

K J Somaiya College of Engineering, Mumbai-77

(Somaiya Vidyavihar University)

Batch:A3 Roll No.: 16010121051

Experiment / assignment / tutorial No.

Grade: AA / AB / BB / BC / CC / CD / DD

Signature of the Staff In-charge with date

Title – Elastic and Inelastic Collision

CO1

Objective

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

Theory

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.

Department of Mechanical Engineering

July-Dec-2020

K J Somaiya College of Engineering, Mumbai-77

(Somaiya Vidyavihar University)

Types of Collision:

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 involved are conservative in nature.

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 indicate 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:

$$\begin{aligned}p_1 + p_2 &= p'_1 + p'_2 \\ \text{or} \\ M_1 V_1 + M_2 V_2 &= M_1 V'_1 + M_2 V'_2 \\ KE_1 + KE_2 &= KE'_1 + KE'_2 \\ \text{or} \\ \frac{1}{2} M_1 (V_1)^2 + \frac{1}{2} M_2 (V_2)^2 &= \frac{1}{2} M_1 (V'_1)^2 + \frac{1}{2} M_2 (V'_2)^2 \\ V'_1 &= \frac{M_1 - M_2}{M_1 + M_2} V_1 + \frac{2M_2}{M_1 + M_2} V_2 \\ \text{And} \\ V'_2 &= \frac{2M_1}{M_1 + M_2} V_1 + \frac{M_1 - M_2}{M_1 + M_2} V_2 \\ \text{If } M_1 &= M_2 \text{ then } V'_1 = V_2 \text{ and } V'_2 = V_1\end{aligned}$$

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

$$\begin{aligned}V'_1 &= \frac{M_1 - M_2}{M_1 + M_2} V_1 \\ \text{And} \\ V'_2 &= \frac{2M_1}{M_1 + M_2} V_1\end{aligned}$$

Department of Mechanical Engineering

July-Dec-2020

K J Somaiya College of Engineering, Mumbai-77

(Somaiya Vidyavihar University)

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;

