Name _____Period_____ Date_____

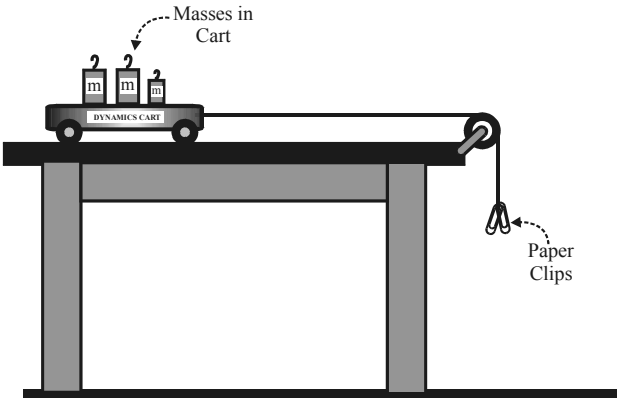
Lab 3:4 Newton's 2nd Law

GOAL - The goal of this lab is to verify Newton's Second Law of Motion: "Whenever an unbalanced force F is applied to a mass m the result is an acceleration that is directly proportional to the force, inversely proportional to the mass and in the same direction as the accelerating force.

[Each of the following directions assumes the use of Pasco carts, sensors, tracks and pulleys. If you are using some other manufacturer's apparatus some details may have to be adjusted.]

PROCEDURE -

1. First assemble a low friction track, dynamics cart, string, pulley, stopwatch [or other timing sensor] and weights as shown in the diagram at the right.
2. Measure and record the mass M of the dynamics cart.
3. If necessary level the low friction track. To do this place the cart on the center of the track and adjust the "feet" of the track until the cart remains substantially at rest.



Part A - Acceleration vs. Force

4. Select and place 50 grams of mass in the dynamics the cart, attach a thin string to the front of the cart, stretch the string over the table clamp pulley and attach paper clips to the end of the string hanging over the pulley until the cart barely moves at a constant speed when gently pushed. This small mass compensates for the frictional force acting on the cart and any additional weight will now be responsible for any acceleration that occurs.
5. Record the number and mass of the paper clips used throughout the lab procedure.
6. Remove 10 grams of mass m from the dynamics cart and attach it to the end of the string hanging over the pulley [leaving the above paper clips attached!].
7. Measure and record the distance from the bottom of the falling mass to the floor below.
8. Start your stop watch [or other timing device] as you release the cart, allowing the system to accelerate and then press stop just as, or slightly before, the falling mass m reaches the floor.
9. Using the kinematics equations you learned in freefall calculate the average acceleration of the cart as the mass falls to the floor.
10. Repeat steps 7 through 9. If your acceleration is the same go to the next step. If your values are significantly different repeat a third time and take the average.
11. Remove an additional 10 grams from the cart and add it to the string hanging over the pulley. [There should now be 20 grams on the end of the string (plus some paper clips) and 30 grams still sitting in the cart.] Why did you remove the mass from the cart rather than just add an additional 10 grams?
12. Repeat steps 7 through 10.

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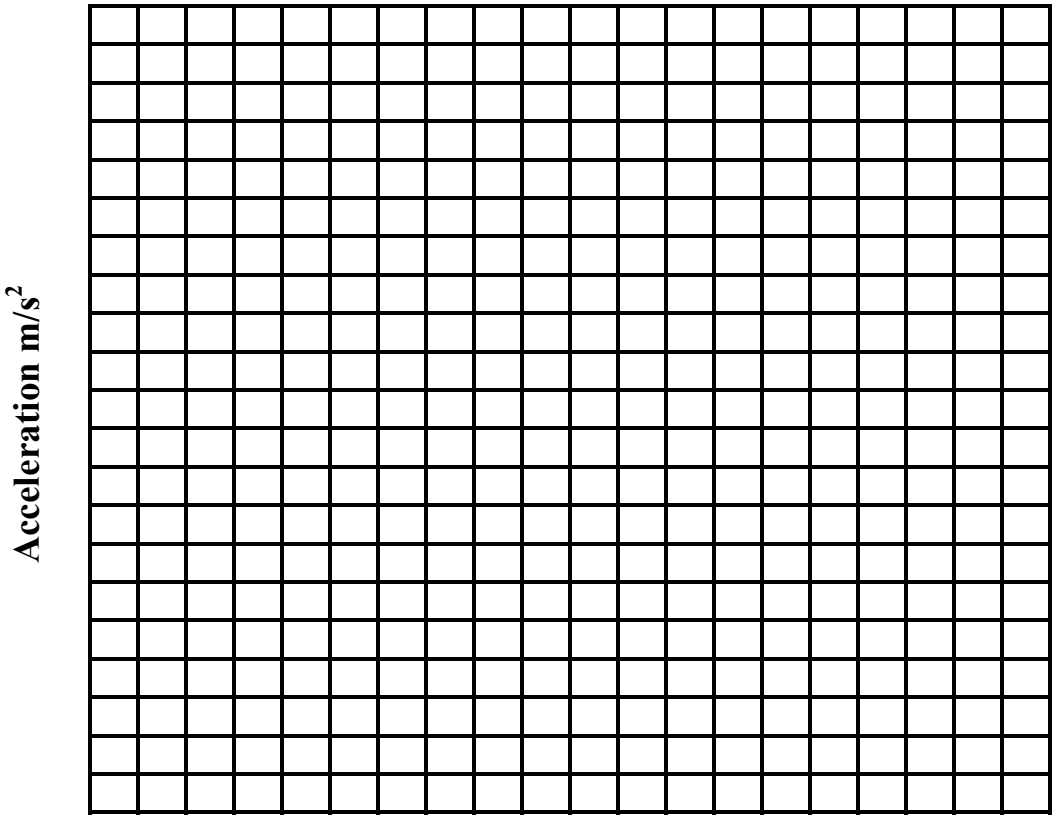
13. Continue to transfer 10 grams from the cart to the string and repeat steps 7 through 10 until no more mass remains on the cart.

