Elastic and Inelastic Collisions – NEET Physics Revision Notes

---

Index

1. Theory & Concepts
2. Coefficient of Restitution: Formula & Physical Meaning
3. Application to 1D & 2D Problems
4. Worked Examples
5. MCQs for Practice
6. Assertion–Reasoning Practice Questions
7. Solutions (MCQs & Assertion–Reasoning) – Explanations Included
8. Master Steps for Any Collision Problem
9. Common Mistakes to Avoid
10. Key Points to Memorise
11. Contact & Branding

---

1. Theory & Concepts

Elastic Collisions

- Momentum and kinetic energy are **both conserved**.
- Colliding bodies 'bounce apart'; no permanent energy loss.
- Example: Billiard balls, gas molecules.

Inelastic Collisions

- **Momentum conserved, kinetic energy NOT conserved.**
- Bodies may stick together or deform.
- Example: Clay sticking, bullet embedding in block.

---

2. Coefficient of Restitution (e)

- **Definition:** Ratio of speed of separation to speed of approach
- **Formula for 1D collision:** $e = \frac{\text{speed of separation}}{\text{speed of approach}} = \frac{v_2 - v_1}{u_1 - u_2}$
- **Physical meaning:** Quantifies "bounciness"
  - $e = 1$: perfectly elastic (no energy lost)
  - $0 < e < 1$: inelastic
  - $e = 0$: perfectly inelastic (stick; max KE lost)

Bounciness describes **how well an object rebounds after a collision**. A highly bouncy object returns with a large speed; a less bouncy object barely comes back.

The **coefficient of restitution (e)** is the **numerical measure** of this bounciness. It compares how fast bodies move apart after collision to how fast they were approaching before collision.

If e = 1, the collision is perfectly elastic — the object bounces back fully with **no loss** of kinetic energy.

If 0 < e < 1, the collision is inelastic — the object bounces back partially because **some energy is lost** as sound, heat, or deformation.

If e = 0, the collision is perfectly inelastic — the object **does not bounce at all** and the bodies stick together, losing the **maximum** possible kinetic energy.

---

3. Application to 1D & 2D Problems

1D Collisions

- Always conserve momentum.
- Use restitution for speeds after collision.

2D Collisions

- Conserve momentum along both axes.
- Apply e along the normal direction to impact.

Important In a 2-dimensional collision (like a ball hitting a wall at an angle, or two balls hitting off-center):

- The velocity of each body has **two components**:
  1. **Normal component** (perpendicular to the surface of impact)

2. **Tangential component** (along the surface)

The **collision force acts ONLY along the normal direction** — never along the tangential direction.

⭐ **2. Meaning of "Normal Direction"**

The **normal direction** is the line along which the two bodies push each other during impact.

Examples:

- Ball hitting a vertical wall → normal direction is **horizontal**
- Ball hitting the floor → normal direction is **vertical**
- Two balls colliding → normal direction is the line joining their centres at the moment of collision

⭐ **3. Coefficient of Restitution (e) applies ONLY along this normal direction**

In every 2D collision:

- **Normal components change according to "bounciness" (e)**
- **Tangential components DO NOT change during impact** (no impulse along tangential direction)

So when we say:

"Apply e along the normal direction to impact,"

it means:

👉 Use the COR formula **only for the components of velocities along the normal direction**.

4. Worked Examples

Example 1 (Elastic, 1D):

Two balls, mass m each, $u_1 = 4$ m/s, $u_2 = -2$ m/s. Find final velocities.

Stepwise:

- Momentum: $mu_1 + mu_2 = mv_1 + mv_2 \rightarrow 4 - 2 = v_1 + v_2$
- Elasticity: $u_1 - u_2 = -(v_1 - v_2) \rightarrow 4 - (-2) = -(v_1 - v_2) \Rightarrow 6 = -v_1 + v_2$
- Solving: $v_1 = -2$ m/s,

Example 2 (Perfectly Inelastic, 1D):

$m_1 = 3$ kg,. After collision:

- $v = \frac{3\times10+2\times0}{3+2} = 6$ m/s
- Both move together at 6,m/s.

Example 3 (Coefficient of Restitution):

Ball dropped from 2m ($e = 0.8$). How high after bounce?

