Theory report example

Health & Medicine, Body

A collision refers to a physical situation where kinetic energy of momentum of an object is transferred from an object to the other one. In physics, collisions are classified as either elastic or inelastic. Conservation laws; energy conservation and momentum conservation are important tools in the analysis of collisions. Various literatures and experimental studies have confirmed that it is difficult to assess the interaction of bodies during collision. Therefore, main objective of this work is to demonstrate to relate the various parameters such as velocities and masses of the system using the principle of conservation of energy and momentum.

The momentum of an object of mass, m and velocity, v is represented mathematically as shown below:

momentum, p= m*v.. Equation 1

The momentum of a system of more than one body is given by the vector sum of the momentum of the respective bodies as shown below:

p1+p2= m1*v1+m2*v2Equation 2

According to Newton's second law of motion, the rate of change of momentum with time is equal to the sum of all the external forces acting on the system. Thus, we can observe that the resultant/net force acting on the system is zero when the system is closed. For a closed system, the total momentum of the system is conserved.

Elastic collisions

In an elastic collision, bodies come together and separate with deformation no loss in total kinetic energy. Assuming two bodies of m1 and m2, with initial velocities of v1i and v2i respectively collide without the influence of an external force, the resulting final velocities of the two bodies are v1f and v2f (where i and f stand for initial and final parameters). For a closed system (no external forces), the total momentum is conserved. For a collision, this means that the momentum before the collision equals to the momentum after the collision. As shown in Equation 3.

pi= pf.. Equation 3

The total momentum of the system is the sum of the momentums of object 1 and object 2. Thus,

Initial momentum and final momentum are expressed as:

Initial momentum

pi= m1v1i+m2*v2iEquation 4,

and final momentum

pf= m1v1f+m2*v2fEquation 5.

The total energy in a closed system is also conserved. However, the energy of the system can be changed from one form to the other. Kinetic energy is always present in two colliding bodies.

Initial kinetic energy of the system is

k1= 12m1v1i2+ 12m2v2i2. Equation 6, and

the final kinetic energy is

kf= 12m1v1f2+ 12m2v2f2. Equation 6

Thus, for elastic collisions

ki= kf. Equation 7

% descrepancy= Xf-XiXi*100 %. Equation 8

Inelastic collisions

In inelastic collisions, the bodies that collide do not bounce back from each other and thus some kinetic energy is lost (converted to other forms of energy such as sound). The total momentum of the system is conserved. Thus, using the same notation as before:

pi= pf.. Equation 9

Initial momentum

pi= m1v1i+m2v2iEquation 10,

After the collision, the two bodies sticks together and moves with the same final velocity. Thus, final momentum is expressed as.

pf=(m1+m2)*vfEquation 11.

The initial kinetic energy of the system is

k1= 12m1v1i2+ 12m2v2i2. Equation 12

Final kinetic energy is

kf= 12(m1+ m2)vf2. Equation 13

For inelastic collision

ki> kf. Equation 14

Data analysis and Graphs

The experimental data obtained for both elastic and inelastic was recorded in Table 1 as shown:

Length of cart 1: 0. 129 m

Length of cart 2: 0. 128 m

Sample calculation

The various mathematical formulations developed in theory have been used to determine the various parameters as shown below:

case1: Trial 1

Initial velocity of cart 1

v1i= length of cart 1t1i= 0. 1290. 0773= 1. 67 m/s

Final velocity of cart 1

v1f= length of cart 1t2i= 0. 1291. 5741= 0. 0819 m/s

Initial velocity of cart 2

v2i= length of cart 2t2i= 0. 1280= 0 m/s

Final velocity of cart 1

v2f= length of cart 2t2f= 0. 1280. 1003= 1. 276 m/s

Initial momentum

pi= m1v1i+m2*v2i

pi= 0. 19915*1. 67 +0. 20068 *0= 0. 333 kgm/s

Final momentum

pf= m1v1f+m2*v2f

pf= 0. 19915*0. 0819 +0. 20068 *1. 276= 0. 227 kgm/s

% Discrepancy in momentum

% Descrepancy in momentum= pf-pipi*100 %

% Descrepancy in momentum= 0. 227 -0. 3330. 333 *100 %= 31. 8 %

Initial kinetic energy

k1= 12m1v1i2+ 12m2v2i2

k1= 12*0. 19915*1. 672+ 120. 2068*0= 0. 278 joules

Final kinetic energy

kf= 12m1v1f2+ 12m2v2f2

kf= 12*0. 19915*0. 08192+ 12*0. 20068*1. 2762= 0. 1702 joules

% Discrepancy in kinetic energy

% discrepancy in kinetic energy= kf-kiki*100 %

% discrepancy in kinetic energy = 0. 1702-0. 278 0. 278*100 = 38. 8 %

Similar analysis was applied for the other cases involved using excels spreadsheets. The data obtained was tabulated as shown in Table 2.

