Name(s): ______________________________ Date: __________ Period: ____

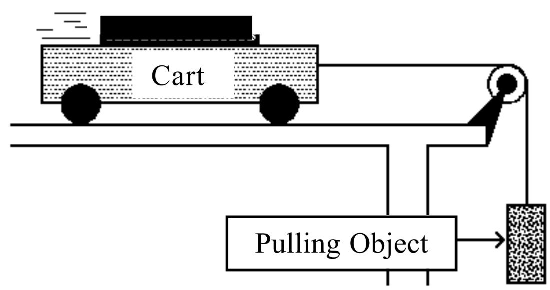
ACTIVITY #3 IMPULSE - MOMENTUM USING RECORDING TIMER

Contributed by Jane Bray Nelson

Purpose: To determine the relationship between total the mass being accelerated, net force, change in velocity, and time interval for a cart using a recording timer.

Materials:

- ❑ Dynamics Cart (e.g., PASCO)
- ❑ Set of Masses (5g – 1,000g)
- ❑ Recording Timer (with carbon and paper tape)
- ❑ Table Pulley
- ❑ Pulley String
- ❑ Meter Stick or cm ruler



Procedures:

1. Set up a dynamics cart having a mass of about 500g, assorted masses, a recording timer, and a hanging object that can change in mass.
2. Add masses to the cart until the total mass is about 1.0 kg.
3. Determine the total mass of the pulling object needed to pull a recording tape through a vibrating timer, when the dynamics cart moving at a constant velocity. For PASCO[1] carts this is about 20 grams. Check that the velocity is constant by observing the tape. The spaces between dots should be even. You instructor may be able to give you a mass to try; otherwise it may take a few trials to determine the appropriate mass needed to balance the frictional force.
4. Set up the cart's path so that the pulling object can fall at least 60 cm.
5. Add about 200g (1.96 N) to the hanging mass that kept the velocity constant. The gravitational force on this **additional** mass will be the constant accelerating force for the system.
6. The **total mass** being accelerated will be the total of the cart, masses added to the cart, and the total pulling mass. Record this value.
7. To make a smooth run, the tape must be straight and taut so that. To ensure this, attach a 1.0 meter piece of recording tape to the cart, hold the tape on the side of the timer opposite the cart with one hand and turn on the timer. Have a partner carefully release the hanging weight, and after the recording timers is on, release the tape so that it can glide through the timer without getting "hung-up".
8. Some recording timers have 40 spaces produced a second, and others have 60 spaces produced a second. If yours is a 40-vibrations/second timer, make sure you have at least 60 spaces. If yours is a 60-vibrations/second timer, make sure you have 90 spaces on your pulled tape.
9. Count from the very first spaces you can see. Do not skip any. Count 0.5 seconds worth of spaces. That will be 20 or 30 spaces depending upon your timer. If you used a 40-vibration/second timer, measure the distance as precisely as you can from the beginning two spaces before the 0.5-second mark to the end of two spaces after the 0.5-second mark, (i.e., A total of four spaces). If you used a 60 vibration/second timer, you would measure the distance from the beginning of the space three in front of the 0.5-second mark to the end of the space three after the 0.5-second mark, (i.e., A total of six spaces).

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[1] Other carts may be about 50 grams.

10. The distance you have just measured represents the distance traveled by the cart during 0.1 second just as the force has been applied for 0.5 seconds.

11. Determine the average velocity of the cart at 0.5 seconds.

12. Since the original velocity was zero, the velocity at 0.5 s will be the change in velocity during that time interval. Add a direction, and record the time interval with its corresponding change in velocity.

13. Count further down the tape to a point where 0.7s of time elapsed.

14. Determine the velocity and the change in velocity and record it with its coordinating time interval.

15. Repeat for 0.9 s, 1.1 s, 1.3 s, and 1.5 s. Continue further if you have data on a tape.

16. Graph your data and determine the relationship between change in velocity and the time interval during which the force has been applied. The time interval is the independent variable. If needed, re-graph your data until you obtain a straight line.

17. <u>On the graph page,</u> record the equation of the line, the slope with its units, and the slope's meaning. Do not forget to determine what the slope represents. It must be something that is constant since the slope of a straight line is constant. It might even represent two variables that are held constant. Since the experiment is using only the variables for mass, force, change in velocity and time interval, the slope should involve one or more of these variables. Finish with an equation that represents the data and includes only physics symbols.

PART II

18. Keep the accelerating force and the time interval constant for the next steps by always counting enough spaces to represent 1.1 s. That would be 44 spaces if you use the 40-vibrations/second timer, and 66 spaces for the 60-vibrations/second timer.