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

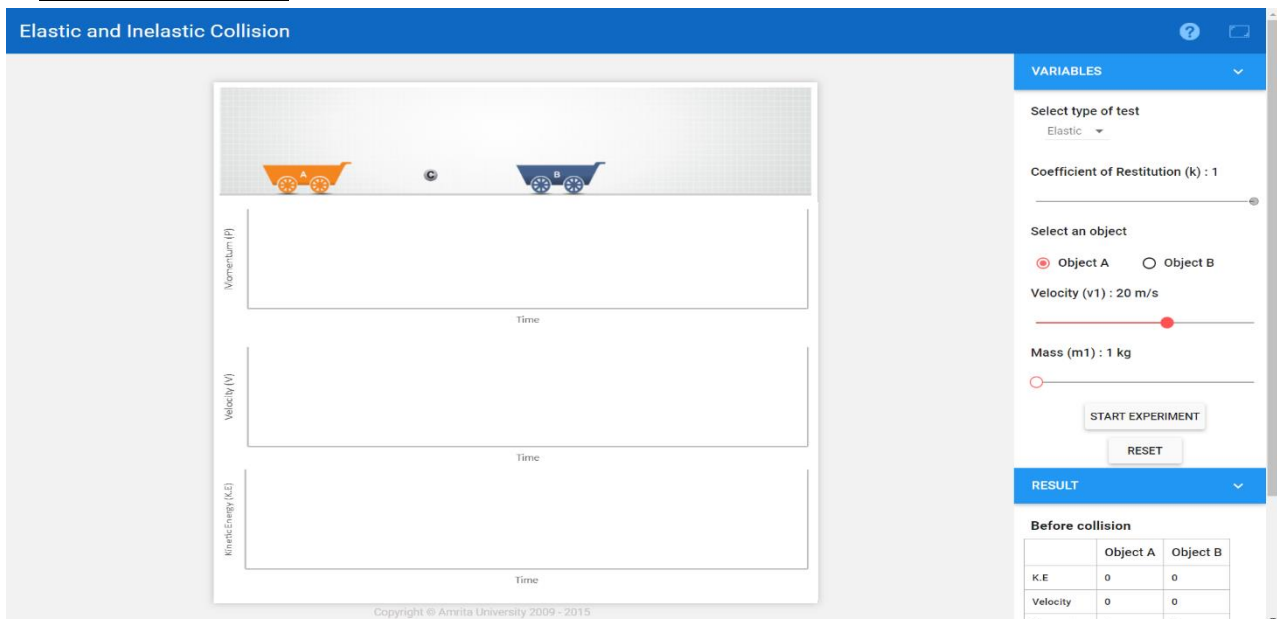
And

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

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

Setup Diagram:

PROCEDURE:



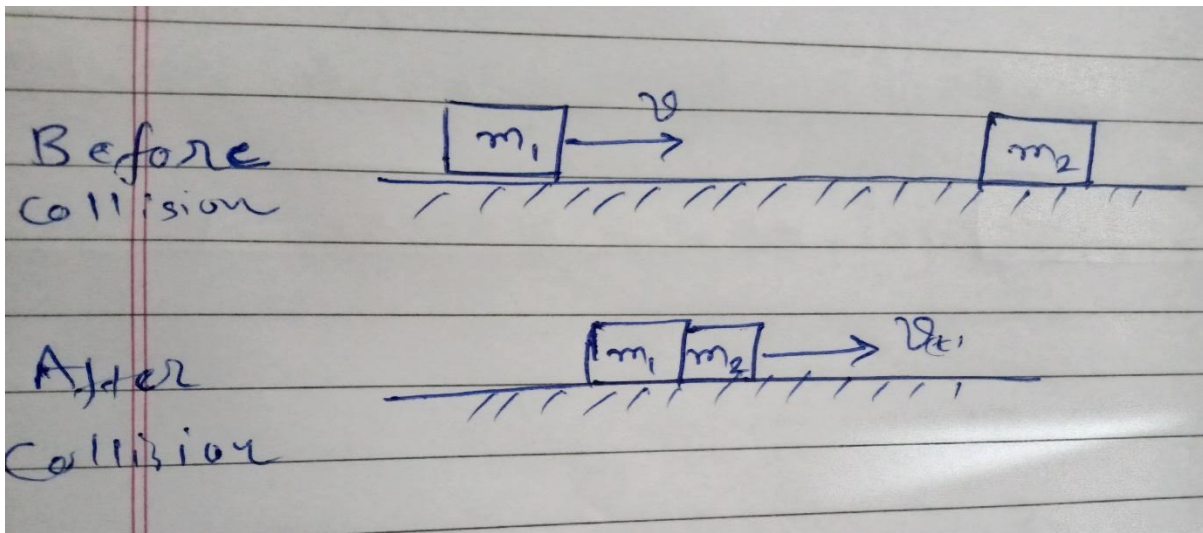
July-Dec-2020

K J Somaiya College of Engineering, Mumbai-77

(Somaiya Vidyavihar University)

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 verses Time, Velocity verses Time, Momentum verses 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.