- Upward velocity after bounce: $v' = ev = 0.8 \times 6.32 = 5.06$ m/s (using $v = \sqrt{2gh}$)
- Height after bounce: $h' = \frac{v'^2}{2g} \approx 1.28$ m

---

5. MCQs for Practice

Q1. In an elastic collision:

- (A) Only momentum conserved
- (B) Only kinetic energy conserved
- (C) Both conserved
- (D) Neither is conserved

Q2. Coefficient of restitution for perfectly elastic collision:

- (A) 0
- (B) 1
- (C) Between 0 & 1
- (D) Infinity

Q3. In perfectly inelastic collision:

- (A) Both conserved
- (B) Only momentum conserved
- (C) Only kinetic energy conserved
- (D) Neither conserved

Q4. Two identical balls collide elastically. Ball A hits, ball B at rest. After collision the velocity of A:

- (A) Halved
- (B) Zero
- (C) Same as initial
- (D) Transferred to B

Q5. Ball rebounds to 36% of original height. What is e?

- (A) 0.6
- (B) 0.5
- (C) 0.36
- (D) 0.8

---

6. Assertion–Reasoning Practice

Q1. Assertion: An elastic collision conserves both momentum and kinetic energy.
Reason: No energy lost to other forms.

Q2. Assertion: Momentum always conserved in all collisions.
Reason: The system is isolated.

Q3. Assertion: For e = 0, bodies stick together.
Reason: Maximum kinetic energy lost.

Q4. Assertion: In 2D elastic collision, both x and y momentum are conserved.
Reason: No external force acts horizontally or vertically.

Q5. Assertion: For e = 1, all energy and momentum are conserved.
Reason: Such collision is perfectly elastic.

---

7. Solutions (MCQs & Assertion–Reasoning)

MCQ Solutions:

Q1. (C) Both conserved
Both momentum and KE are conserved in elastic collisions.

Q2. (B) 1
By definition, e is 1 for perfectly elastic collisions.

Q3. (B) Only momentum conserved
KE is not conserved in perfectly inelastic collisions.

Q4. (B) Zero
Moving ball stops; resting ball takes initial velocity (velocity is transferred).

Q5. (A) 0.6
If $h' = e^2 h$, $e = \sqrt{0.36} = 0.6$.

Assertion–Reasoning Solutions:

Q1. Both true; R explains A.
Elastic collisions conserve both momentum and energy because there are no losses.

Q2. Both true; R explains A.
Momentum is always conserved in an isolated system.

Q3. Both true; R explains A.
If e = 0, bodies stick together and maximum kinetic energy is lost.

Q4. Both true; R explains A.
Both x and y momentum conserved as no external force in those directions.

Q5. Both true; R explains A.
By definition, e = 1 means both momentum and energy conserved.

---

8. Master Steps for Any Collision Problem

Step 1: Read the situation and fix the system

- Identify the interacting bodies.
- System is usually isolated for the short collision interval.

Step 2: Identify collision type

- Elastic: Both momentum and KE conserved.
- Perfectly inelastic: Momentum conserved; stick together.
- Partially inelastic: Momentum and COR equation (given e).

Step 3: Choose direction and assign signs

Step 4: Write momentum conservation equation

- 1D: $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
- 2D: Use components along x and y.

Step 5: Write second equation per type

- Elastic: Use KE conservation or relative speed.
- Inelastic: Sticking ($v_1 = v_2$), momentum only.
- Partially inelastic: Use COR ($e = \frac{v_2 - v_1}{u_1 - u_2}$).

Step 6: Solve equations

Step 7: Compute loss of kinetic energy if asked

$$\Delta KE = KE_{\text{initial}} - KE_{\text{final}}$$

Step 8: Answer what is specifically asked

SPECIAL CASE (2D):

- Resolve velocities into components.
- Apply momentum conservation separately.
- Use trigonometry for angles and directions.
- Read the above Section TITLED **Application to 1D & 2D Problems**

---

9. Common Mistakes to Avoid

- Using KE conservation where not valid (e.g., inelastic).
- Forgetting that momentum is always conserved (with correct system).
- Getting signs wrong for velocities.
- Forgetting to use COR when e is provided.
- Mixing up approach and separation for COR formula.

---

10. Key Points to Memorize

- Elastic: $e = 1$, both momentum and KE conserved
- Inelastic: $e < 1$, only momentum conserved, KE lost
- Perfectly inelastic: $e = 0$, bodies stick and lose max KE
- MCQs and assertion questions check concepts and definitions
- Always set up equations systematically for accurate solutions

---

11. Contact & Branding

Website: www.crackneetphysics.com
YouTube: https://www.youtube.com/@CrackNeetPhysics
Phone: +91-9899271335, +91-9899271779
