Investigating Forces

Brief Introduction

In this investigation, you will be trying to establish a working definition of force and understand the relationships among force, kinematical quantities and energy. You will be using force sensors, as well as motion detectors to collect data.

Pre-Lab
When a new concept is introduced in this course it adds to the complexity of the models you are able to construct. This lab will formally introduce the concept of force, and thus you need to integrate force concepts into the models you can already use. As a result, prior to any data collection, you will construct a model using what you already know which will highlight the new components to your models.

The very first thing you are going to investigate with the force sensors will be "A person constantly pulls a cart (initially at rest) along the very smooth track." Before collecting data on this, you should first construct a model for this situation using all the tools you have thus far.

Which model(s) did you apply to this situation? Why?

Is energy conserved in this situation?

How does the concept of force, as you understand it, apply to this situation?

Data Collection – Part One

Connect the Motion Detector and Force Sensor to the computer. After all hardware is connected, turn on the computer. Open Logger Pro and include graphs of velocity vs. time, acceleration vs. time, and force vs. time.

The first situation you are going to collect data on will be the situation you modeled previously. The diagram below shows the configuration of the track, cart and motion detector. .

This is important: Before collecting data using the force sensor, you need to Zero the force sensor on Logger Pro. Make sure nothing is touching the hook on the force sensor when you do this.

Motion
Detector   Force Sensor with
                hook attached   Pull toward bumper   Stopper

        Start at
        least 15 cm
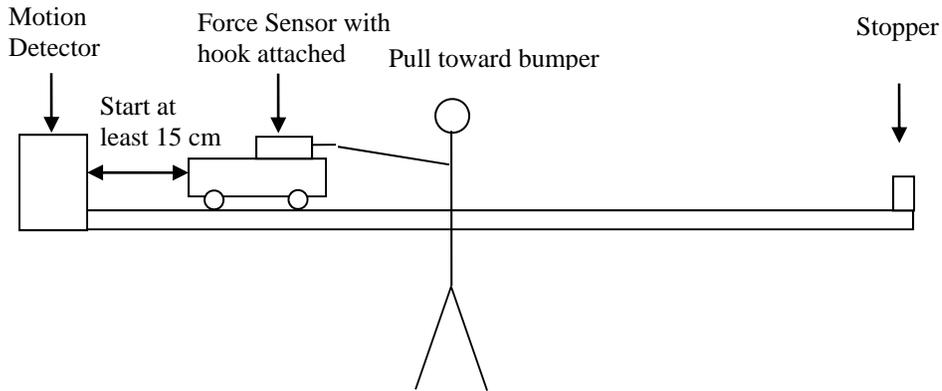
Collect data as you *constantly* pull the cart (initially at rest) along the very smooth track, sketch the data collected on the axes below:

vel   accel   force

        time   time   time
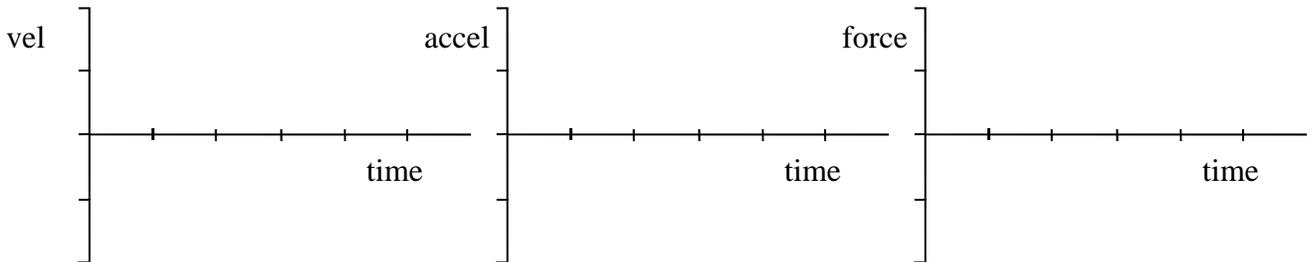
Data Collection – Part Two

Now that you have collected one run of data you will have to use this data to predict the outcome of the next trial. In the next trial you will be **_gently_** pushing and pulling the cart back and forth using the hook on the force probe. Prior to conducting this trial, you have to predict the force vs. time, velocity vs. time, and acceleration vs. time graphs. Record your predictions on the axes below.

