PHYSICS INVESTIGATION
IB PHYSICS SL

What is the relation between the alacrity and different materials in the elastic and inelastic collision, what is the effect of the materials?

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Word Count:

Purpose:

Measure the different speed after the elastic and inelastic collisions .

Measure the different energies absorbed after elastic and inelastic collisions.

The law of conservation of energy and momentum conservation law.

The law of conservation of energy, a fundamental concept of physics, states that the total amount of **energy remains constant in an isolated system. It implies that energy can neither be created nor destroyed, but can be change from one form to another.**

mgh=(1/2)mv^2

«For a collision occurring between object 1 and object 2 in an isolated system, the total momentum of the two objects before the collision is equal to the total momentum of the two objects after the collision. **That is, the momentum lost by object 1 is equal to the momentum gained by object 2**.»

Momentum conservation law

$$m_1\vec{v}_{10} + m_2\vec{v}_{20} = (m_1 + m_2)\vec{v}$$

$$\vec{v} = \frac{m_1\vec{v}_{10} + m_2\vec{v}_{20}}{m_1 + m_2}$$

«**Internal energy** is defined as the **energy** associated with the random, disordered motion of molecules. It is separated in scale from the macroscopic ordered **energy** associated with moving objects; it refers to the invisible microscopic **energy** on the atomic and molecular scale.»

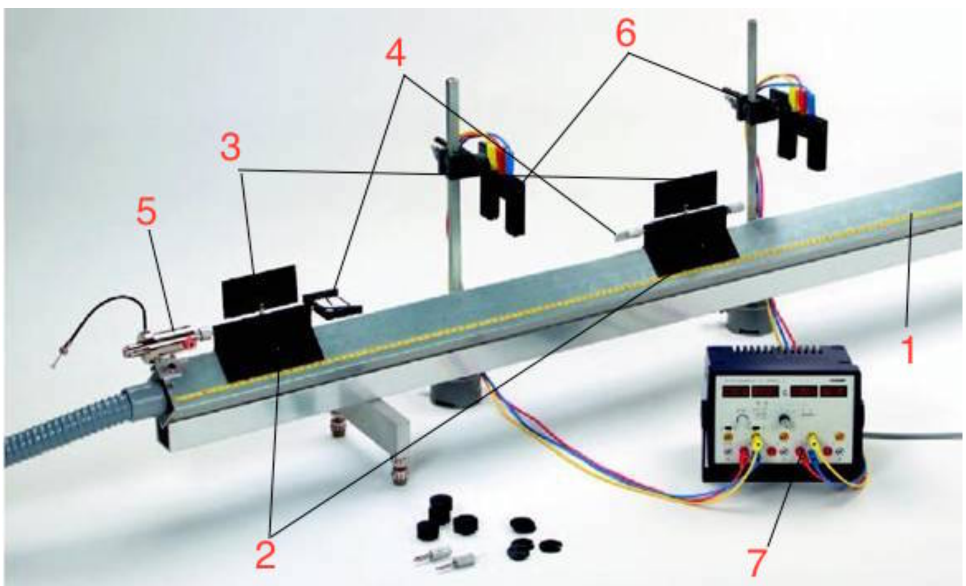
When inelastic collision occurs, there is a loss of mechanical energy of the colliding balls.

«**Mechanical energy** is the sum of potential **energy** and kinetic **energy**.»

Needed materials for the elastic and inelastic collisions.

Description of the lab
1) rail
2) trolleys
3) flat plates
4) plugs
5) launch pad
6) light barriers

- Rubber and plastic plate - in order to see the **elastic collision**
- Needle and plug - in order to see the **inelastic collision**



The experimental apparatus is a rail, on which two carts can move almost without friction. At the sides of the two carts there are inserted plates of a certain length 10 cm. Plugs of different types can be attached to the ends of the carts: Rubber and plastic plate - in order to see the **elastic collision;** Needle and plug - in order to see the **inelastic collision.** At the left side of the first cart you can see a starting system, which can be used to create speed for the first cart. This start system allows you to select three values of speed. At the top of of the rail there are two devices called light barriers. They consist of a light source and a light receiver. When the cart goes through this light barrier, it cover a ray of light for a while, which gives light barrier an opportunity to measure the speed of the cart for specific time. This time can be measured and hence help to determine the speed of the cart. Light barriers are connected to the timer. The instrument has a 4 displays, on which I can see the time for the left and right cart and for the movement forward and backwards. Using this time I calculate the velocity of each carriage before and after the elastic and inelastic collision.

Inelastic collision

Given numbers:

m1,m2 - weights of the two carts
v(Line)10 and v (Line)20 speeds of the two carts before the inelastic collision
v - is the speed after the carts had an inelastic collision

Formulas used:

Momentum conservation law

$$m_1\vec{v}_{10} + m_2\vec{v}_{20} = (m_1 + m_2)\vec{v}$$

$$\vec{v} = \frac{m_1\vec{v}_{10} + m_2\vec{v}_{20}}{m_1 + m_2}$$

All of this might be calculated using the scalar expression, which can be used to show the path, way of the cart. Plus(+) sign can be used to show that the carts are going in one direction, while Minus(-) sign can be used to show that the carts are going in the direction of each other.

$$v = \frac{m_1 v_{10} \pm m_2 v_{20}}{m_1 + m_2}$$

It's also interesting to know, that the amount of the mechanical energy, which transformed into the internal energy, equals in amount to the energy difference before and after inelastic collision.

