Page No.
Date

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Experiment No-6

Determination of coefficient of Restitution between two colliding bodies

Page No.
Date

* Questions -

Q1) what is the direct central impact?

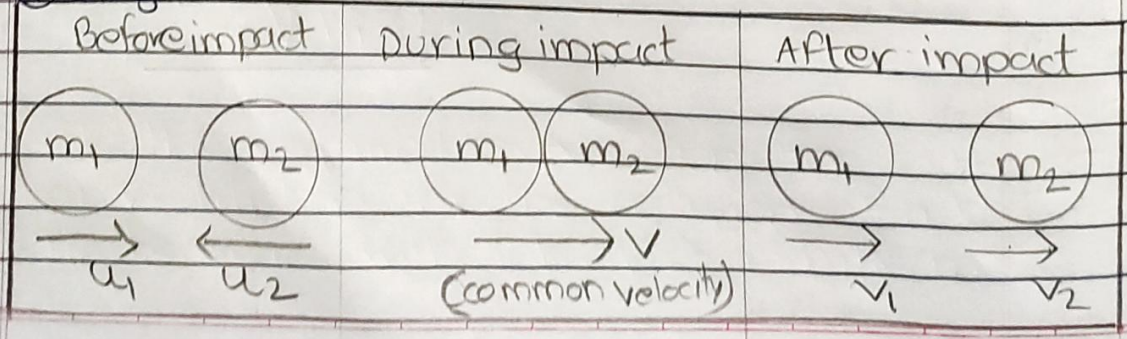
Ans → Collision of two bodies in which each body exerts tremendous pressure on the other for a very short interval of time is called as impact. When the mass centers of the colliding bodies are lying on the line of impact and their velocities are collinear to the line of impact then it is called as direct central impact.

Q2) what is the conservation of linear momentum?

Ans → Conservation of linear momentum, general law of physics according to which the quantity called momentum that characterizes motion never changes in an isolated collection of objects; that is, the total momentum of a system remains constant.

Q3) what is the expression for coefficient of restitution for the collision of two bodies of finite mass?

Ans → ① Diagram



Page No.
Date

- Consider two colliding bodies 1 & 2

Let m_1 = mass of body 1,
m_2 = mass of body 2,
u_1 = velocity of body 1 before impact,
u_2 = velocity of body 2 before impact,
v_1 = velocity of body 1 after impact,
v_2 = velocity of body 2 after impact

- collision between two bodies

	Impulse of Deformation	Impulse of recovery
Body 1	$m_1v - m_1u_1$	$m_1v_1 - m_1v$
Body 2	$m_2v - m_2u_2$	$m_2v_2 - m_2v$

$\therefore e = \frac{m_1v - m_1u_1}{m_1v - m_1v_1} = \frac{v_1 - u_1}{v - u_1}$ & $e = \frac{m_2v_2 - m_2v}{m_2v - m_2v_2} = \frac{v_2 - v}{v - v_2}$

$$e = \frac{v_1 - v_2}{v - v_1} = \frac{v_2 - v}{v - u_2} = \frac{v_1 - v - v_2 + v}{v - u_1 - v + u_2}$$

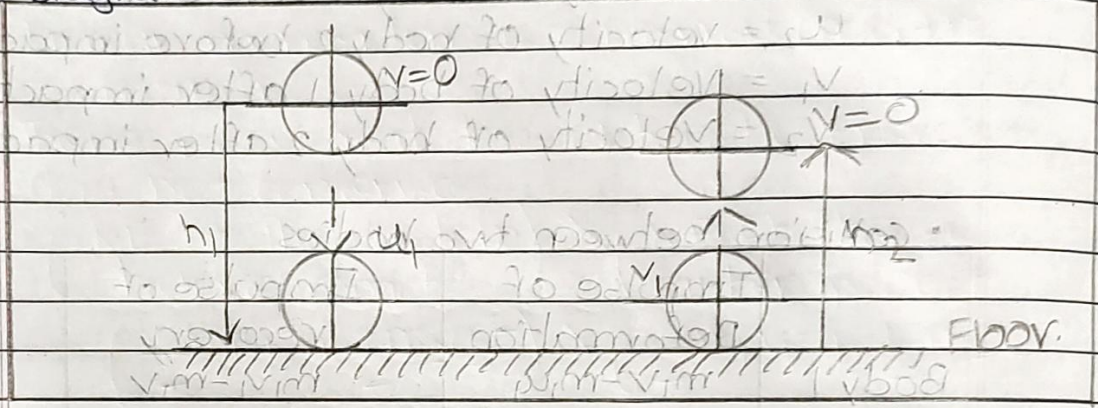
$$e = \frac{v_1 - v_2}{u_2 - u_1} = \left[\frac{v_1 - v_2}{u_1 - u_2}\right] = \left[\frac{v_1/_2}{u_1/_2}\right]$$

