Lesson 8.5 Inelastic Collision In One Dimension

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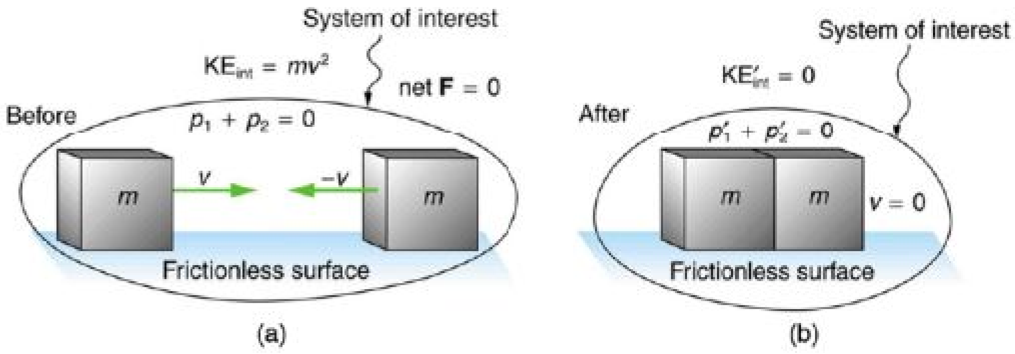
What is an inelastic collision?

An inelastic collision is when the internal kinetic energy is not conserved, or changes

- Internal Kinetic Energy is the sum of the kinetic energies of the objects in the system



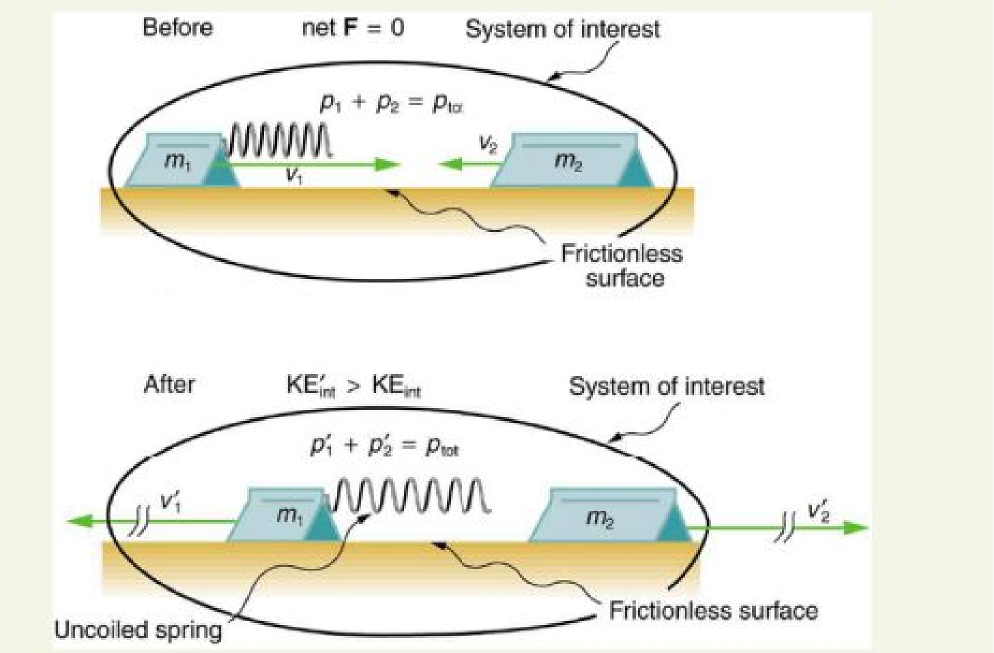
Perfectly Inelastic Collisions

A collision in which the objects stick together would be a perfect inelastic collision

