PHY131 Practicals Day 3 Student Guide

Summer 2009

Concepts of this week's Module

- Dynamics: Forces
- Newton's Second Law

Mechanics Module 2, Activity 14

In this Activity you will use a *Fan Accessory*. The fan accessory clamps to the collision cart and produces an approximately constant force upon it.

- **Avoid a runaway Cart falling off the Track.**

Level the Track and leave the Motion Sensor mounted on one end. Warm up the bearings of the wheels of the Cart by rolling it up and down the Track a few times. Set the fan angle at zero degrees.

To get the software running:
Double-click: the Labview icon, which should be on your desktop.
Click: File → Open → P:/Labview/motion-sensor
Click: Start Detector
Click: Collect Data

A. Put 4 AA batteries in the Fan Accessory. Carefully clip the fan accessory to the top of the collision cart, avoiding putting too much pressure on the wheels of the cart. Place the Cart on the Track close to the Motion Sensor but at least 0.15 m away from it. You will want the direction of the air from the fan to blow towards the Motion Sensor. Turn the fan on and use the Motion Sensor to measure the acceleration of the Cart.
B. Sketch a motion diagram of the Cart.
C. Consider the Cart, motor, fan and the housing for the fan as the system under consideration. Sketch a Free Body Diagram of all the force acting on the system when the Cart was accelerating in Part A.
D. Use the Spring Scale to measure the net horizontal force acting on the system when it is not moving. Is this the force acting on the system when it is moving?
E. Repeat Parts A – D with two batteries swapped out for aluminum dummies. This will halve the voltage provided to the fan motor, decreasing the fan speed and

decreasing the force on the system. Put the real batteries back where the dummies were so that the mass of the system remains the same.

F. Sketch a graph of acceleration versus force, with the force on the horizontal axis. Be sure to include the origin on the graph. Although you only have two data points, what do you think the shape of the graph is for an arbitrary number of data points?
G. Is there a "free" third data point that you can include in your graph? Hint: what is the acceleration of the Fan Cart when the fan is off?
H. Sketch a straight line that "fits" the two data points. Should the line go through the origin?
I. How much can you vary the slope of the line and still more-or-less "fit" the data? Graphical estimation of slopes and their errors was discussed in Section 14 – **Graphical Analysis** of the document on error analysis that was also the assignment due at the first Practical.
J. Write down the relation between the force F and acceleration a as an equation including any necessary constants. Include as estimate of the error in those constants.

Course Concepts *Mechanics Module 2, Activity 15*

A key aspect of the scientific method is that often when a physical system has many variables we can keep all but two of the variables constant, and can investigate how those two variables relate to each other. In Activity 14 you varied the force applied to the Cart and saw how different forces cause different accelerations of the Cart. In this Activity you will apply the same constant force to the Cart but will vary its mass.

A. Measure the mass of the Fan Accessory, the Cart, and the two black rectangular masses.
B. The Fan Accessory snaps on top of the cart. In addition, the black rectangular masses can be placed on the Cart. How many possible values of the total mass are possible with and without the rectangular masses?
C. Measure the acceleration for three different values of the mass.
D. Sketch a graph of acceleration versus total mass, with the mass on the horizontal axis. What is the shape of the graph?
E. Sketch a graph of acceleration versus one over the mass, with one over the mass on the horizontal axis. Include the origin in the graph. Is this graph simpler than the one in Part D?
F. For the graph of Part E, draw a straight line that "fits" the data. Should the line go through the origin? Why?
G. Write down the relation between mass m and acceleration a including any necessary constants and their errors.
H. Combine your result for Part G and Activity 14 Part H into a single equation involving F in newtons, m in kg, and a in m/s^2 and any necessary constants. You may find the following useful:

- What is the value of constant you found in Part J of Activity 14 in terms of any physical parameters of the system?
- What is the value of the constant you found in Part G of this Activity in terms of any physical parameters of the system?

If you have time: Mechanics Module 2, Activities 16, 4

[***STOP!*** Please go back and take a second look at what you have recorded in your notebook for the mandatory activities. Is there anything missing? Can anything be improved? Does your TA have advice on what you might be able to do better? Please do not attempt this "If you have time" activity until you feel confident that the other activities are completed to the best of your ability, and you have obtained permission from one of your TAs.]

A. For one-dimensional motion in the x direction, here are three ways to write Newton's 2^{nd} Law:

1. $F_x = ma_x$
2. $a_x = \frac{1}{m} F_x$
3. $m = \frac{F_x}{a_x}$

Although these three forms are *mathematically* equivalent, in terms of using mathematics as a language to describe the relation between forces, masses and acceleration they are not. Which form best describes the central idea of Newton's 2^{nd} Law? Explain.

Hint: when you write that some variable *y* is a function of another variable *x*, such as:

$y = \mathrm{f}(x)$

one variable is called the *independent variable* and another is called the *dependent variable*. Which is which, and why is this terminology used?

B. Two vectors have different magnitudes. Can their sum be zero? Explain.
C. If one component of a vector is nonzero, can the vector have zero magnitude? Explain.

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This Mechanics Module Guide was written in July 2007 by David M. Harrison, Dept. of Physics, Univ. of Toronto. Some parts are based on Priscilla W. Laws et al, **Workshop Physics Activity Guide** (John Wiley, 2004) Unit 5.