Changes in Energy and Momentum

Name:

Group Members:

Date:

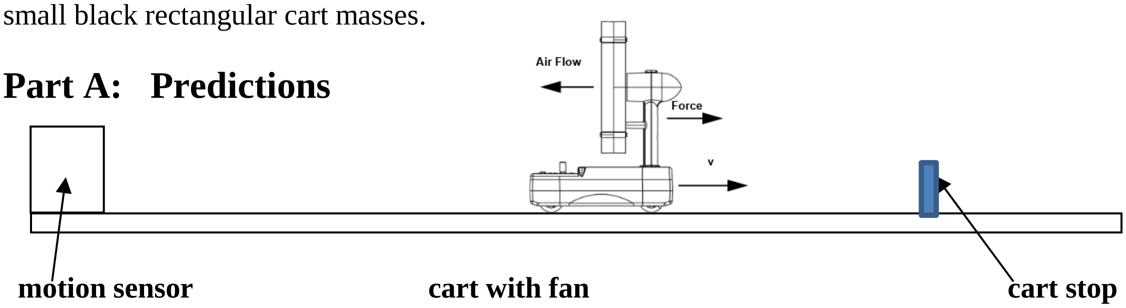
TA's Name:

Learning Objectives:

1. Understanding the relationship between force, distance and changes in kinetic energy.
2. Understanding the relationship between force, time and changes in momentum.
3. Understanding the relationship between force and work.
4. Understanding the relationship between force and impulse.

Apparatus: Aluminum track, track legs, cart, cart fan, cart stop, motion sensor, PASCO interface, and small black rectangular cart masses.

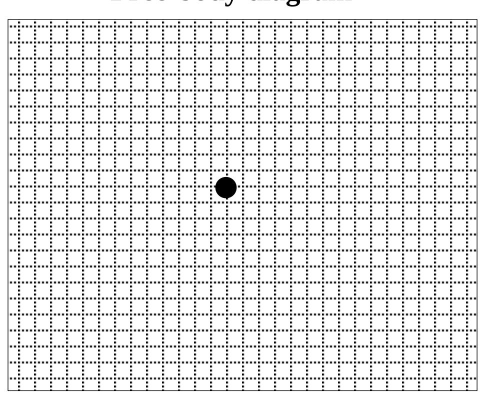
Part A: Predictions



Before setting up the equipment, consider the situation shown above (call this case #1). The cart (mass *m*) starts from rest a distance *d* from the cart stop. The fan is used since it provides a ***constant force*** as the cart moves to the right and collides with the cart stop. Just before the collision the cart is moving with velocity v_{xf}.

1. Identify the forces on the cart when the fan is running. Then draw the free body diagram for the cart. Indicate the direction of the net force and acceleration next to the free body diagram.

<u>Forces</u> | **Free-body diagram** | **net force vector**

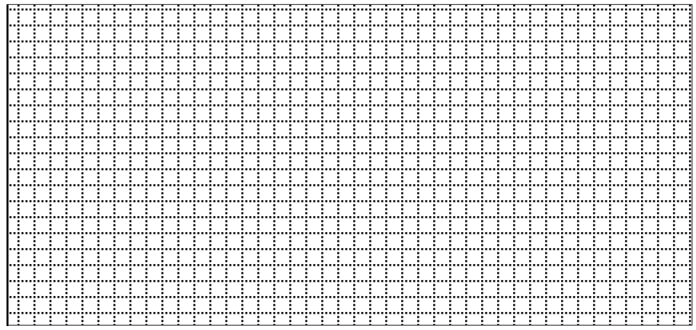


acceleration vector

2. Draw your prediction for the velocity vs. time graph for case #1.

Velocity

(m/s)



Time (s)

3. If mass is added to the cart and the experiment is repeated (call this case #2), will the time it takes to travel to the cart stop be shorter, longer, or the same as it will be for case #1 (no added mass)? Explain your reasoning.

4. For the case #2 (with added mass), will the velocity just before it hits the cart stop be smaller, larger, or the same as it will be for case #1 (no added mass)? Explain your reasoning.

5. On the graph in Question 2, also predict the velocity vs. time curve for case #2 (with added mass). Make sure the scales for time and velocity are the same as for your first prediction so that the graphs can be compared. Make sure you indicate which graph is case #1 or case #2.

