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Elastic & Inelastic Collision

EM Virtual Lab Experiment II

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Aim

- The Elastic and Inelastic collision simulation will help to analyse the collision variations for different situations.
- Demonstration of collision behaviour for elastic and inelastic type.
- Variation of collision behavior in elastic and inelastic type.
- Study of variation of Momentum, Kinetic energy, Velocity of collision of the objects and the Center of Mass with different velocity and mass.
- Calculation of the Momentum, Kinetic energy, and Velocity after collision.

What is Collision?

The abrupt change in path of a moving body (or bodies) due to its interaction with other body (or bodies) is called collision. The magnitude and direction of the velocity of the colliding bodies may change in a collision. The force involved in collision acts only for a very short period of time. We come across many examples of collision daily. The coins of a carom game colliding with one another or collision between vehicles in road etc, are examples of collision. The Conservation Laws applied here are;

Law of Conservation of Linear Momentum: Total linear momentum of a system of a particle is conserved if there is no external force acting on the system.

i.e., Total linear momentum before collision is equal to total linear momentum after collision, if no external force acts on the system.

Law of Conservation of Energy: Energy can neither be created nor destroyed. But can be converted from one form of energy into another.



Types of Collision:

1. Elastic collision: The type of collision in which both the momentum and kinetic energy of the system are conserved is called elastic collision. The collision between subatomic particles is generally elastic. The collision between two steel or glass balls is nearly elastic. In elastic collisions, the forces involving are conservative in nature.
2. Inelastic collision: The type of collision in which only momentum is conserved, not kinetic energy is called inelastic collision. Most of the collisions in daily life are inelastic in nature.

Formulas Used:

In an elastic collision both kinetic energy and momentum are conserved. In the following equations, 1 and 2 indicate the two different objects colliding, unprimed variables indicates those before collision and primed variables indicate those after the collision, p is momentum, KE is kinetic energy, M is mass, and V is velocity.

Conservation of Momentum:

$$p_1 + p_2 = p'_1 + p'_2$$

or

$$M_1 V_1 + M_2 V_2 = M_1 V'_1 + M_2 V'_2$$

$$KE_1 + KE_2 = KE'_1 + KE'_2$$

or

$$\frac{1}{2} M_1 (V_1)^2 + \frac{1}{2} M_2 (V_2)^2 = \frac{1}{2} M_1 (V'_1)^2 + \frac{1}{2} M_2 (V'_2)^2$$

$$V'_1 = \frac{M_1 - M_2}{M_1 + M_2} V_1 + \frac{2M_2}{M_1 + M_2} V_2$$

And

$$V'_2 = \frac{2M_1}{M_1 + M_2} V_1 + \frac{M_1 - M_2}{M_1 + M_2} V_2$$

If $M_1 = M_2$ then $V'_1 = V_2$ and $V'_2 = V_1$

If the second object had a velocity $V_2 = 0$ before the collision the equations become;

$$V'_1 = \frac{M_1 - M_2}{M_1 + M_2} V_1$$

And

$$V'_2 = \frac{2M_1}{M_1 + M_2} V_1$$

If the objects stick together after the collision the collision is a perfectly inelastic collision. In such a collision the velocities of the two objects after the collision are the same. Only momentum is conserved in the inelastic collision.

Conservation of Momentum:

$$p_1 + p_2 = p'_1 + p'_2$$

Or

$$M_1 V_1 + M_2 V_2 = M_1 V'_1 + M_2 V'_2$$

Since $V_2 = 0$ and $V'_1 = V'_2$ the above solved for the velocities after the collision becomes;

$$V'_1 = V'_2 = \frac{M_1 V_1 + M_2 V_2}{M_1 + M_2} V_1$$

Another approach is to combine elastic and inelastic collisions equations into one equation using the concept of the coefficient of restitution. The coefficient of restitution is defined by the relation;

$$e = \frac{V'_2 - V'_1}{V_1 - V_2}$$

Where the coefficient of restitution for a perfectly elastic collision is $e = 1$ and for a perfectly inelastic collision is $e = 0$. The equation for the velocities after the collision becomes;

$$V'_1 = \frac{M_1 - e M_2}{M_1 + M_2} V_1$$

And

$$V'_2 = \frac{(1 + e) M_1}{M_1 + M_2} V_1$$

These two equations give the same results as obtained for the elastic collision if $e=1$ and for the inelastic collision if $e=0$.

Performing the Simulation:

Choose the type of collision (Elastic or Inelastic). The Coefficient of Restitution slider is fixed at 1 for Elastic collision. The mass and velocity of both the objects can be adjusted. The simulation will start on clicking the 'Play' button. The graphs like; Kinetic Energy versus Time, Velocity versus Time, Momentum versus Time, are shown for the objects depending upon the object movement. The velocity, momentum and kinetic energy after collision can be found out and crosschecked using the simulation.

Help:

Variable Region:

1. The 'Choose Type' Combo box lets you choose the type of collision, the simulation have to perform.
2. The 'Coefficient of Restitution' Slider is fixed at 1 for elastic collision, but can be change for inelastic collision.
3. The 'Mass' and 'Velocity' sliders allow you to change the mass and velocity values for objects A and B.

Measurement Region:

1. The 'Start' button lets you play the simulation.
2. The 'Reset' button lets you reset the simulation.

 1) Which of the following statements is true in the case of inelastic collision?

- Only linear momentum is conserved
- Only KE is conserved
- Both linear momentum and KE are conserved.
- None of these

 2) Coefficient of restitution for a perfectly elastic collision is

- equal to zero equal to one
- between zero and one greater than one

 3) What is the unit of impulse?