Graphs

For the inelastic case, kinetic energy is not conserved. Thus, the final kinetic energy is not equal to the initial kinetic energy. The expression for percentage error is obtained as shown below using equations 12 and 13 by defining x as x= m1m1+m2 in order to remove v3

% descrepancy= kf-kikf*100 %.

The best line of fit obtained in this graph cannot fit these data accurately as predicted by the R2 value. This is because for the inelastic collision, the kinetic energy before and after collision cannot be equal and thus linear relation between the initial and final values is not possible.

Questions

1. Comparison of initial momentum pi and final momentum pf for the elastic case shows some discrepancy. The discrepancy is small when one of the

carts was moving while the other one was at rest. It is also noted that the margin of error is bigger when cart 1 travelled in the opposite direction after collision.

2. When the initial velocity or cart 2 was zero, the initial momentum comprised of the momentum of cart 1. After collision, velocity of cart 2 increases from 0 to some value while that of cart 1 decreases. Thus, after collision the momentum of cart 1 becomes less because of lower velocity and mass compared to cart two. When some mass is added to cart 2, the contribution of cart 2 to the total momentum becomes higher.

3. The analysis of kinetic energy before and after collision and the percentage deviation between the two values show that the kinetic energy of the system is not conserved within the expected limits of accuracy. The deviation between the two values is very high (over 38 percent) for all the trials involved. The high deviation between the two values is attributed to experimental errors. The experimental errors involved for both elastic and inelastic case are described later in this work.

4. The kinetic energy is not conserved because after the collision, some energy is converted to other forms of energy such as sound and heat energy that we have not considered in our computation. On the other hand, it appears that the momentum is not conserved because the tracks were assumed to be straight and leveled. However, this was not the case.

5. The percentage discrepancy change in total momentum for inelastic case is low in trial 5 and 6 when one of the bodies is initially at rest. However, when the two bodies are moving before collision the discrepancy is high implying that momentum is not being conserved. This is caused by the

experimental errors that we have discussed later in this work.

6. Analysis of momentum before and after collision shows that the deviation is small for trials 5 and trial 6 where cart 2 starts at rest. However, the deviation becomes bigger when both carts were moving before the collision. It has also been noted that adding 100 gram weight increases the margin of error.

7. The kinetic energy for the inelastic case behaved as we expected. The large deviation between the initial and final kinetic energy is in agreement with the fact that kinetic energy is not conserved in an inelastic collision.

8. In real life situations, there is nothing like perfect elastic collisions. This is because some portion of the kinetic energy is always converted to other forms of the energy such as sound energy and some absorbed in mechanical deformation. As long as the two bodies come into contact during collision, we cannot have a perfect elastic collision.

9. After comparing the various collision parameters in Table 2 for both the elastic and inelastic collisions, the following were the deductions. First, we noted that in both collisions the margin of error was less when the second cart was initially at rest. Secondly, it was also evident that in both cases the error margin increased with addition of an extra 100g weight. Finally, it was observed that in both collisions, the velocity of cart 1 reversed after the collision when the two carts were moving before collision.

Conclusion

In this experiment, we have demonstrated the principle of conservation of energy and momentum using collision theory. To achieve this, the various collision parameters (velocity and mass) for the two carts before and after collision have been obtained in this experiment. In order, to have different scenarios to validate the conservation principles, initial parameters velocity and mass of one of the systems was varied in the experiment. This was done by having an initial velocity of zero for cart 2. The mass of the cart 2 was also increased by 100 g. The effect of these two adjustments has been demonstrated in this work. The experimental values obtained in this work for both elastic and inelastic collisions were not in agreement with the expectations because of the large margin of error observed in the results. The deviation of the experimental values from the expected values in this experiment is attributed to the following experimental errors.

1. In the experiment, we assumed that the track was level and straight. This was a very ideal assumption. Inspection of the track showed some misalignment. This largely affected the momentum which is a vector quantity.
2. In the experiment, the acceleration of the carts before collision was not taken into consideration. Only the final velocity was at the gate was considered. This affected the values obtained for the kinetic energy.
3. The analysis involved this work ignored the effect of vibration of the carts and friction on the track. These could have affected the kinetic energy and momentum after collision.

These errors resulted to the huge discrepancy observed in the experiment. Thus, the following should be ensured in the future in order to reduce the error margin. First, the track should be inspected before the experiment to check and correct the straightness. Secondly, the acceleration of the tract should be incorporated in the mathematic expression since it's not possible to have uniform velocity. Finally, the mass of the tracks should be reduced as much as possible since from the experiment the deviation is less when no extra mass is added to one of the carts.