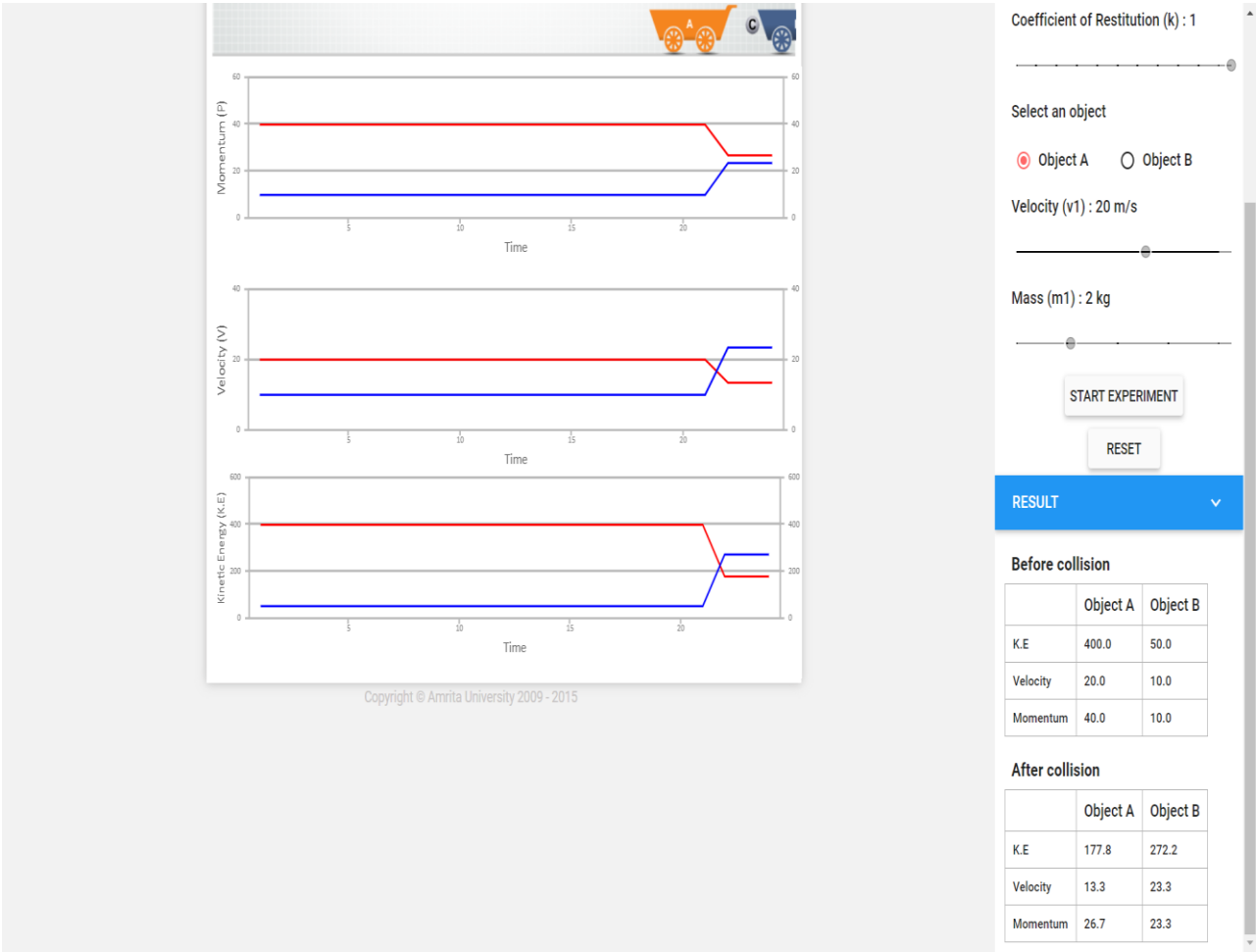
Free Body Diagram:



Simulator:

Department of Mechanical Engineering

July-Dec-2020



K J Somaiya College of Engineering, Mumbai-77

(Somaiya Vidyavihar University)

OBSERVATION TABLE:

S · N	m 1 k g	m 2 k g	e	Before Impact						After Impact											
										Experimental						Analytical					
				V ₁	KE ₁	P ₁	V ₂	KE ₂	P ₂	V' ₁	KE' ₁	P' ₁	V' ₂	KE' ₂	P' ₂	V' ₁	KE' ₁	P' ₁	V' ₂	KE' ₂	P' ₂
				m/s	J	Kg.m/s	m/s	J	Kg.m/s	m/s	J	Kg.m/s	m/s	J	Kg.m/s	m/s	J	Kg.m/s	m/s	J	Kg.m/s
1	2	1	1	20	400	40	10	50	10	13.3	177.8	26.7	23.3	272.2	23.3	13.3	176.8 9	26.6	23. 3	272.2	23.3
2	1	3	0	30	450	30	25	937.5	75	26.3	344.5	26.3	26.3	1033.6	78.8	26.2 5	344.5 3	26.2 5	26. 25	1033.5 9	78.7 5
3	3	2	0.7	40	2400	120	25	625	50	29.8	1332.1	89.4	40.3	1624.1	80.6	29.8	1332. 06	89.4	40. 3	1624.0 9	80.6
4	5	4	1	70	12250	350	50	5000	200	52.2	6817.9	261.1	72.2	10432.1	288.9	52.2 2	6817. 89	261. 1	72. 22	10432. 098	288. 8
5	1	1	0	6	18	6	2	2	2	4	8	4	4	8	4	4	8	4	4	8	4
6	3	3	0.7	-35	1837.5	-105	-55	4537.5	-165	-52	4056	-156	-38	2166	-114	-52	4056	-156	-38	2166	-114