- N. s Kg m/s
- None of the above Both a and b

 4) When two bodies stick together after collision, the collision is said to be;

- Perfectly elastic Perfectly inelastic
- Partially inelastic None of these

 5) The collision between the gas molecules of an ideal gas in a cylinder is

- Perfectly elastic Perfectly inelastic
- Partially inelastic None of these

VARIABLES



Select type of test

Elastic ▾

Coefficient of Restitution (k) : 1



Select an object

Object A Object B

Velocity (v1) : 20 m/s



Mass (m1) : 1 kg



START EXPERIMENT

RESET

VARIABLES



Select type of test

Elastic ▾

Coefficient of Restitution (k) : 1



Select an object

Object A Object B

Velocity (v2) : 0 m/s



Mass (m2) : 1 kg



START EXPERIMENT

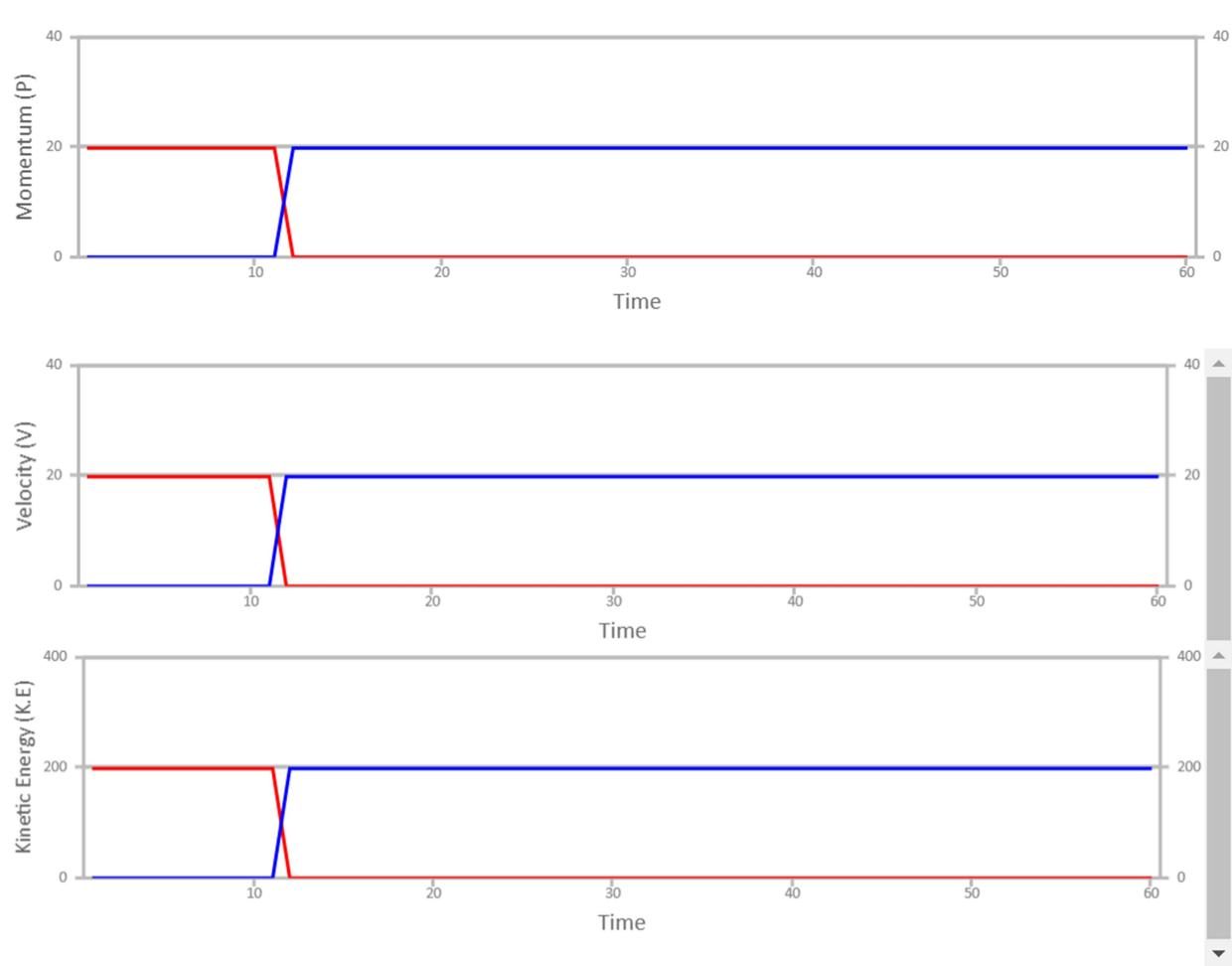
RESET

RESULT**Before collision**

	Object A	Object B
K.E	200.0	0.0
Velocity	20.0	0.0
Momentum	20.0	0.0

After collision

	Object A	Object B
K.E	0.0	200.0
Velocity	0.0	20.0
Momentum	0.0	20.0



VARIABLES

Select type of test

Inelastic ▾

Coefficient of Restitution (k) : 0.2



Select an object

- Object A Object B

Velocity (v1) : 20 m/s



Mass (m1) : 1 kg



START EXPERIMENT

RESET

VARIABLES

Select type of test

Inelastic ▾

Coefficient of Restitution (k) : 0.2



Select an object

Object A Object B

Velocity (v2) : 0 m/s



Mass (m2) : 1 kg



START EXPERIMENT

RESET

RESULT**Before collision**

	Object A	Object B
K.E	200.0	0.0
Velocity	20.0	0.0
Momentum	20.0	0.0

After collision

	Object A	Object B
K.E	32.0	72.0
Velocity	8.0	12.0
Momentum	8.0	12.0

