Name _____ Period _____ Date Due _____

Physics I - Mini Lab: Tailgated by a Dart

Purpose: To estimate the speed of an object by applying conservation of momentum to an inelastic collision.

Equipment:

Velcro hook and loop fasteners
Toy dart gun with rubber-tipped darts
Meter stick
Safety goggles
Small toy car with a flat back (bus or van)
Stopwatch
Balance

Pre-Lab Discussion Questions:

What is an elastic collision? Give an example.

What is a perfectly inelastic collision? Give an example.

What does "Conservation of Momentum" mean for a collision?

Procedure:

Step 1: Fasten one type of Velcro tape to the back end of a toy car. Fasten the opposite type of Velcro to the rubber tip of a dart. When the car is hit, it must be free to coast in a straight line on a level table or the floor until it comes to a stop. Practice shooting the dart onto the back end of the car. The dart should stick to the car and cause it to coast.

> What is the relationship between the momentum of the dart before the impact and the combined momenta of the dart and the car immediately after the impact? Use words and an equation in your answer.

Step 2: Measure the distance and time that the car coasts after it is hit by the dart, until it comes to a stop. Record your data in the data table. Repeat for two more trials.

Step 3: Calculate the average speed of the car after impact for Trial 1 here. Show your equation and your work. Enter your average speed for trial 1 in the data table on the back of this page.

> Calculate the average speed for trials 2 and 3 and record these speeds in the data table.

Name _____ Period _____ Date Due _____

Trial	Coasting Distance (cm)	Coasting Time (s)	Average speed of car after impact (cm/s) (Step #1)	Speed of car at impact (cm/s) (Step #4)	Initial speed of dart (cm/s) (Step #7)
1					
2					
3					

1. Was the speed of the car constant as it coasted? Explain.

2. What force slowed the car down?

3. If this retarding ("slowing down") force is assumed to be nearly constant, how does the speed of the car immediately after impact compare with the average speed? (Hint! How do you find the AVERAGE of two numbers?)

4. Enter values for the speed of the car at impact into the data table.

5. You have several values for speed (or velocity). What other piece(s) of information do you need to calculate momenta for the car and the dart? Get those pieces of information and record them here. (Hint: you need a scale!)

6. Write an equation that shows the momenta before and after the collision. This is the conservation equation for the experiment.

7. Using the conservation equation, calculate the initial speed of the dart for each trial. Show one sample calculation here. Enter your answers in the last column of the data table.

8. Find an average value for the initial speed of the dart. Show your calculations here.

9. Convert the average initial speed of the dart to miles/hour.
   1 mile = 5280 feet 1 foot = 0.3 meters 1 hour = 3600 seconds

10. Is the momentum of the tailgated car constant the whole time it is moving? Explain.

Name _____ Period _____ Date Due _____

Physics I - Mini Lab: Tailgated by a Dart TEACHER NOTES

Purpose: To estimate the speed of an object by applying conservation of momentum to an inelastic collision.

Equipment:

Velcro hook and loop fasteners
Toy dart gun with rubber-tipped darts
Meter stick
Safety goggles
Small toy car with a flat back (bus or van)
Stopwatch
Balance

Pre-Lab Discussion Questions:

What is an elastic collision? Give an example.

A collision where objects bounce apart and do not lose any kinetic energy (Ex: Newton's Cradle and atoms colliding are near-perfect examples. Truly elastic collisions only exist in theory)

What is a perfectly inelastic collision? Give an example.

A collision where object stick together. (Ex: Train cars coupling, blob of clay thrown at the wall)

What does "Conservation of Momentum" mean for a collision?

The momentum you start with is the momentum you end up with. Momentum may be transferred between objects, but the total momentum remains constant.

$p_{net\ i} = p_{net\ f}$

Procedure:

Step 1: Fasten one type of Velcro tape to the back end of a toy car. Fasten the opposite type of Velcro to the rubber tip of a dart. When the car is hit, it must be free to coast in a straight line on a level table or the floor until it comes to a stop. Practice shooting the dart onto the back end of the car. The dart should stick to the car and cause it to coast.

What is the relationship between the momentum of the dart before the impact and the combined momenta of the dart and the car immediately after the impact? Use words and an equation in your answer.

The momentum of the dart before the collision is equal to the combined momenta of the car and the dart after the collision.

$p_{dart\ i} = (p_{dart+car})_f$

Step 2: Measure the distance and time that the car coasts after it is hit by the dart, until it comes to a stop. Record your data in the data table. Repeat for two more trials.

Note: It is not necessary to convert to meters and kilograms. Explain that a g-cm/s is a legitimate unit for momentum, and as long as units are consistent, not converting anything may make your life easier.

Step 3: Calculate the average speed of the car after impact for Trial 1 here. Show your equation and your work. Enter your average speed for trial 1 in the data table on the back of this page.

Average speed = distance/time

Calculate the average speed for trials 2 and 3 and record these speeds in the data table. (4th Column)

Name _____ Period _____ Date Due _____

Trial	Coasting Distance (cm)	Coasting Time (s)	Average speed of car after impact (cm/s) (Step #1)	Speed of car at impact (cm/s) (Step #4)	Initial speed of dart (cm/s) (Step #7)
1					
2					
3					

1. Was the speed of the car constant as it coasted? Explain.

No. It accelerated very quickly, then slowed down and eventually stopped

2. What force slowed the car down? Friction

3. If this retarding ("slowing down") force is assumed to be nearly constant, how does the speed of the car immediately after impact compare with the average speed? (Hint! How do you find the AVERAGE of two numbers?)

$V_{max} = V_{initial} = 2(v_{average})$ Use the kinematic equation delta x = $(1/2)(v_f + v_i)(t)$ with a v_f=0

4. Enter values for the speed of the car at impact into the data table. (5^{th} column)

5. You have several values for speed (or velocity). What other piece(s) of information do you need to calculate momenta for the car and the dart? Get those pieces of information and record them here. (Hint: you need a scale!)

Mass of the car and mass of the dart

6. Write an equation that shows the momenta before and after the collision. This is the conservation equation for the experiment.

$p_{dart} = p_{dart+car}$ $(m_{dart})(v_{dart\ as\ it\ leaves\ the\ gun}) = (m_{dart+car})(v_{i\ dart+car})$

7. Using the conservation equation, calculate the initial speed of the dart for each trial. Show one sample calculation here. Enter your answers in the last column of the data table.

(Students are solving for $(v_{dart\ as\ it\ leaves\ the\ gun})$)

8. Find an average value for the initial speed of the dart. Show your calculations here.

9. Convert the average initial speed of the dart to miles/hour.

1 mile = 5280 feet 1 foot = 0.3 meters 1 hour = 3600 seconds

10. Is the momentum of the tailgated car constant the whole time it is moving? Explain.

No. Since the velocity is changing, the momentum also has to change since p=mv