**M1.Being Impulsive About Momentum Change Lab**

**Question:**

How does the impulse experienced by an object in a collision compare to the resulting momentum change of that object?

**Purpose:** To compare the impulse experienced by an object to the resulting change in momentum of the object.

A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion/Discussion of Results. The Data section should include a sketch of any relevant graphs obtained from the LabPro interface software; comments, descriptions and relevant quantitative information should be provided for each graph. The Conclusion should respond to the Purpose of the Lab (as always). The Discussion of Results should include a discussion of the manner in which the evidence supports the conclusion; specific data results should be referenced. Wherever relevant, percent difference calculations should be considered.

**M2. Balloon Toss Lab**

**Question:**
What variables affect the impact force in a collision and in what manner do they affect the force?

**Purpose:** To investigate the effect of three variables (mass, collision time, velocity change) upon the impact force in a collision.

A complete lab write-up includes a Title, a Purpose, a Data section, a Conclusion and a Post-Lab Questions section. The Data section should include some observations of the effect of varying mass, collision time and velocity change upon the impact force on a balloon. The Conclusion should respond to the question raised in the Purpose. The provided Post-Lab Questions should be completed and taped into your lab notebook.

**For Balloon Toss Lab**

(Tape the following into your Post-Lab Question section and complete.)

**Post-Lab Questions:**

Assume that we were able to collect the following table of data for a balloon toss lab. The table

represents numerical values for force, time, mass, velocity change, impulse, and momentum change for

various catches of a balloon. Use the table to answer the following questions.

Mass

(kg)

ΔVelocity

(m/s)

ΔMomentum

(kg m/s)

Impulse

(N s)

Force

(N)

Time

(s)

a.

0.50 -4.0 0.010

b.

0.50 -2.0 0.100

c.

0.10 -0.40 0.010

d.

0.20 -8.0 -80

e.

0.50 -400 1.0

f.

0.50 -8.0 0.010

1. Use the impulse-momentum change theorem (and the definitions of impulse and momentum

change) to fill in the above table.

2. The force required to stop a balloon is dependent upon the mass, velocity change, and collision

time. Use the data in the table above to express your understanding of these relationships.

a. What effect does a ten-fold increase in time have upon the subsequent force which is required

to change an object's momentum (assuming other quantities are constant)?

Identify at least one set of two rows which illustrate this cause-effect relationship.

b. What effect does a five-fold increase in mass have upon the subsequent force which is

required to change an object's momentum (assuming other quantities are constant)?

Identify at least one set of two rows which illustrate this cause-effect relationship.

c. What effect does a two-fold increase in velocity change have upon the subsequent force

which is required to change an object's momentum (assuming other quantities are constant)?

Identify at least one set of two rows which illustrate this cause-effect

**M3. Rebounding versus Sticking Lab**

**Question:** How does the impulse and resulting momentum change of an object compare for two different collisions – an elastic collision involving rebounding and an inelastic collision in which the object sticks to the collision surface?

**Purpose:** To conduct an impulse-momentum change analysis for two types of collisions - one elastic and the other inelastic - and to compare the momentum change and impulse for the two collision types.

A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion/Discussion of Results. The Data section should include a sketch of any relevant graphs obtained from the LabPro interface software; comments, descriptions and relevant quantitative information should be provided for each graph. The Conclusion should respond to the Purpose of the Lab (as always). The Discussion of Results should include a discussion of the manner in which the evidence supports the conclusion; specific data results should be referenced.

**M4. Before and After Lab**

**Question:** What predictive principles might be capable of describing the post-collision results for simple inelastic and elastic collisions?
**Purpose:** To qualitatively and systematically analyze a several simple collisions in an effort to develop some predictive principles associated with a collision analysis.
A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion/Discussion of Results. The Data section should include a description (diagrams preferred) of the before- and after-collision momentum of two colliding carts. Several trials of observations for a systematic method of variable manipulation should be documented; at least four inelastic and at least two elastic collisions should be tested. The Conclusion/Discussion should reference the data trials in an effort to state some general principles regarding changes in momentum of individual objects and total system momentum. Words and/or sample numbers should be used in the discussion.

