Goals:

Newton's 2\textsuperscript{nd} Law is one of the most important concepts you will learn in physics. During this lab, you will explore some applications of this beautiful and powerful idea. Not incidentally, you will become familiar with the measurement of force, and while we are at it introduce Newton’s 3\textsuperscript{rd} Law.

Materials:

PC with LabQuest interface for measuring instruments
Motion Sensor
Two force probes
PASCO cart on aluminum tracks with bracket to fix the force probe on the cart
PASCO cart without the mounting bracket
Two rectangular weights for the cart
Balance to measure masses
String
**Activity 1: Discovering Newton’s 2nd Law**

Set the cart with the force probe on the track, with the hook of the force probe facing away from the motion sensor.

Start LoggerPro 3.8.5.

Create four graphs; position vs. time, position vs. force, velocity vs. force, and acceleration vs. force. Make sure that the motion detector correctly detects the cart along the entire length of the track.

Zero the force probe by going to the “Experiment” menu and clicking on “Zero”. Then click on “Zero Force”.

The force probe works properly only when the push or the pull is precisely aligned along its length, i.e. it must not be at all perpendicular. (This takes some practice and may be aided by mounting the probe on a second cart, then moving the 2nd cart in order to move the first cart, which is being tracked by the Motion Detector.)

Start collecting data. Grab the cart by holding on to the force probe’s hook, and start moving the cart back and forth gently and smoothly. Be very careful to move only along the track axis and not perpendicular to the track axis. Make the motion irregular along the axis defined by the track, i.e. don’t repeat the same pattern over and over again. Once try to apply a large short pulling force while being careful to keep the cart on the track. Then later suddenly push it back. Remember to apply the force to the force probe hook only and only along the track axis.

PRINT graphs of position vs. force, velocity vs. force, and acceleration vs. force to your report. Underline or write on your print out what the scale is, and especially where the value 0 N is.

**Q1. Is the position a simple function of the force?**

**Q2. Is the velocity a simple function of the force?**

**Q3. Is the acceleration a simple function of the force? What kind of function could it be?**
Q4. What does Newton’s 2nd Law predict for functional dependence of acceleration on force? Does your data agree with this expectation?

Q5. From Newton’s 2nd law, what value do you expect for the slope of the acceleration vs. force graph?

2. Imagine you are a scientist in space station.

Q6. Imagine yourself in the space station, finding an unknown object, and you want to measure its mass. How would you accomplish this if you had a force probe, a motion sensor and Logger Pro?

Now it is time to make your imagination real and check to see if your experiment will allow you to accurately measure the mass. To make sure that your experiment is accurate, graph your data. Autoscale and Print your graph and table.
Q7. What object did you want to measure the mass of? What value did you obtain from your experiment? How different is this mass from the mass obtained from the balance? Is this difference large or small compared to the balance mass?

3. Newton’s 3\textsuperscript{rd} Law

Q8. What does Newton’s 3\textsuperscript{rd} Law predict if you connect two Force Probes in opposite directions and pull them apart with the connection stable and not moving?

Q9. Try it. Simply connect a second Force Probe. Calibrate them carefully. Then attach the two by their hooks with a rubber band or string and pull apart. Plot the force of one against the other on the computer and PRINT the result. What is the trend of the curve?

Q10. Does this confirm Newton’s 3\textsuperscript{rd} Law?

Replace the hooks on your Force Probes with bumpers, mount the Force probes on two carts, and set them on the track so the Force Probes face each other. Make sure that force is defined as being positive when directed toward the computer end of the cart for both
probes. This means that you need to reverse the direction of one of the force probes. Now press Collect and gently crash the bumpers of the force probes together.

Q11. What is the trend of the curve of Force 1 against Force 2? Zoom in to examine these forces.

PRINT the graph.

4. Forces between two pushed masses

Suppose you had two carts on a frictionless track, one with two rectangular weights attached and one without added weights. Suppose these carts were placed together and you pushed one of them with a set force $F$.

Q12. Would the inter-cart force be $F$, or some other value? Is the inter-cart force the same for each experiment below? Why?

![Diagram](image)

(1) ![Diagram](image)

(2)

Try it. Put a Force Probe on the lighter cart. Use another Force Probe to push the first cart with a measured force, $F$. Do an experiment to test your expectation and describe it below. Create the appropriate graph(s) of results and PRINT it out.

Q13. Please explain your result.
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**Prelab Lab 6**

**Name ___________________________**

1. What is your weight in Newtons? If no appropriate measuring device is available, use the rule that 2.2 pounds equals 10 Newtons.

2. How strong a force can you exert? How do you know? (Can you lift your own weight? A lot more?)

3. Having read about Newton’s Second law in your textbook or a previous physics class or heard about it in lecture you are at least somewhat familiar with \( F = ma \) (Force equals the mass of an object times its acceleration in the absence of friction). Suppose you have an elevator of mass \( m \) which is being pulled up by a cable. The gravity and tension of the cable provide forces that are oppositely directed along the vertical axis.

   a. If the elevator is not moving, what is the tension on the cable if the mass of the elevator, \( m = 1000 \) kg? The acceleration of gravity, \( g \), is \( 9.8 \) m/s\(^2\).

   b. What is the tension on the cable if the mass of the elevator, \( m = 1000\) kg and the elevator is accelerating upward at \( 1 \) m/s\(^2\)?

   c. What is the tension on the cable if the mass of the elevator, \( m = 1000\) kg and the elevator is accelerating downward at \( 1 \) m/s\(^2\)?