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Research Question:What is the relationship between kinetic energy and momentum in an oblique collision between two objects, and to what extent are kinetic energy and momentum conserved in the collision:

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Aim:
To investigate the conservation of kinetic energy and the conservation of momentum in an oblique collisions between two objects.

Hypothesis:

By law of conservation the momentum and kinetic energy should be conserved in an oblique collision between two objects however in our case I hypothesize there will be a slight difference due to the fact that the system is not isolated and forces from outside will act upon it. With regards to kinetic energy, the total energy must also remain constant throughout the collision, however calculations won't take into account the kinetic energy converted to other forms of energy, like heat energy.

Despite the fact that the metal spheres used in this experiment are indeed very hard and very elastic, the collision will not be perfectly elastic but partially elastic, meaning a percentage of the kinetic energy and momentum will be converted during the experiment. Total momentum in any collision does not change, even if the individual momentums do.

Momentum is defined as: mass × velocity

The kinetic energy is defined as = ½ mass x velocity²

Momentum has the special property that it is always conserved, even in collisions. Kinetic energy, on the other hand, is not conserved in collisions if they are inelastic

Another important idea to grasp deals with projectile motion and the fact that two spheres dropped from the same height, or even projected horizontally will hit the floor at the exact same time. Moreover, a sphere that is projected horizontally at a bigger speed than another but from the same height will also reach the ground at the exact same time but will go a further horizontal distance.

In this experiment the main source of error will not come from the idea that the experiment is not perfectly elastic but due to errors in calculations and measurement

Variables:

In this experiment, the independent variable would definitely be the angle of the target ball to the incident ball. Throughout the 3 trials, we had to turn and rotate the screws so that the angle of the ball that was being hit by the bigger ball coming down was different. The angle to change it to was picked at random and done to show that no matter what the angle of the collision was, conservation of momentum and energy should still occur.

With regards to the dependant variable, the thing that changed throughout the experiment and that relied on the independent variable was the distances and the angles at which the metal spheres landed on the carbon paper. After the angle changed, the spheres landed in new positions and at greater/less distances.

Many things remained the constant throughout the experiment such as the main apparatus used to perform the experiment – the ramp and the clamps and pivot that was attached to the table. Also it was very important to keep the two metal spheres constant throughout the 3 trials, and more importantly not to get them mixed with one another since the incident ball had a greater mass than the target ball. Also kept constant was the initial height of the spheres and the place where we released the incident ball from. The acceleration at which the spheres accelerated towards the floor remained the same.

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Data Collection:
Mass of Incident Ball (heavier one that comes down): **6.8 grams**
Mass of Target Ball (lighter one that gets hit): **4.4 grams**
Distance from the ground to the ball platform: **82.4 centimeters**
Distance the Initial Ball covered by itself: **46.2 cm**

To find initial momentum,
We must have the velocity, and in order to have that we must have the time.
$S = ½ at^2$, isolate the t, we then have $t = \sqrt{2s / g}$
where g = gravity = 9.8 m/s^2

Therefore we have, $t = \sqrt{2(0.824) / 9.8}$ then t = 0.410 s (3.s.f)

Using the formula, s = vt, we can isolate velocity, v = s/t, v= (0.462m / 0.410s) = 1.12m/s

Now that we have our velocity and mass for our initial incident ball, we can find the momentum of the system by the formula p = mv

So we get p = 6.8g x (1.12m/s) = **7.61 gm/s** as the momentum for the system

To find initial kinetic energy,
We use the formula = ½ mass x velocit²y. In order to get the answer in easy to use joules, the mass must be in kilograms and the velocity in m/s The mass we know as .0068 grams and the velocity as 1.12, therefore we get:
$½ \times .0068 \times (1.12)^2$ = **.0043** joules

Results for Trail 2,
In this case, the incident ball hit the target ball head on, giving the following results
For incident ball (6.8 grams): s = 0.17 meters t = 0.41 seconds v = 0.424… m/s
P = 2.9 gm/s
Ek = 0.00061 joules
For target ball (4.4 grams): s = 0.41 meters t = 0.41 seconds v = 1 m/s
P = 4.4 gm/s
Ek = 0.0022 joules
Total momentum = **7.3 gm/s**
Total Kinetic Energy = **.0028 J**

Results for Trail 3,
In this case, the incident ball hit the target ball at an angle (65º), giving the following results
For incident ball (6.8 grams): s = 0.30 meters t = 0.41 seconds v = 0.73 m/s
P = 5.0 gm/s Ek = 0.0018 joules
For target ball (4.4 grams): s = 0.378 meters
t = 0.41 seconds v = 0.92 m/s
P = 4.0 gm/s
Ek = 0.0019 joules
Total momentum = **7.63** (**see graphing) gm/s**
Total Kinetic Energy = **.0037 J**

To find differences:
We know the initial momentum and kinetic energy of the system, and the law of conservation says that the momentum and kinetic energy should be conserved, we can see to what extent we got this correct by calculating the percent difference:

For Trial 2 (momentum):
(7.61 – 7.3) / 7.61 = 4.0745… = **4.1 %**
(kinetic energy):
(.0043-.0028)/.0043 = 34.8837… = **34.9 %**

For Trial 3 (momentum): (7.61 – 7.63) / 7.61 = 0.26281… = **0.26 %**
(kinetic energy):
(.0043-.0037)/.0043 = 13.9537… = **14.0 %**

CONCLUSION

As I had predicted in my hypothesis, results for the kinetic energy and the momentum for each of the spheres after the collision will be equal to or very close to the initial momentum and kinetic energy of the system which we found by looking at just the incident ball. We can therefore conclude that there is a clear relationship between the kinetic energy and momentum in an oblique collision, however the energy or momentum could be lost out to other factors outside the system, as it happened in my experiment.

Momentum is a vector due to the fact that velocity is a vector. By finding the momentum of each ball before and after the collision, and then the vector sum of these, we can see that the momentum and kinetic energy are unchanged by a collision between the two.

The differences in initial and final kinetic results could have happened for a couple of valid reasons. The scientific reasons for the sharp decrease in kinetic energy is explained by the fact that the kinetic energy was transformed into other types of energy, notably heat energy.The loss of kinetic energy was greater when the objects collided head on then when they collided at an angle because there is greater contact and more is lost on the heavier impact.

The reason the difference in kinetic energy was far greater in both cases than the related momentum was because kinetic energy is proportional to velocity squared, and momentum is simply proportional to velocity, this causes a larger disruption in results if some of the data is already a bit off.

EVALUATION

The sources of error in this experiment included several factors. First of all, only one trial was performed for each of the procedures increasing the likelihood of a mistake. The kinetic energy lost to heat could not actually be found and added on to the final KE making some of the statements about the final KE false. Also concerns arose about the accuracy of measurements since we had several problems with measuring angles and distances from the point of impact to the points of landing, and often times we had to round digits greatly. The paper itself on which we recorded the results was often accidentally shifted which caused another error to the distances.

If granted another opportunity to repeat this experiment, I would certainly change some things. I would perform more trials for each of the procedures and then find the more consistent and reliable results. Also I would prefer to work with the graphing paper itself instead of duplicating scaled vectors, and present it in this lab investigation, but since there was more than one person in my lab group, the sheet would have to be photocopied several times. Also I would advise to make sure the sheet of paper does not move at all and that an eye is kept at all times on which sphere made which mark.