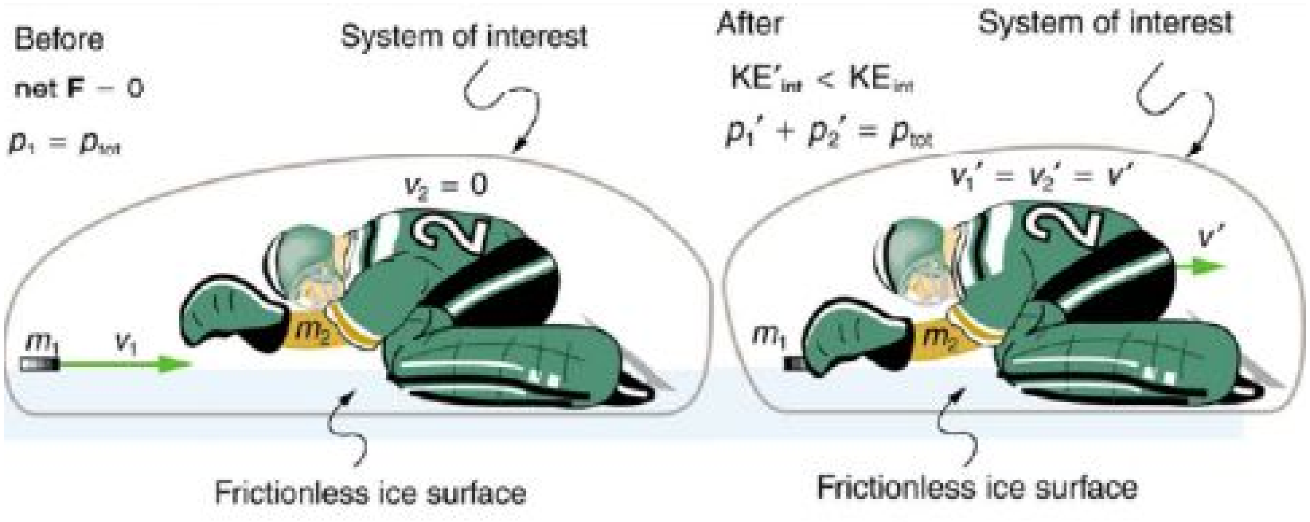
- It reduces internal kinetic energy more than any other type of inelastic collision
- Reduces internal kinetic energy to its minimum while still conserving momentum

Releasing stored energy

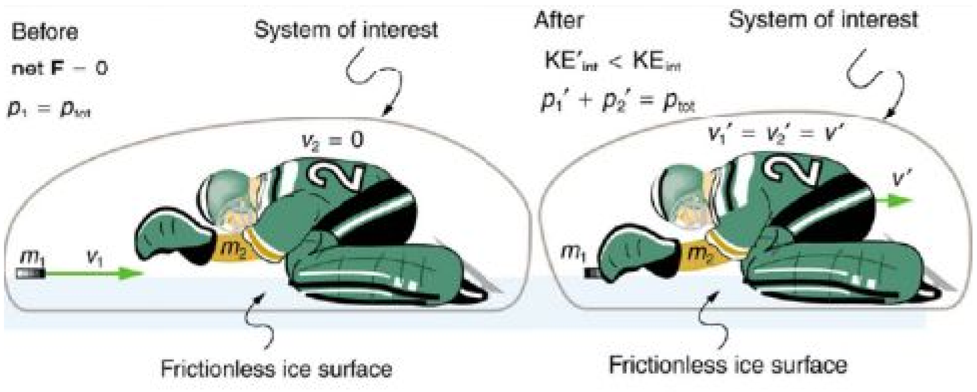
An inelastic collision can also release stored potential energy.



Example



An ice hockey goalie catches a hockey puck and recoils backwards. The initial kinetic energy of the puck is almost entirely converted to thermal energy and sound in this inelastic collision.



Find the recoil velocity of a 70.0 kg ice hockey goalie, originally at rest, who catches a 0.150 kg hockey puck slapped at him at a velocity of 35.0 m/s

Momentum is conserved because the net external force on the puck-goalie system is zero

$m_1v_1 + m_2v_2 = m_1v'_1 + m_2v'_2$

Because the goalie is initially at rest, we know $v_2 = 0$

Because the goalie catches the puck, the final velocities are equal

$m_1v_1 = (m_1 + m_2)\, v'$

$$v' = \left(\frac{0.150\text{ kg}}{70.0\text{ kg} + 0.150\text{ kg}}\right)(35.0\text{ m/s}) = 7.48\times10^{-2}\text{ m/s}.$$

HW Question 16

What is an inelastic collision? What is a perfectly inelastic collision?

An inelastic collision is when two objects collide and the internal kinetic energy is not conserved.   A perfectly inelastic collision is when the two objects stick together after the collision.

31. A 0.240-kg billiard ball that is moving at 3.00 m/s strikes the bumper of a pool table and bounces straight back at 2.40 m/s (80% of its original speed). The collision lasts 0.0150 s. (a) Calculate the average force exerted on the ball by the bumper. (b) How much kinetic energy in joules is lost during the collision? (c) What percent of the original energy is left?