6. How will the final momentum of the cart (just before it strikes the cart stop) compare in the two cases, that is, case #1 with no added mass and case #2 with added mass? Explain.

7. How will the final kinetic energy of the cart (just before it strikes the cart stop) compare in the two cases, that is, case #1 with no added mass and case #2 with added mass? Explain.

Part B: Constant Force Acting Over the Same Distance

Equipment Set-up: Now you are going test out your predictions. Set up the aluminum track on the table and make sure the track is level. Attach motion sensor and cart stop to the track. Set the cart stop so that the edge closest to the motion sensor is at the 100 cm mark. Attach the fan to the cart.

Determine the total mass of cart and cart fan. m = ____________________

Experiment: Launch the CAPSTONE software, open one window display, and set it up to capture velocity vs. time data. ***Change the number of decimal places to 3 as you have done in the previous experiments.*** Hold the cart with the edge closest to the cart stop at the 40 cm mark while you turn the fan on to its lower setting. Start recording data and then let go of the cart. Stop recording data just after the cart strikes the cart stop. We want the cart to travel 60 cm from the time it is released to when it strikes the cart stop. ***Label your graph and then copy and paste it into a Word document.***

8. Does your prediction for the velocity graph for case #1 in Question 2 agree with your data? Explain.

9. From your velocity vs. time graph, determine the velocity of the cart just before the collision with the cart stop. Also determine the time interval it took to travel 60 cm, that is, find the time when the cart is released and the time when it strikes the cart stop and determine the time difference, Δt. Make sure your signs and units are correct.

   v_{xf} = ______________________ Δt = ________________________________

10. Use your data to determine the change in kinetic energy and the magnitude of the change in momentum of the cart during its travel from rest to the point that it struck the cart stop.

    ΔK = ______________________ $|\Delta\vec{P}|$ = ________________________________

    Show your calculations for each below:

11. Make a table in Excel like the one below and enter your data for this first run. Then repeat the experiment with mass added to the cart in 0.25 kg increments using the small black rectangular cart masses. Use formula and the fill down operation to complete the kinetic energy and momentum columns. ***Do not delete any of the data from runs because you will use it again.***

Table 1: Same Distance					
***m* (kg)**	***d (m)***	**v_{xf} (m/s)**	**Δt (s)**	**ΔK (J)**	**ΔP (kg m/s)**

12. Is the change in kinetic energy nearly the same in each of your experimental runs?

13. If the force provided by the fan was the same for each run, how does the work done by that force compare from one run to another? Make sure that you use the definition of work in your explanation.

14. Is the change in momentum nearly the same for each of the runs?

15. If the force provided by the fan was the same for each run, how does the impulse from that force compare from one run to another? Make sure that you use the definition of impulse in your explanation.

16. In what situation will the impulse be the same for same constant force acting on carts with different total mass?

Part C: Constant Force acting for the Same Time

17. Choose a time interval that is smaller than the time of travel for your quickest run. Then look back at your data to determine the velocity of the cart for that time interval *after the release time* for each run. You can view the data from all the runs using the menus in Capstone. Make a table in Excel like the one below calculate values for changes in K and P using a formula and the fill down operation. ***Remember that the time intervals start when the cart is released from rest.***

Table 2: Same Time				
***m* (kg)**	**Δt (s)**	**v_x (m/s)**	**ΔK (J)**	**ΔP (kg m/s)**

18. If the force is the same in each run and we look at equal time intervals as we do in Table 2 above, how will the impulse from the fan compare for the different runs? Use the definition of impulse to explain your answer.

19. From your data in Table 2, how do the changes in momentum compare for equal force and equal time? Explain why you think you got that result.

20. From your data in Table 2, how do the changes in kinetic energy compare for equal force and equal time? Explain why you think you got that result.

Part D: Conclusions

21. What do you conclude about work and changes in kinetic energy from the data you got in Tables 1 and 2?

22. What do you conclude about impulse and changes in momentum from the data you got in Tables 1 and 2?

Instructions on how to submit the graphs:

1. Open a Word document and type the names of all present group members.
2. Paste labeled graph of velocity vs. time for first experiment into your Word document.
3. Paste Tables I and II from Excel into your Word document.
4. Pay attention to formatting of the Word document so you don't waste paper.
5. Print your word document and attach to the lab write-up.