19. Do not change accelerating force. Keep it at 1.96 N. This is the <u>constant accelerating force.</u>

20. Remove the large masses from the cart, and start with a total mass for the cart and load of about 700 grams, 0.70 kg. Remember to add the total mass of the hanging mass to the cart and its load to record the total mass being accelerated. If the friction changes noticeably, you may need to change the mass used to maintain a constant velocity. Refer to step #3.

21. Let the cart pull a tape while accelerating for at least 1.3 s. Use the same procedure for maintaining a taut tape as described in step #7.

22. Determine the velocity change from the start to a point at 1.1 s for the total mass being accelerated using a procedure similar to, but not exactly the same as, that described in step #9. The 1.1 s time interval is the <u>constant time interval</u> you will use throughout this part of the investigation.

23. Continue to add mass to the cart and repeat the previous two steps for each addition of mass until you have at least five data points and a total mass of around 1.7 kg.

24. Graph your data and determine the relationship between change in velocity and the total mass being accelerated. Mass is the independent variable.

25. If needed, re-graph your data until you obtain a straight line.

26. <u>On the straight-line graph page</u>, record the equation of the line, the slope with its units, and the slope's meaning. Do not forget to determine what the slope represents. It must be something that is constant since the slope of a straight line is constant. Remember the appropriate variables and that the slope may even represent two variables that are held constant. Finish with an equation that represents the data and includes only physics symbols.

27. Use your two graphs to determine the relationship that relates force, time interval, mass, and change in velocity.

Data:

- ❑ Attach data tables that are organized, neat, labeled, and clearly show the data you used to graph or calculate.
- ❑ Attach calculations charts that are organized, neat, labeled, and show the calculated values used to make graphs.
- ❑ Attach the graphs that are clearly labeled, have metric axis divisions, and are easy to read.

Calculations:

1. Show a sample calculation indicating how you determined the average velocity at 0.7s and/or change in velocity in step #14.

2. Show a sample calculation indicating how you determined the average velocity at 1.1s and/or change in velocity in step #22.

3. Show the values you used to determine the slope of the graph of Δv versus Δt by drawing dotted lines on your graph. Show the calculation of the slope.

4. Show the values you used to determine the slope of the straight-line graph of Δv versus mass, or some aspect of mass, by drawing dotted lines on your graph. Show the calculation of the slope.

Questions:

1. How are Δv and Δt related when the accelerating force and the total mass being accelerated are constant?

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2. How are Δv and the total mass being accelerated related when the accelerating force and Δt are constant?

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3. Write the equation that shows the relationship that relates force, time interval, mass, and change in velocity? Keep force and time interval on the same side of the equation.

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4. The product of force and time interval is called, “impulse.” How is an impulse related to mass and change in velocity?

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5. If a net force of 5.0 N is applied to a stationary mass of 6.0 kg for 3.0 s, what is the final velocity of the mass? Use your equation from question number 3 to calculate the answer. Show your work in the space provided.

6. How much braking force must be applied to stop a 300.0 kg cart in 2.50 s if the cart is initially moving at 15 m/s? Use your equation from question number 3 to calculate the answer. Show your work in the space provided.

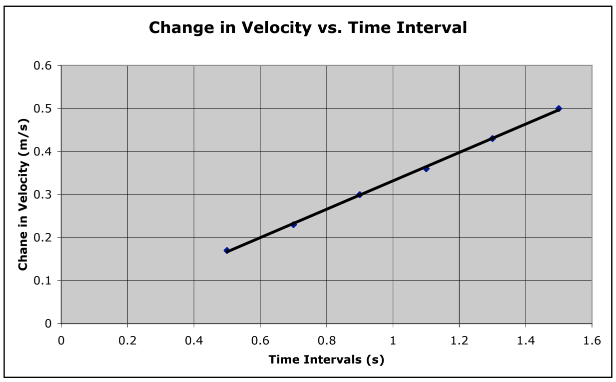
ACTIVITY #3 IMPULSE - MOMENTUM USING RECORDING TIMER (TEACHER NOTES)

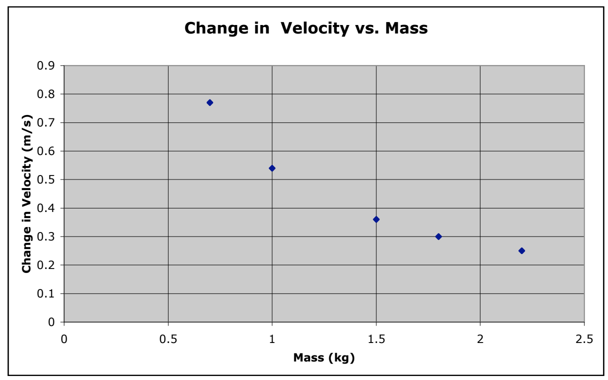
Teacher's Strategies with sample data charts, graphs and answers to questions.