«**Mechanical energy** is the sum of potential **energy** and kinetic **energy**.»

$$M.E = K.E + P.E$$

$$M.E = \frac{1}{2}mv^2 + mgh$$

$$Q = (W_{10} + W_{20}) - W = \frac{m_1 v_{10}^2}{2} + \frac{m_2 v_{20}^2}{2} - \frac{(m_1 + m_2)v^2}{2}$$

**Extra case 1
 We can even check if the cart m2 has no motion (v20=0). Consequently, we can use another formula

$$v = \frac{m_1 v_{10}}{m_1 + m_2}$$

We can suppose if the mass of the second colliding cart is bigger than the mass of the first cart.(m2>m1). Consequently we will have mechanical energy formula without the energy of the second cart.

$$Q \approx \frac{m_1 v_{10}^2}{2}$$

In this case all of the K.E. goes into warm energy and disappears.

**Extra case 2 when (m1<m2) we can use this formula. When m2 is a hammer and m1 is a nail.

$$v = \frac{m_1 v_{10}}{m_1 + m_2} \approx v_{10}$$

The speed of a nail will be equal to the speed of the hammer. That means that the speed of the hammer transforms to the speed of the nail. Consequently, the K.E. from the hammer transforms to the nail, which is later used as the force to overcome the resistance of the board into which the nail is being hit.

This shows us the dependence of the Mechanical Energy on the masses of m1 and m2.

t10 s	t1 s	t2 s	v10 m/s	v1 m/s	v2 m/s
0,169	0,378	0,189	0,627	0,28	0,568
0,171	0,798	0,214	0,622	0,26	0,509
0,173	0,593	0,264	0,614	0,181	0,404
0,186	0,535	0,287	0,569	0,21	0,371
0,176	0,556	0,309	0,61	0,193	0,344
0,169	0,419	0,314	0,63	0,254	0,338

m1 kg	m2 kg	P10 kg m/s	P1 kg m/s	P2 kg m/s	P2-P1 kg m/s	W10 J	W1 J	W2 J	W2+1 J
0,39	0,63	0,245	0,109	0,358	0,249	0,076	0,015	0,102	0,117
0,39	0,69	0,242	0,101	0,351	0,25	0,075	0,131	0,089	0,22
0,39	0,79	0,239	0,071	0,32	0,249	0,074	0,006	0,065	0,071
0,39	0,84	0,222	0,082	0,312	0,23	0,063	0,009	0,058	0,067
0,39	0,89	0,234	0,075	0,306	0,23	0,072	0,007	0,053	0,0537
0,39	0,94	0,245	0,099	0,295	0,196	0,077	0,013	0,054	0,067

Elastic collision

Given numbers:
v(Line)10 and v (Line)20 speeds of the two carts before the elastic collision
v1 and v2- are the speed after the carts had an elastic collision

Formulas used:

Momentum conservation law and The law of conservation of energy

$$m_1\vec{v}_{10} + m_2\vec{v}_{20} = (m_1 + m_2)\vec{v}$$

$$\frac{m_1\vec{v}_{10}^2}{2} + \frac{m_2\vec{v}_{20}^2}{2} = \frac{m_1\vec{v}_1^2}{2} + \frac{m_2\vec{v}_2^2}{2}$$

in order to get the speeds of v1 and v2 we can can use the momentum conservation law

$$\vec{v}_1 = \frac{2m_2\vec{v}_{20} + (m_1 - m_2)\vec{v}_{10}}{m_1 + m_2}$$

$$\vec{v}_2 = \frac{2m_1\vec{v}_{10} + (m_2 - m_1)\vec{v}_{20}}{m_1 + m_2}$$

** Extra case
If we have exactly the same masses of the carts, we will get from the v1 and v2 formula

$$\vec{v}_1 = \vec{v}_{20}, \qquad \vec{v}_2 = \vec{v}_{10}$$

Consequently, the carts changed the speed with each other
If one of the carts didn’t have any speed. V20=0, then after the elastic collision it will move the speed equal of the first cart in the same direction, and the first cart will stop.

m1 kg	m2 kg	L(distance) m	t10 s	t s	v10 m/s	v m/s
0,39	0,44	0,1	0,164	0,318	0,625	0,292
0,39	0,49	0,1	0,17	0,334	0,614	0,243
0,39	0,54	0,1	0,161	0,321	0,622	0,26
0,39	0,59	0,1	0,169	0,325	0,634	0,252
0,39	0,64	0,1	0,168	0,325	0,611	0,23
0,39	0,69	0,1	0,169	0,326	0,603	0,225

m1 kg	m2 kg	m2/m1	p10 kgm/s	W10 J	W J	Q J
0,39	0,44	1,13	0,244	0,076	0,038	0,038
0,39	0,49	1.3	0,24	0,074	0,033	0,05
0,39	0,54	1.4	0,243	0,075	0,0365	0,047
0,39	0,59	1.51	0,247	0,078	0,03	0,04
0,39	0,64	1.64	0,238	0,073	0,027	0,032
0,39	0,69	1.77	0,235	0,071	0,025	0,037

Conclusion:

During **inelastic collision** kinetic energy is completely or partially converted into internal energy, leading to a rise in temperature of the bodies . After impact, a colliding body move together at the same speed or at rest. In this case, after the impact bodies move together. When inelastic collision is performed only the law of conservation of momentum is working.

When there is a completely **elastic collision** kinetic energy of the colliding bodies passes first into the potential energy of elastic deformation . Then, the body is back to its original shape , pushing each other . As a result, the potential energy of elastic deformation is again converted into kinetic energy , and body flies at speeds , the magnitude and direction of which is determined by two laws - the law of conservation of energy and momentum conservation law .