Report -- NEWTON’S LAWS (PART I) 11-MAC

Name: ___________________________________________       Section: ____________
Partner: __________________________________________       Date:     ____________
Partner: __________________________________________

Part I

Activity 1: Graphing.
A. What value of correlation R would you expect if you make a simple (linear fit) to your data? ___________. What value did you obtain for R? ___________. What do you conclude that R tells you about your data?

B. What value of correlation R would you expect if you make a simple (linear fit) to your data? ___________. What value did you obtain for R? ___________. What do you conclude that R tells you about your data?

What are the slope and y-intercept of the best-fit line? What would you expect them to be?

Include the graphs in your report.

Your assignment is to determine how $F$, $m$, and $a$ are related. You will use the setup sketched on page 3-4 of the manual. To keep the experiment simple, you first want to keep the ‘mass’ constant and vary the ‘force’ to see whether the ‘acceleration’ changes and how. The first step is to design the experimental procedure.

Before you do anything, consider the following questions:
What will you do with the two masses in this experiment, $m$ and $M$? Which mass do you want to keep constant and which mass will be varied? Or do you want to keep $m + M$ constant? Which of the forces is the actual $F$ that is relevant in Newton’s Second Law? How will you determine this relevant force? The force probe will measure the tension in the string. Is this tension the force $F$ in Newton’s Law?

The answer to above questions depends crucially on which ‘mass system’ you consider.

In the first experiment we will keep M (cart) fixed and vary m. In this case the net force on M is caused by the tension in the string. The tension varies as the weight m in the basket is varied. Clearly here the mass system you consider is the cart with fixed mass M.
Give a free body diagram of the system you are studying in this setup.

Make sure the track is perfectly horizontal. What goes wrong if it is not horizontal?

Make sure that the force sensor reads zero for zero force. (To calibrate, click on ‘Experiment’, then click on ‘Zero’, choose ‘force probe’. IMPORTANT CAVEAT: Only calibrate the force sensor while no forces act on the force sensor). The force probe is easily thrown off its calibration. Also note that its range switch is set correctly to 10 N.

Keeping the mass M constant, vary mass m and (using the motion sensor) measure the acceleration of the cart for FIVE different forces acting on M. For each case, record the mass M of the cart, the varied mass m of basket + weights (suggested is to use weights 20, 30, 40, 50, 60 gram for the FIVE cases). Record the value of the force, and the corresponding acceleration. For each choice of (M,m) make THREE runs and find the average acceleration a(average). Record all your measurements in a Table-format below.

<table>
<thead>
<tr>
<th>m-weights (kg) (+basket)</th>
<th>Force(N)</th>
<th>M-cart(kg)</th>
<th>a1(m/s^2)</th>
<th>a2(m/s^2)</th>
<th>a3(m/s^2)</th>
<th>a(average,m/s^2)</th>
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Plot the data using Logger Pro in Lab Apps and make a linear regression. Give your plot an appropriate title, label the two axes, identify the plot also with your name. Make a copy of the plot for your report. Interpret the meaning of the 2 constants (slope and intercept) in the linear regression. What is the coefficient of correlation?

What aspect of Newton’s Second Law has been addressed by this first experiment?

Can you interpret the slope in your graph in terms of the mass M(cart)?
List all forces acting on mass M (include all horizontal and vertical forces). Represent all forces by arrows in a figure. For each force identify the origin/source (caused by whom) of the force, and the ‘nature’ (gravitational or non-gravitational) of the force.

Repeat this inventory for forces acting on mass m.

In the second experiment we keep the force F constant and the ‘mass system’ is M + m. The force is kept constant by fixing mass m (weight + basket). Now the fixed gravitational force is mg and this force acts on the system M + m, where we will vary M. Record the value of the fixed force F = mg in your experiment.

(Note that the tension is not relevant here, so ignore the reading of the force probe.) We will measure the acceleration ‘a’ of the mass system M + m for five different values of the cart mass M. M(cart) is varied by placing 0, 1, 2, 3, or 4 metal bars (~500 gram each) on top of the cart. Record your data in the Table below.

We will find the correlation between the mass of the system and its acceleration, while the force F remains constant.

<table>
<thead>
<tr>
<th>F(N), fixed</th>
<th>Mcart(kg), Variable</th>
<th>Mcart+weight+basket, “mass whole system”</th>
<th>Inverse system-mass</th>
<th>a1(m/s^2)</th>
<th>a2(m/s^2)</th>
<th>a3(m/s^2)</th>
<th>a(average)</th>
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Make a graph of acceleration ‘a’ versus ‘inverse mass’, \(1/(M + m)\) and make a linear digression. Report the correlation coefficient.

If this relation is linear, one can conclude that \((M + m) a = \text{constant}\) in this part of your experiment.

How does this relate to Newton’s Second Law?

The slope in your graph should tell you the value of the force \(F\) you used. Why? Calculate the value of the force \(F\) from the parameters (slope and intercept) of your fit.