Head-on Collisions — Elastic & Inelastic

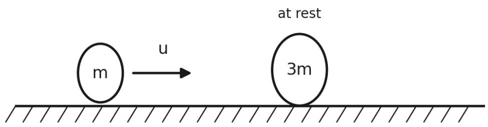
Assignment · Class XI Physics · Work, Energy & Power / Centre of Mass · JEE Main & Advanced level

Questions: 22 **Time:** 75 min **Max. marks:** 88 **Take:** g = 10 m/s² unless stated

- All collisions in this paper are **head-on (collinear)** and surfaces are **frictionless** unless the question says otherwise.
- **Section A** – single-correct MCQ (4 marks, −1). **Section B** – one or more correct (4 marks, partial marking as in JEE Advanced). **Section C** – numerical / integer type (4 marks, no negative). **Section D** – short-answer qualitative (4 marks each).
- Questions marked PYQ are previous-year AIEEE / JEE Main questions (year shown). Others are of the same level.
- Draw *before* and *after* diagrams for every numerical — momentum bookkeeping is where most marks are lost.

Section A — Single correct (Q1 – Q10)

1. A particle of mass m with initial velocity u collides perfectly elastically with a particle of mass 3m at rest. If the first particle moves with velocity v after the collision, the ratio v/u is PYQ · JEE Main 2020



(A) 1/2 (B) −1/2 (C) 1/4 (D) −1/4

2. A body of mass 2 kg makes an elastic head-on collision with a second body at rest and continues to move in the original direction with one-fourth of its original speed. The mass of the second body is PYQ · JEE Main 2019

(A) 1.0 kg (B) 1.2 kg (C) 1.5 kg (D) 1.8 kg

3. In a collinear collision, a particle with initial speed v_0 strikes a stationary particle of the same mass. If the final total kinetic energy is 50% greater than the original kinetic energy, the magnitude of the relative velocity between the two particles after the collision is PYQ · JEE Main 2018

(A) $v_0/\sqrt{2}$ (B) $v_0/4$ (C) $\sqrt{2}\,v_0$ (D) $v_0/2$

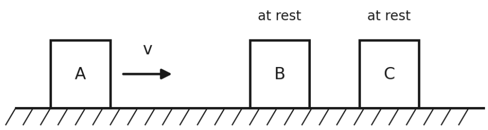
4. A block of mass 0.50 kg is moving with a speed of 2.00 m/s on a smooth surface. It strikes another block of mass 1.00 kg at rest and then the two move together as a single body. The energy loss during the collision is PYQ · AIEEE 2008

(A) 0.16 J (B) 1.00 J (C) 0.67 J (D) 0.34 J

5. A neutron (mass 1 u) moving with kinetic energy K makes a head-on *elastic* collision with a stationary carbon nucleus (mass 12 u). The fraction of its kinetic energy that the neutron **loses** is

(A) 12/169 (B) 48/169 (C) 121/169 (D) 1/13

6. Three identical blocks A, B, C lie in a line on a frictionless table. A moves with speed v towards B; B and C are at rest and are not touching each other. All collisions are elastic. After all collisions are over, the speeds of A, B, C are respectively

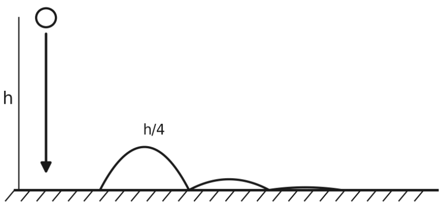


(A) 0, 0, v (B) 0, v/2, v/2 (C) v/3, v/3, v/3 (D) 0, v, 0

7. Two identical balls collide head-on. The coefficient of restitution is e = 1/3. Ball 1 was moving with speed u and ball 2 was at rest. The ratio of the speeds of ball 1 and ball 2 after the collision is

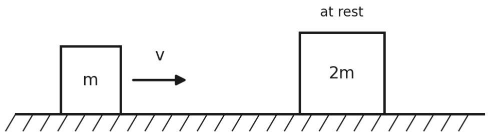
(A) 1 : 3 (B) 1 : 2 (C) 2 : 3 (D) 1 : 1

8. A ball is dropped from a height h on a horizontal floor and rises to a height h/4 after the first bounce. The **total distance** travelled by the ball before it finally comes to rest is JEE Main pattern



(A) 4h/3 (B) 5h/3 (C) 2h (D) 3h

9. A block of mass m moving with speed v hits a block of mass 2m at rest. The coefficient of restitution is e = 1/2. The impulse delivered to the 2m block is



(A) mv/2 (B) 2mv/3 (C) mv (D) 4mv/3

10. **Statement 1:** Two particles moving in the same direction do not lose all their energy in a completely inelastic collision.
Statement 2: Principle of conservation of momentum holds true for all kinds of collisions.
PYQ · AIEEE 2010

(A) Statement 1 is true, Statement 2 is true; Statement 2 is the correct explanation of Statement 1.

(B) Statement 1 is true, Statement 2 is true; Statement 2 is *not* the correct explanation of Statement 1.

(C) Statement 1 is false, Statement 2 is true.

(D) Statement 1 is true, Statement 2 is false.

