PHYS 2211L - Principles of Physics I Laboratory

Laboratory Advanced Sheets
Collisions

Objective. The objective of this laboratory is to study the conservation of linear momentum and energy transformations in elastic and inelastic collisions.

Theory.

The law of conservation of linear momentum states that the total momentum of a system is conserved if the net external force acting on the system is zero:

$$\vec{p}_i = \vec{p}_f$$

where $\vec{p}_i$ and $\vec{p}_f$ are the total initial and final linear momenta of the system, correspondingly.

This principle allows us to study the situations in which forces acting between the interacting objects are too complicated to be dealt with directly and provides us with the outcome of such interactions without the explicit knowledge of these forces. One of the excellent examples of this approach is the study of collisions. When collisions occur, the forces between colliding bodies are internal to the system and do not affect the overall linear momentum of the system. Hence, the total linear momenta of the system of colliding bodies before and after the collision are the same. For the system consisting of just two bodies

$$\vec{p}_i = \vec{p}_{1i} + \vec{p}_{2i}$$

and

$$\vec{p}_f = \vec{p}_{1f} + \vec{p}_{2f}$$

where $\vec{p}_{1i} = m_1\vec{V}_{1i}$ and $\vec{p}_{2i} = m_2\vec{V}_{2i}$ are the initial momenta of the two colliding bodies, and $\vec{p}_{1f} = m_1\vec{V}_{1f}$ and $\vec{p}_{2f} = m_2\vec{V}_{2f}$ are the final momenta of the two colliding bodies.

Substituting the individual momenta into the total linear momentum of the system before and after collision we obtain:

$$m_1\vec{V}_{1i} + m_2\vec{V}_{2i} = m_1\vec{V}_{1f} + m_2\vec{V}_{2f}$$

Elastic collisions. Elastic collisions are such, in which not only the total linear momentum but also the total kinetic energy of the system is conserved. This allows us the use of another equation:

$$\frac{1}{2}m_1\vec{V}_{1i}^{\,2} + \frac{1}{2}m_2\vec{V}_{2i}^{\,2} = \frac{1}{2}m_1\vec{V}_{1f}^{\,2} + \frac{1}{2}m_2\vec{V}_{2f}^{\,2}$$

Perfectly inelastic collisions. A perfectly inelastic collision is one in which the objects stick together and move as a single body after the collision. In this type of collision momentum is conserved, but kinetic energy is not conserved.

Apparatus and experimental procedures.

- Equipment.
    1. Air track.
    2. Collision carts (2).
    3. Meter stick/ruler.
    4. Camera.
    5. Computer with the Tracker software.

- Experimental setup. The experimental setup is shown in Figure 1 (provided by the student).
- Capabilities. To be provided by the student.

. **Requirements**.

- In the laboratory **(Note: These requirements are waived for the on-line laboratory).**
    1. Take a video of an elastic collision between two carts of equal mass with one of the carts being stationary before the collision.
    2. Take a video of a perfectly inelastic collision between two carts of equal mass with one of the carts being stationary before the collision.
- After the laboratory. Complete the following portions of the laboratory report.

Para. 3. Apparatus and experimental procedures.

1. Provide a figure showing the experimental setup.
2. Provide a description of the capabilities of the equipment used in the experiment.

Para. 4. Data.

1. Provide a video of your experiment.
2. Provide a copy of your spreadsheet with calculations. Include the following:
    A. The Tracker data for the two carts colliding elastically.
    B. Graphs of the *x*- coordinates of both carts as a function of time with the linear regression equation included on the graph.
    C. Calculation of the linear momenta of both carts before and after collision.
    D. Calculation of the total kinetic energy of the two carts system before and after collision.
    E. Calculation of the Percent Discrepancy for the total momentum and total kinetic energy of the system before and after elastic collision.
    F. The Tracker data for the two carts colliding perfectly inelastically.
    G. Graphs of the *x*- coordinates of both carts as a function of time with the linear regression equation included on the graph.
    H. Calculation of the linear momenta of both carts before and after collision.
    I. Calculation of the total kinetic energy of the two carts system before and after collision.
    J. Calculation of the Percent Discrepancy for the total momentum and total kinetic energy of the system before and after perfectly inelastic collision.

Para. 5. Results and Conclusions.

1. Provide a statement of the validity of conservation of linear momentum principle in elastic and perfectly inelastic collision.
2. Provide a statement of the validity of conservation of kinetic energy principle in elastic collision.
3. Provide a statement on the accuracy and precision of your experiment.
4. Describe sources of systematic error in the experiment.
5. Describe sources of random error in the experiment.