box.

Repeat, this time using a mass with built-in hook hanging from a Force Sensor (use Force PRACTICE.CMBL). Define up as (+). Note that you will be treating the mass (and not the Force Sensor) as the object.

Quantity	A) Cart while it is				B) Mass while it is	
	i. at rest (no hitting or tapping)	ii. Moving, being hit with pen in dir. of motion	iii. Moving but pen is not hitting	iv. pen tapping in dir. opp. to motion	at rest	being pulled upwards from rest by Force Sensor
Motion						
Change in motion						
Net force						

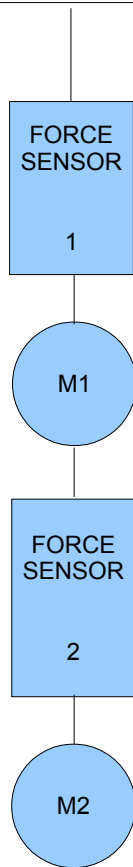
What is your conclusion, based on the above results, about how motion (or change in motion) depends upon net force? Write it in the hand-in sheet.

### Activity 2

Open up "FORCE SENSOR.cmb1". Using two force sensors, design an experiment to determine the magnitudes and directions of the forces between two objects that interact with each other directly (touching or pushing or pulling or colliding). What is your conclusion? Write it in the hand-in sheet.

*(Note: Makes sure your two sensors are set to the same range, e.g., both 10N or both 50N). If your force sensors do not register zero before they experience forces, you may have to press the Zero button near the top right of the Logger Pro window before you begin your experiment.)*

### Activity 3



#### Preparation

Look at the setup on the left. You have, from top to bottom, Force Sensor 1, Mass 1, Force Sensor 2 and Mass 2, all connected to each other, and exerting forces on each other. Force Sensor 1 is hanging from a string, which you are holding so that the whole setup is above your lab desk.

Before connecting them all together, weigh both force sensors on the electronic scale at one end of the room. Use 200g for each mass in your calculations (no need to weigh masses).

Draw a FBD (Free Body Diagram) for each of these four objects, clearly drawing a vector to represent every force on each object. Remember that the force of Gravity acts on all the objects. You will do this on your hand-in sheet.

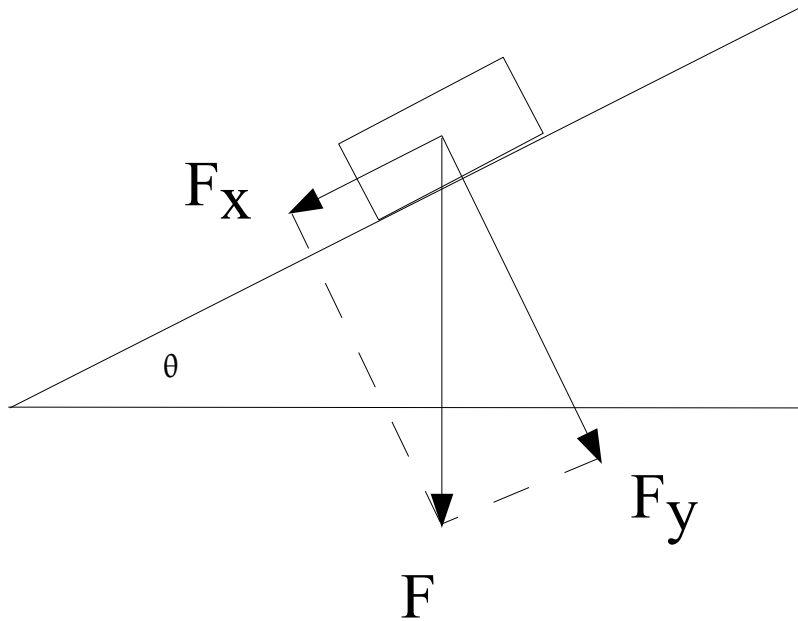
Using your conclusion from Activity 2, and Newton's Second Law  $\vec{F}_{net\ external} = m\vec{a}$ , calculate and predict the reading on both force sensors when they are arranged as on the left. Show your calculation to your TA before proceeding.

#### Experiment

First open HANGING FORCE SENSORS.cmbl. Without putting any weight on the force sensors (or pulling/pushing on their hooks), position them individually in the orientation on the left and press the Zero button in Logger Pro. Then put together the setup as on the diagram on the left, press the Collect button and compare with your predictions. If you did not come close, discuss the reasons for the discrepancy with your partner. Record all your work in the hand-in sheet.

### Activity 4

Elevate one side of your track so that it makes an angle of a few degrees above the plane of your lab table. Calculate, using your newly-acquired knowledge of dynamics, how long it will take for the Pasco cart to travel 1.5 meters down the track at this angle of inclination. Open up Motion Sensor.cmbl and actually measure the time it takes. The diagram below may be useful in helping to resolve forces into X and Y components:



$$F_x = F \sin \theta$$

$$F_y = F \cos \theta$$

### Questions (Hand-in Sheet/Lab Notebook)

Write the results from the four activities above in the hand-in sheet. Then answer these questions:

1. Does your result for Activity 1 conclusively prove Newton's First Law? Why or why not? What modifications in equipment or conditions would you need to prove it conclusively?
2. Standing on a frictionless surface (like a sheet of ice), two boys, one strong and one weak, are attempting to break a string in half by pulling on its opposite ends. If the only horizontal forces they exert are on the string, who is exerting more force?
3. In order for a car to accelerate forward from rest, an external force must act on it. Which direction does this external force act? *What* is providing this external force on the car? According to Newton's Third Law, there should be an opposite reaction force – *where* is this reaction force coming from, and *what* is it acting on?