Department of Mechanical Engineering

July-Dec-2020

K J Somaiya College of Engineering, Mumbai-77

(Somaiya Vidyavihar University)

CALCULATION:

$$\begin{aligned} \Rightarrow v_2 &= 10, v_1 = 20, m_1 = 2, m_2 = 1 \\ \Rightarrow v_1' &= \frac{e \times m_2 (v_2 - v_1) + m_1 v_1 + m_2 v_2}{m_1 + m_2} \\ &= \frac{1 \times 1 (10 - 20) + 2(20) + (1)(10)}{2 + 1} \\ &= \frac{40}{3} \\ \boxed{v_1' &= 13.3 \text{ m/s}} \\ \Rightarrow p_1' &= m_1 v_1' = 2 \times (13.3) \\ \boxed{p_1' &= 26.6 \text{ kg m/s}} \\ \Rightarrow KE_1' &= \frac{1}{2} m_1 v_1'^2 = \frac{1}{2} m_1 (13.3)^2 \\ &= (13.3)^2 \\ \boxed{KE_1' &= 176.89 \text{ Joule}} \\ \Rightarrow p_2 &= m_2 v_2' = (1)(23.33) \\ \boxed{p_2 &= 23.33 \text{ kg m/s}} \\ \Rightarrow KE_2' &= \frac{1}{2} m_2 (v_2')^2 = \frac{1}{2} (1) (23.33)^2 \\ &= 544.44/2 \text{ Joule} \\ \boxed{KE_2' &= 272.22 \text{ J}} \\ \Rightarrow v_2' &= \frac{e \times m_1 (v_1 - v_2) + m_1 v_1 + m_2 v_2}{m_1 + m_2} \\ &= \frac{1 \times 2 (20 - 10) + 2(20) + 10}{2 + 1} \\ &= \frac{20 + 40 + 10}{3} \\ \boxed{v_2' &= 23.33 \text{ m/s}} \end{aligned}$$

K J Somaiya College of Engineering, Mumbai-77

(Somaiya Vidyavihar University)

classmate
Date _____
Page _____

②
→ $V_1 = 30 \text{ m/s}$, $V_2 = 25 \text{ m/s}$, $m_1 = 1 \text{ kg}$, $m_2 = 3 \text{ kg}$, $e = 0$

$$V_1' = \frac{e m_2 (V_2 - V_1) + m_1 V_1 + m_2 V_2}{m_1 + m_2}$$

$$= 0 + \frac{1(30) + 3(25)}{4}$$

$$\Rightarrow V_1' = \frac{105}{4} = 26.25 \text{ m/s}$$

$$\Rightarrow V_2' = \frac{e m_1 (V_1 - V_2) + m_1 V_1 + m_2 V_2}{m_1 + m_2}$$

$$= 0 + \frac{30(1) + 3(25)}{4}$$

$$\Rightarrow V_2' = 26.25 \text{ m/s}$$

$$\rightarrow P_1' = m_1 V_1'$$
$$= (1)(26.25)$$

$$P_1' = 26.25 \text{ kg m/s}$$

$$P_2' = m_2 V_2'$$

$$= 3(26.25)$$

$$P_2' = 78.75 \text{ kg m/s}$$

$$\Rightarrow KE_1' = \frac{1}{2} m_1 V_1'^2$$

$$= \frac{1}{2} (1) (26.25)^2$$

$$KE_1' = 344.53 \text{ Joule}$$

$$KE_2' = \frac{1}{2} m_2 V_2'^2$$

$$= \frac{1}{2} (3) (26.25)^2$$

$$KE_2' = 1033.59 \text{ Joule}$$

K J Somaiya College of Engineering, Mumbai-77

(Somaiya Vidyavihar University)

Conclusion:

The laws of conservation are applicable to all the types of collision. In case of elastic collision both the momentum and kinetic energy are conserved while in case of inelastic collision only momentum is conserved. Thus, the laws of conservation of momenta are verified.