HW Problem 31 (a)

$$net\ F = \frac{\Delta p}{\Delta t} = \frac{m\Delta v}{\Delta t} = \frac{m(v'_f - v_i)}{\Delta t} = \frac{(2.40\ kg)(-2.40\ m/s - 3.00\ m/s)}{0.015\ s} = -86.4\ N$$

Parts b and c

(b) initial KE = $\frac{1}{2}mv^2$ = ½ * 0.240kg * $(3m/s)^2$ = 1.08 J

final KE = ½ * 0.24kg * $(2.4m/s)^2$ = 0.6912 J

Lost KE = 0.389 J

(c) 0.6912 * 100% / 1.08 = 64%

(makes sense -- the speed is 80% of what it was, and the speed gets squared --

$80\%^2 = 64\%$

Problem 34

34. A battleship that is 6.00×10^7 kg and is originally at rest fires a 1100-kg artillery shell horizontally with a velocity of 575 m/s. (a) If the shell is fired straight aft (toward the rear of the ship), there will be negligible friction opposing the ship's recoil. Calculate its recoil velocity.

HW Problem 34

$V = -1100 \times 575 / (6 \times 10^7)$

$V = -.0014583$ m/sec or -1.4583 mm/s

Problem 43

43. During a circus act, an elderly performer thrills the crowd by catching a cannon ball shot at him. The cannon ball has a mass of 10.0 kg and the horizontal component of its velocity is 8.00 m/s when the 65.0-kg performer catches it. If the performer is on nearly frictionless roller skates, what is his recoil velocity?

HW Problem 43

$10*8 = (65 + 10) V$

$V = 80/75$

$V = 1.067 m/s$

Problem 37

37. Professional Application

Space probes may be separated from their launchers by exploding bolts. (They bolt away from one another.) Suppose a 4800-kg satellite uses this method to separate from the 1500-kg remains of its launcher, and that 5000 J of kinetic energy is supplied to the two parts. What are their subsequent velocities using the frame of reference in which they were at rest before separation?

HW Problem 37

By conservation of momentum: $m_1v_1 + m_2v_2 = 0 \Rightarrow v_2 = \dfrac{-m_1v_1}{m_2}$

By conservation of energy: $\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 = \Delta KE$, so that $m_1v_1^2 + m_2v_2^2 = 2\Delta KE$ or

$$m_1v_1^2 + m_2\frac{m_1^2v_1^2}{m_2^2} = 2\Delta KE$$

$$v_1 = \left(\frac{2\Delta KE}{m_1 + (m_1^2/m_2)}\right)^{1/2} = \left[\frac{2(5000\ \mathrm{J})}{4800\ \mathrm{kg} + [(4800\ \mathrm{kg})^2/1500\ \mathrm{kg}]}\right]^{1/2} = 0.7043\ \mathrm{m/s} = \underline{0.704\ \mathrm{m/s}}$$

(assuming three significant figure accuracy)

$$v_2 = \frac{-m_1v_1}{m_2} = \frac{-(4800\ \mathrm{kg})(0.7043\ \mathrm{m/s})}{1500\ \mathrm{kg}} = \underline{-2.25\ \mathrm{m/s}}$$

Problem 40

40. Professional Application

The Moon's craters are remnants of meteorite collisions. Suppose a fairly large asteroid that has a mass of 5.00×10^{12} kg (about a kilometer across) strikes the Moon at a speed of 15.0 km/s. (a) At what speed does the Moon recoil after the perfectly inelastic collision (the mass of the Moon is 7.36×10^{22} kg) ? (b) How much kinetic energy is lost in the collision? Such an event may have been observed by medieval English monks who reported observing a red glow and subsequent haze about the Moon. (c) In October 2009, NASA crashed a rocket into the Moon, and analyzed the plume produced by the impact. (Significant amounts of water were detected.) Answer part (a) and (b) for this real-life experiment. The mass of the rocket was 2000 kg and its speed upon impact was 9000 km/h. How does the plume produced alter these results?

HW Problem 40

$$m_m v_m + m_a v_a = \left(m_m + m_a\right) v'_m, \ \ given \ \ v_m = 0 \ \ m/s$$

$$v'_m = \frac{m_a v_a}{m_m + m_a} = \frac{\left(5.00\times10^{12}\ \ kg\right)\left(1.50\times10^{4}\ \ m/s\right)}{7.36\times10^{22}\ \ kg + 5.00\times10^{12}\ \ kg} = 1.019\times10^{-6}\ \ m/s\ \ = 1.02\times10^{-6} m/s$$