Section B — One or more correct (Q11 – Q14)

11. Consider the following two statements for a system of particles: PYQ · AIEEE 2003 (adapted)
A. Linear momentum of the system is zero. **B.** Kinetic energy of the system is zero.
Then

(A) A implies B (B) B implies A

(C) A does not imply B (D) B does not imply A

12. A heavy body of mass M moving with speed u makes a head-on *elastic* collision with a light body of mass m (m ≪ M) at rest. Then, to a good approximation,

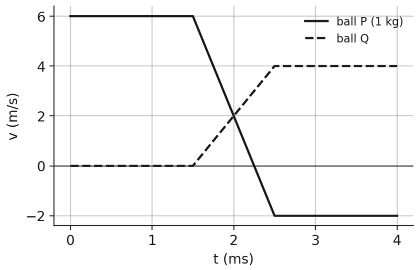
(A) the heavy body continues with speed ≈ u

(B) the light body moves off with speed ≈ 2u

(C) the light body moves off with speed ≈ u

(D) if instead the *light* body were the projectile hitting the heavy body at rest, it would rebound with almost the same speed

13. The velocity–time graphs of two balls P (mass 1 kg) and Q, which collide head-on, are shown. Positive direction is to the right. Which statements are correct?



(A) The mass of Q is 2 kg (B) The collision is perfectly elastic

(C) The impulse on Q is 8 N·s (D) Kinetic energy lost is 2 J

14. A body of mass m_1 moving with speed u hits a body of mass m_2 at rest, head-on, with coefficient of restitution e. Which of the following are correct?

(A) m_1 comes to rest after the collision only if $e = m_1/m_2$

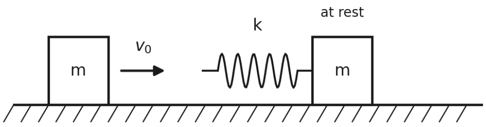
(B) m_1 can come to rest even if $m_1 > m_2$

(C) The loss of kinetic energy is $\frac{1}{2} [m_1 m_2/(m_1+m_2)] (1 - e^2) u^2$

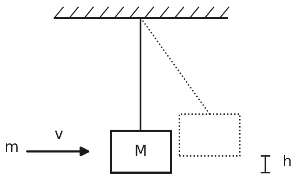
(D) The velocity of the centre of mass is the same before and after the collision for every value of e

Section C — Numerical / integer type (Q15 – Q19)

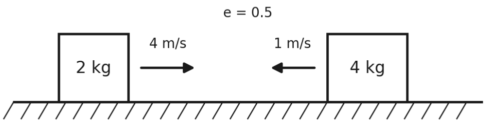
15. A block of mass m moving with speed v_0 on a smooth surface collides with an identical block that has a massless spring of stiffness k attached to it (figure). Find (a) the velocity of each block at the instant of maximum compression and (b) the maximum compression x of the spring. Express x in terms of v_0, m, k.



16. A bullet of mass 20 g moving horizontally at 400 m/s strikes a wooden block of mass 1.98 kg hanging from a light string and gets embedded in it (ballistic pendulum). Find (a) the height h to which the block rises, and (b) the percentage of the bullet's kinetic energy lost in the collision.

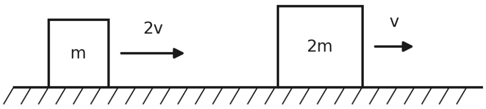


17. Two blocks of masses 2 kg and 4 kg approach each other on a smooth surface with speeds 4 m/s and 1 m/s respectively. The coefficient of restitution is 0.5. Find (a) the velocities of the two blocks after the collision, (b) the kinetic energy lost, and (c) the kinetic energy that *would* have been lost had the collision been perfectly inelastic.



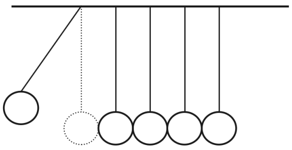
18. A ball of mass 1 kg moving at 12 m/s collides head-on with a ball of mass 2 kg at rest. After the collision the 2 kg ball moves at 5 m/s. Find the coefficient of restitution and the kinetic energy lost (in J). *(Integer answer for energy.)*

19. A body of mass m moving with speed 2v catches up with a body of mass 2m moving in the same direction with speed v and sticks to it. Find the common velocity and the loss in kinetic energy in terms of m and v.



Section D — Qualitative / short answer (Q20 – Q22)

20. In a Newton's cradle, one ball is pulled aside and released to strike four identical stationary balls. Only **one** ball flies off at the far end with the same speed. Explain, using conservation laws, why two balls cannot fly off with half the speed each, even though that would conserve momentum.



21. (a) Define the coefficient of restitution e for a head-on collision and state its value for perfectly elastic and perfectly inelastic collisions. (b) A body of mass m_1 collides head-on with a body of mass m_2 at rest. Show that the fraction of kinetic energy transferred to m_2 in a perfectly elastic collision is $4m_1m_2/(m_1+m_2)^2$, and hence explain why heavy water or graphite (not lead) is used as a moderator in a nuclear reactor.

22. "Momentum is conserved in a collision but the kinetic energy of the colliding bodies is not necessarily conserved." Explain the physical reason: what happens to the "lost" kinetic energy, and why is the total momentum unaffected by the same internal forces that cause the energy loss? Also explain why, during the brief compression phase of even a perfectly elastic collision, the total kinetic energy is momentarily less than its initial value.

Quick formulae (head-on, m_1 with u_1, m_2 with u_2): $v_1 = [(m_1 - e\, m_2)\, u_1 + (1+e)\, m_2\, u_2]/(m_1+m_2)$; $v_2 = [(m_2 - e\, m_1)\, u_2 + (1+e)\, m_1\, u_1]/(m_1+m_2)$;
$\Delta K = \frac{1}{2}\, \mu\, (1 - e^2)(u_1 - u_2)^2$, $\mu = m_1m_2/(m_1+m_2)$.