Partners name report samples

Law

Introduction

In any collision, where the system is not subject to external forces, linear momentum will be conserved. In case the collision is elastic, kinetic energy will also be conserved. In this experiment, two steel balls were made to collide momentarily, and the projection of their 2D collision dynamics was recorded for analysis. The vectors measured using the carbon paper, are related to the momenta of the balls before and after collision. These were used in the respective equations to verify linear momentum conservation and elastic collision, i. e. kinetic energy conservation.

Data Analysis

Sample Calculations

xi = 67 cm; xt’ = 61. 5 cm; xi’ = 13. 6 cm

The measured resultant R which is the vector sum of xt’ and xi’ is 65. 2 cm.

a = 0. 06250; b = 0. 12500; d = 0. 08125 are the respective errors in the measured quantities.

Then through error propagation, the error in R is c = (a2 + b2)0. 5 = (0. 062502 + 0. 125002)0. 5 = 0. 14089.

| xi – R | = 3cm is the magnitude of the vector difference of the experimental and theoretical quantities. The error propagated to this vector is e = (c2 + d2)0. 5 = (0. 140892 + 0. 081252)0. 5 = 0. 16263. The percentage difference or error = 11. 11%

Discussion

First, to get a clearer picture of what the results calculated mean, it may be interesting to substitute the measured values in the equation for conservation of momentum, to see if it is satisfied. In this case, momentum is conserved if the vector sum of xt' and xi' is = xi. The magnitude of LHS is (xt'2 + xi'2 + 2xt'xi'cosΘ)0. 5 (by parallelogram law).

The measured angle is approximately 80 degrees. Therefore theoretically magnitude of xi = 65. 2 cm (verified by the measurement of R). This means the equation is not satisfied, therefore momentum is not conserved.

Similarly, the energy conservation equation is not satisfied too. Now the extent to which the two laws are satisfies needs to be analyzed:

The difference between theory and measurement in momentum is given by | xi – R | = 3 cm. which is > 0. 16263 = e, the error in the vector. This means that there is signification violation of momentum conservation. The angle Θ between xt' and xi' is measured as approximately 80 degrees < 90 = the angle required for perfect elastic collision. This implies that some amount of energy is transferred to the surroundings during the collision process.

Possible reasons for error

Momentum conservation is a universal law which has not been defied so far. Therefore it is reasonable to assume that there was some error in the experimental procedure which has resulted in the law being violated. Or perhaps, there are some compensating factors that have been overlooked.

The main cause of error in the experiment could have been that the first ball touched the track during collision. If this happened, then the premise for momentum conservation that there is no external force on the system is violated since contact (frictional) force develops between the incident ball and the track. This is a gross experimental error which is not very easy to overcome.

Secondly, a number of assumptions have been made to achieve at the final equation for checking momentum conservation:

- The masses of the two balls are assumed to be identical, but even if there were slight differences, it may result in a change in the equation. For example, consider that there was a 5% difference in the masses ($m1 < m2$). This would result in $m1u1 = m1v1 + 1. 05\ m1v2 \Rightarrow xi = xt' + 1. 05\ xi'$, where u refers to initial velocity and v refers to final velocity). In this case, the results are closer to the expected values.
- The time of flight t is considered the same for both the balls. However, this will be true only if they left the track at the same time. Further, the collision must have occurred exactly at the time the balls left the track. Though these criteria seemed to be met during the experiment, there is no way to know exactly.
- In the equation for kinetic energy conservation, the angle between the final velocities of the masses is assumed to be 90 degrees. Or, kinetic energy conservation will be satisfied only if the angle is 90 degrees. Even before performing the experiment, one can expect that this will be violated since there is a sound heard when steel balls collide.
- Finally, the error circles of the vectors denote that there is uncertainty in the measurement itself. In other words, even if the experiment was repeated in a seemingly exact same manner, the results could still vary. Therefore it is best to average many observations to reduce inaccuracies in the measurement. And according to statistics, taking more measurements is the best way to minimize error (intrinsic error and intrinsic systematic error). More measurements will also minimize overall random error.

Questions

- The principle of momentum conservation is valid only if there are no external forces acting on the system. In other words there should be no means of momentum transfer into or out of the system. Such a system is called an isolated system, and will obey momentum conservation.
- A perfectly elastic collision obeys kinetic energy conservation. In other words, there is no loss of energy in any form; the initial kinetic energy of the system equals the final kinetic energy of the system. In an inelastic collision however, there may be a loss in energy in the form of heat, sound, etc. Therefore the initial and final kinetic energies of the system are not equal. Mathematically, for an n particle system,
- In an elastic collision: 12m1v21o+12m2v22o++12mnv2no= 12m1v21f+12m2v22f++12mnv2nf. The velocities with subscript o refer to initial velocities, and those with subscript f refer to final velocities.
- In an inelastic collision: 12m1v21o+12m2v22o++12mnv2no> 12m1v21f+12m2v22f++12mnv2nf
- When steel balls collide, we can hear a sound. This is energy obviously taken from the steel balls; hence the final kinetic energy of the steel ball system can be expected to be less than that of the initial K. E. of the system. Therefore, the system is not perfectly elastic.
- The head (arrow) of a vector is surrounded by a circle to represent the uncertainty in the vector. The radius of the circle is usually the standard deviation of the data points.
- The errors in vectors are propagated using vector addition. In other words, the error in the resultant is calculated as the magnitude of the vector sum of the errors in the respective elements. For example, if vector a + vector b =

vector c, and p and q are the errors in a and b respectively, then the error in c is r = (p2 + q2)0. 5.

- Yes, even in this scenario, momentum will be conserved (provided there are no external forces). The only difference is that there is no medium for sound to be propagated, therefore the loss in energy maybe in a different form, since one can expect that it will still not be perfectly elastic.
- The glancing collision yielded in an angle of approximately 80 degrees between the balls after collision, which means it is about 88. 8% elastic.
- No macroscopic collisions are perfectly elastic, since there is always some loss of energy in the form of heat. Microscopic collisions however, may tend towards perfect elastic collisions.

Conclusion

The experiment carried out violated momentum conservation and kinetic energy conservation. The former implies there were possible errors in the experimental procedure or validity of assumptions, as analyzed in the above section. The latter implies the collision was not perfectly elastic.