Signature of faculty in-charge

Self-Evaluation

Theory	Procedure	Self Evaluation	Simulator	Assignment	Reference	Feedback
<p>✓ 1) Which of the following statements is true in the case of inelastic collision?</p> <p><input checked="" type="radio"/> Only linear momentum is conserved <input type="radio"/> Only KE is conserved <input type="radio"/> Both linear momentum and KE are conserved. <input type="radio"/> None of these</p>						
<p>✓ 2) Coefficient of restitution for a perfectly elastic collision is</p> <p><input type="radio"/> equal to zero <input checked="" type="radio"/> equal to one <input type="radio"/> between zero and one <input type="radio"/> greater than one</p>						
<p>✓ 3) What is the unit of impulse?</p> <p><input type="radio"/> N. s <input type="radio"/> Kg m/s <input type="radio"/> None of the above <input checked="" type="radio"/> Both a and b</p>						
<p>✓ 4) When two bodies stick together after collision, the collision is said to be;</p> <p><input type="radio"/> Perfectly elastic <input checked="" type="radio"/> Perfectly inelastic <input type="radio"/> Partially inelastic <input type="radio"/> None of these</p>						
<p>✓ 5) The collision between the gas molecules of an ideal gas in a cylinder is</p> <p><input checked="" type="radio"/> Perfectly elastic <input type="radio"/> Perfectly inelastic <input type="radio"/> Partially inelastic <input type="radio"/> None of these</p>						

Department of Mechanical Engineering

July-Dec-2020

K J Somaiya College of Engineering, Mumbai-77

(Somaiya Vidyavihar University)

Feedback

index.php?sub=1&brch=74&sim=189&cnt=7

Theory Procedure Self Evaluation Simulator Assignment Reference Feedback

Feedback - Amrita Vishwa Vidyapeetham Virtual Lab

User Feedback

Name of the user
jasmin.dhedhi@somaiya.edu

Department
Physical Sciences

Lab Details

Name of the Lab
Mechanics Virtual Lab (Pilot)

Name of the Experiment
Elastic and Inelastic Collision

Type of Experiment
Simulator

How do you rate the online performance of the experiment?
Excellent

To what extent did you have control over the interactions?
Excellent

To what degree was the actual lab environment simulated?
Very Good

Was the measurement and analysis of data easy for you?
Excellent

The manuals were found to be helpful
Excellent

Were the links provided consistent with the objectives of the experiment?

Elastic and Inelastic Collision

Theory Procedure Self Evaluation Simulator Assignment Reference Feedback

Did you feel confident enough while performing the experiment?
Yes

Was the experiment/process motivating enough?
Yes

Did you go through the manual/ step by step procedure before performing the experiments live?
Yes

Did you get the feel of a real lab while performing the experiments virtually?
Yes

Did you feel the absence of an instructor?
No

Could you run the experiments smoothly, i.e., without interruptions?
Yes

Could you measure and analyse the data successfully?
Yes

Did you follow the step by step procedure before doing the live experiment?
Yes

Could you compare your results with the given typical results?
Yes

Do you think performing experiments through virtual labs were more challenging than the real lab experiments?
Yes

Specify three problems/difficulties you faced while performing the experiments?

Describe three interesting things about the experiments.

Do you think doing experiments through virtual lab gives scope for more innovative and creative research work?
Yes

Thanks for taking the time to share your feedback. We'll use the information you provided to improve our virtual labs.

Department of Mechanical Engineering

July-Dec-2020