$$\boxed{e = \left[\frac{v_1 - v_2}{u_2 - u_1}\right]}$$

Is the required expression for coefficient of restitution for the collision of two bodies of finite mass.

Q4) What is the expression for coefficient of restitution for the collision of a body of finite mass with a body of infinite mass?

Ans → Diagram



- Consider the impact between ball and floor.
- If a ball (body 1 of finite mass m) be released from height h_1. It strikes the floor (body 2 of infinite mass) and rebounds to height h_2 after impact

Let,

u_1 = Striking velocity, v_1 = Rebounding velocity

$u_1 = \sqrt{2gh_1}(\downarrow)$ $\quad u_1 = \sqrt{2gh_2}(\uparrow)$

For body 2, $u_2 = v_2 = 0$

$$\therefore e = \frac{v_1 - v_2}{u_1 - u_2} = \frac{v_1}{-u_1} = \frac{\sqrt{2gh_2}}{\sqrt{2gh_1}}$$

$$\therefore e = \sqrt{\frac{h_2}{h_1}}$$

Is the required expression for coefficient of restitution for the collision of a body of finite mass with a body of infinite mass.

Page No.
Date

Q5) What is the difference between elastic, semi-elastic & plastic impact?

Ans → ① Elastic impact -

i) The two bodies separate after the impact.
ii) Coefficient of restitution, $e=1$
iii) Linear momentum is conserved ($m_1u_1+m_2u_2=m_1v_1+m_2v_2$).
iv) Kinetic energy is conserved

$$\left(\begin{matrix}\text{K.E of the system}\\ \text{before impact}\end{matrix}\right)=\left(\begin{matrix}\text{K.E of the system}\\ \text{after impact}\end{matrix}\right).$$

$$\left(\frac{1}{2}m_1u_1^2+\frac{1}{2}m_2u_2^2\right)=\left(\frac{1}{2}m_1v_1^2+\frac{1}{2}m_2v_2^2\right)$$

v) Recovery is 100% and the two bodies regain their original shape and size.

② Semi-elastic Impact -

i) The two bodies separate after the impact.
ii) Coefficient of restitution varies between zero and one, $0<e<1$.
iii) Linear momentum is conserved ($m_1u_1+m_2u_2=m_1v_1+m_2v_2$).
iv) Kinetic Energy of system is not conserved.

$$\left(\begin{matrix}\text{K.E of the system}\\ \text{before impact}\end{matrix}\right)>\left(\begin{matrix}\text{K.E of the system}\\ \text{after impact}\end{matrix}\right)$$

$$\left(\frac{1}{2}m_1u_1^2+\frac{1}{2}m_2u_2^2\right)>\left(\frac{1}{2}m_1v_1^2+\frac{1}{2}m_2v_2^2\right)$$

Energy lost in impact $=(T_1-T_2)$

% loss in energy $=\left(\frac{T_1-T_2}{T_1}\right)\times 100$

v) The recovery is partial and there is some permanent damage of the bodies.

(3) Plastic Impact -

i) The two bodies do not separate after the impact but they move with a common velocity (v).

ii) Coefficient of restitution $e = 0$

iii) Linear momentum is conserved $(m_1u_1 + m_2u_2) = (m_1 + m_2)v$

iv) There is a great loss of kinetic Energy and it is not conserved.

$$\left(\begin{matrix}\text{K.E of the system}\\ \text{before impact}\end{matrix}\right) > \left(\begin{matrix}\text{K.E of the system}\\ \text{after impact}\end{matrix}\right)$$

$$\left(\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2\right) > \left(\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2\right)$$

Energy lost in impact $= (T_1 - T_2)$

$$\%\text{ loss in energy} = \left(\frac{T_1 - T_2}{T_1}\right) \times 100$$

v) The recover is partial and there is some permanent damage on the colliding bodies.