**M5. Action-Reaction Lab**

**Question:** How do the post-*explosion* momenta of two carts which are propelled away from each other by an identical force compare to each other?

**Purpose:** To compare the post-*explosion* momenta of two carts which are propelled away from each other by an identical force.
A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion/Discussion of Results. The Data section should include a sample sketch of the velocity-time graphs and a table of data, organized in rows and columns in order to describe the results for several trials with carts of varying mass combinations. Both measured and calculated data should be included. At least one example calculation should be provided for each type of calculation. The Conclusion/Discussion should involve a comparison of the post-*explosion*momenta of the two individual carts. An error analysis should be conducted and percent differences should be calculated for the various data trials.

**6. Sand Balloon Lab**

**Question:**
How does the total momentum (vector sum) of two objects before a collision compare to the total momentum after the collision?
P**urpose:** To compare the total momentum of two objects before a collision to the total momentum of the two objects after the collision.
A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion/Discussion of Results. The Data section should include an organized table of pre- and post-collision velocity and mass values. Work should be shown for each type of calculation performed. The Conclusion/Discussion should involve a comparison of the pre- and the post-collision momentum of the *system*of two objects. An error analysis should be conducted and percent differences should be calculated for the various data trials.

**M7. Inelastic Collision Analysis Lab**

**Question:** What is the evidence that momentum is conserved in an inelastic collision between two carts? In what manner does the evidence support the law of momentum conservation?
**Purpose:** To gather convincing evidence that total system momentum is conserved in an inelastic collision between two carts AND to describe how the evidence supports the law of momentum conservation.
A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion/Discussion of Results. The Data section should include the provided table. One example calculation should be shown for each type of calculation. The Conclusion/Discussion should provide a thorough analysis of the results, identifying successful and unsuccessful trials; specific evidence from each trial which indicate success (or lack thereof) should be elaborated upon. Percent error or percent difference calculations should be performed and a complete error analysis included within the discussion.

**M8. Elastic Collision Analysis Lab**

**Question:** What is the evidence that momentum is conserved in an elastic collision between two carts? In what manner does the evidence support the law of momentum conservation?
 **Purpose:** To gather convincing evidence that total system momentum is conserved in an explosion-like impulse between two stationary carts AND to describe how the evidence supports the law of momentum conservation.

A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion/Discussion of Results. The Data section should include two tables - one for collected data and one for calculated data; they should be organized in a row column format. Several data trials should be performed in an effort to accomplish the stated purpose. One example calculation should be shown for each type of calculation. The Conclusion/Discussion should provide a thorough analysis of the results, identifying successful and unsuccessful trials; specific evidence from each trial which indicate success (or lack thereof) should be elaborated upon. Percent error or percent difference calculations should be performed and a complete error analysis included within the discussion.

**M9. What's Cooking? Lab**

Q**uestion:** What is the speed of a ball (in miles/hour) fired from a cannon?
**Purpose:** To determine the speed (in miles/hour) of a tennis ball which is fired from a cannon.
A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion. The Data section should include a diagram of the physical setup, with the specific variables being measured represented in the diagram. Actual data values should be organized in a table with a row-column format. One example calculation should be shown for each type of calculation. The Conclusion should answer the question posed in the Purpose.

**M10. Two-Dimensional Collision Lab**

**Question:** What is the evidence that momentum is conserved in a two-dimensional collision? In what manner does the evidence support the law of momentum conservation?
**Purpose:** To conduct a vector analysis of a two dimensional collision in an effort to gather convincing evidence that the total system momentum is conserved AND to describe how the evidence supports the law of momentum conservation.
A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion/Discussion of Results. The Data section should include a sketch of the experimental results as gathered by the carbon paper impressions (collision location, pre-collision landing location and striker and target sphere post-collision landing location). Actual measurements taken from the large paper should be recorded on your sketch and labeled using the usual conventions (p1, p1', p2', Theta1, Theta2, etc.). A well-organized mathematical analysis should be conducted to show that momentum is conserved (or not conserved) in both the x- and the y-dimensions. Work should be labeled and follow-able. The Conclusion should explain how it is known that total system momentum is conserved; it should also include an error analysis.