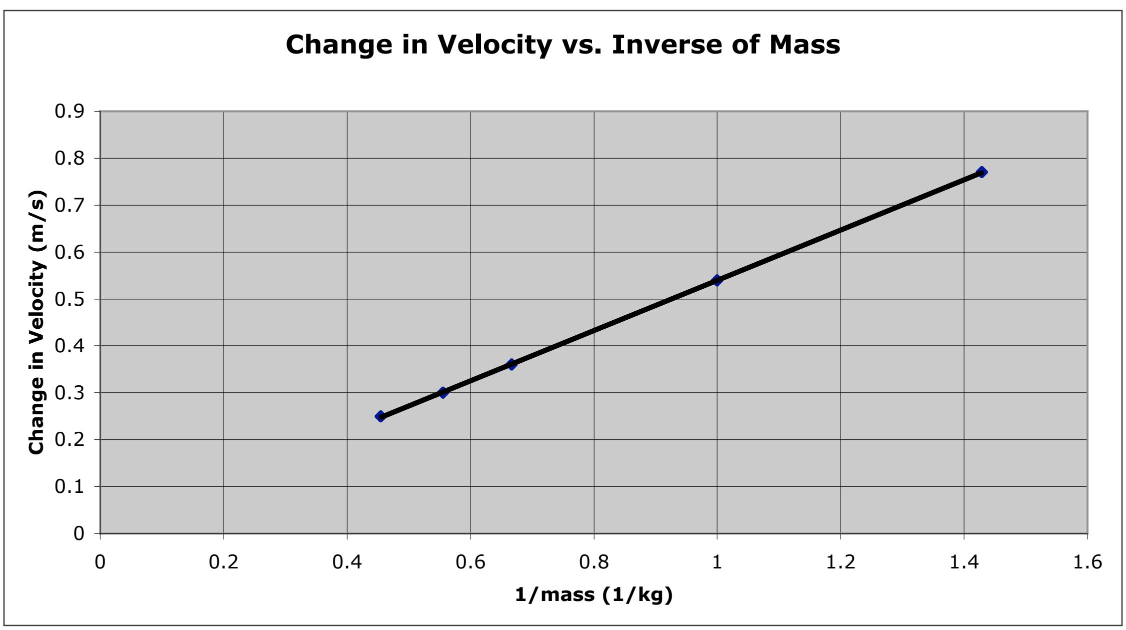
Data:

X = time interval (seconds)	Y = change velocity (meters/second)	X = mass (kilograms)	Y = change velocity (meters/second)
0.5	0.17	0.7	0.77
0.7	0.23	1.0	0.54
0.9	0.30	1.5	0.36
1.1	0.36	1.8	0.30
1.3	0.43	2.2	0.25
1.5	0.50		

Graphs:







Questions:

1. How are Δv and Δt related when the accelerating force and the mass being accelerated are constant?
They are directly proportional.

2. How are Δv and the mass being accelerated related when the accelerating force and Δt are constant?
They are inversely proportional.

3. Write the equation that shows the relationship that relates force, time interval, mass, and change in velocity? Keep force and time interval on the same side of the equation.
$F * \Delta t = m * \Delta v$

4. The product of force and time interval is called, "impulse." How is an impulse related to mass and change in velocity?
Impulse is directly proportional to the product of the mass and the change in velocity.

5. If a net force of 5.0 N is applied to a stationary mass of 6.0 kg for 3.0 s, what is the final velocity of the mass? Use your equation from question number 3 to calculate the answer. Show your work in the space provided.
$F * \Delta t = m * \Delta v$ *or* $5.0N * 3.0s = 6.0kg * (v_f - 0m/s)$ $\therefore$ $v_f = 2.5\ m/s$

6. How much braking force must be applied to stop a 300.0 kg cart in 2.50 s if the cart is initially moving at 15 m/s? Use your equation from question number 3 to calculate the answer. Show your work in the space provided.
$F * \Delta t = m * \Delta v$ $F * 2.5s = 300.0kg * (0m/s - 15m/s)$ $F = 1{,}80\ 0N$