Prediction

vel   accel   force

                   time   time   time
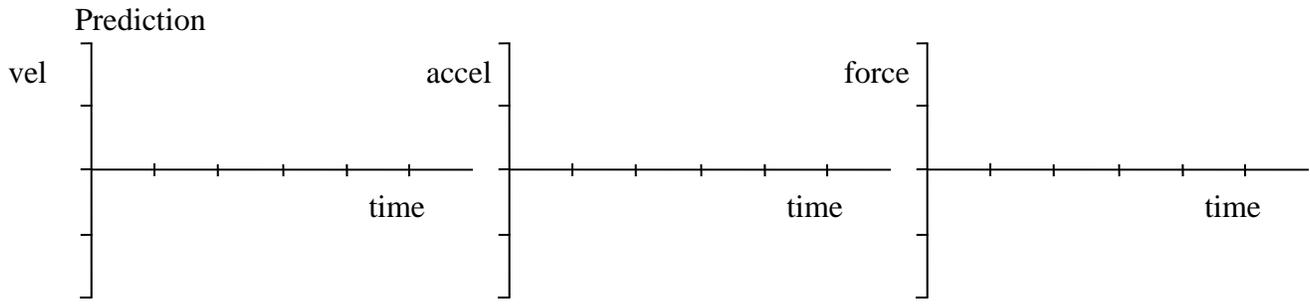
Now conduct the trial. Sketch the three graphs on the axes below.

Data Collected

vel   accel   force

                   time   time   time
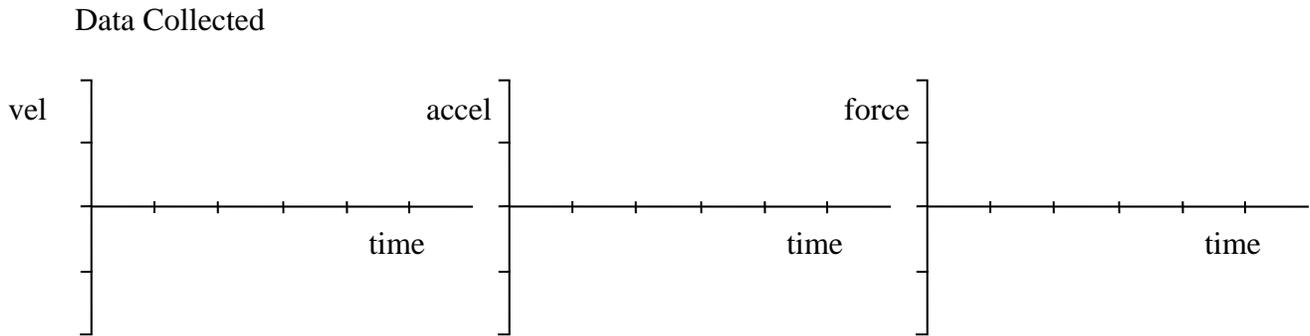
Questions from Data Collection One and Two

1. Did your predictions from Data Collection Two match the data you collected? Why or why not?

2. What principle(s) did you use to make your prediction?

3. How do the data you collected about force vs. time fit into the models you already have?

4. Use the data you have collected to suggest a rule that governs force.

Modeling Forces
Now that you have some data to augment your intuitions about forces, it is imperative that you begin to incorporate forces in the construction of models. In order to provide some guidance about how forces can be modeled, consider the following questions:

1. In the previous two trials, what caused the cart to move as it did?

2. What was the Force Probe you used in the previous trials measuring? Be as specific as possible.

3. One of the keys to creating models including forces is to identify all of the forces on an object. Try to identify all the forces that were acting on the cart in trials 1 and 2.

4. For each force you listed above, what is causing the force?

You have used system schema to identify elements of a system when you are using energy in your models. You can use system schema to help you model forces as well. Create a system schema for Trial 1 and put the system schema on your whiteboard.

Generalizing a force law

On page 4 you made a prediction about the nature of the law that governs forces, you will need to investigate that law through experimentation. Often, formal experiments follow initial rounds of informal investigations which suggest ways of running controlled experiments, basically messing around. In order that this messing around is not fruitless, you should take some rough notes: what did you try, what did you find, how does that influence your rule…etc. Over the next 25-30 minutes, you are going to mess around with the understanding that at the end of that time you are going to have to propose 3 formal experiments that you will conduct to determine the force law. At this point your instructor should provide you with additional equipment to enhance your messing around.

Space for rough notes:

On this page you should propose three experiments. You should describe the set-up, what you are going to measure and how you are going to measure it.

Proposal #1:

Proposal #2

Proposal #3

Data Collection Parts 3-5

Once you have gotten approval for the three controlled experiments described above, go ahead and conduct the experiments, record the data on the axes below as well as saving a copy for yourself.

Data for Trial 3

Data for Trial 4

Data for Trial 5

Wrap-Up Questions for Investigating Forces

1. Propose a "law" that governs forces. (Notice "law" is in quotes to establish a law, there will need to be much wider testing and validation.)

2. How do the data you have collected support the "law" you have proposed?

3. Return to the beginning of this lab, to the initial model of "A person constantly pulls a cart (initially at rest) along the very smooth track." Revise the model you made at the beginning of the lab to include forces (include new representations of forces, as well as the "law" you have proposed).