    F_1 = _____ F_2 = _____ F_3 = _____ F_4 = _____ F_5 = _____

    a_1 = _____ a_2 = _____ a_3 = _____ a_4 = _____ a_5 = _____

14. At this point you should have 5 different applied forces with their corresponding accelerations. Plot a graph of Acceleration as a function of the Force applied. From the shape of the resulting graph determine the relationship between the acceleration of an object and the magnitude of the applied force.



15. Record the total mass accelerating during the first procedure. [The cart, the masses, the paper clips etc] Since you are performing a controlled experiment this total mass should, of course, remain constant throughout the first procedure!

    total mass = _____

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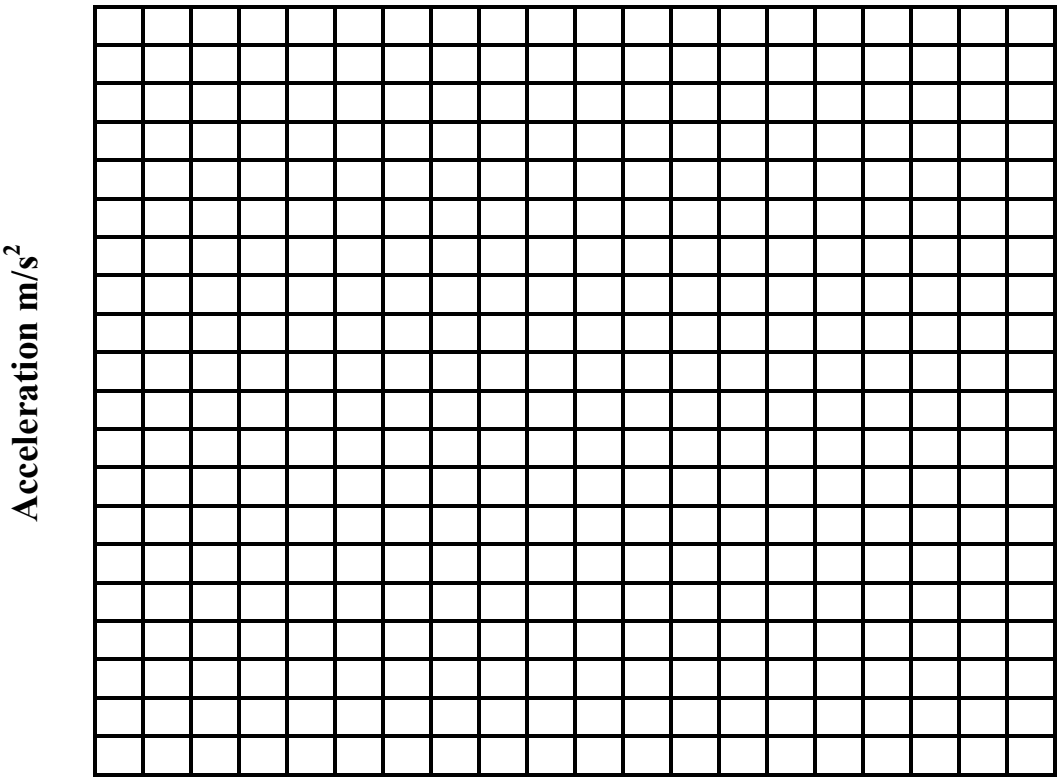
Part B - Acceleration vs. Mass

16. Add an extra ½ kg mass to the cart, stretch the string over the table clamp pulley and attach paper clips to the end of the string hanging over the pulley until the cart barely moves at a constant speed when gently pushed. As above, this small mass compensates for the frictional force acting on the cart and any additional weight will now be responsible for any acceleration that occurs. Attach 50 grams to the end of the string hanging over the pulley. Release the falling mass. Determine and record the acceleration of the cart as before.
17. Increase the mass on the cart by ½ kg and repeat step 16.
18. Add one more ½ kg mass and repeat step 16 until the cart has a total mass of approximately 2.0 kg.

m_1 = _____ m_2 = _____ m_3 = _____ m_4 = _____

a_1 = _____ a_2 = _____ a_3 = _____ a_4 = _____

19. At this point you should have at least four different data points. Plot a graph comparing the Acceleration of the cart as a function of the Mass of the cart. [Don't forget to include ALL of the mass that is accelerating including the falling weight and paper clips!]



20. From the shape of the resulting graph determine the relationship between the Acceleration of an object under the influence of a constant force and the Mass of the object.

21. Record the total mass accelerating during each procedure. Note that the force applied to the cart remained constant throughout this procedure thus keeping it a controlled experiment.

    total mass = _____

Part C - Final Analysis

22. Combine the results of the two graphs above into a single relationship. Determine the value of any appropriate constants and develop an equation relating the acceleration of an object, its mass and the magnitude of the applied force.

23. Test your equation at a random data point and make an appropriate bar graph.