Momentum Conservation and Explosion Analysis

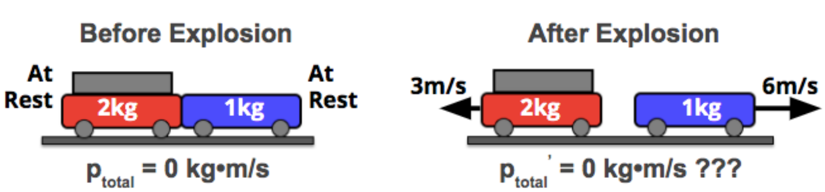
Lesson Notes

Focus Questions

- What is meant by saying that *momentum is conserved in an explosion*?
- How do you use the momentum conservation principle to solve Physics word problems involving explosions?

The Law of Momentum Conservation:

For any collision or explosion occurring in an isolated system, the total amount of momentum possessed by objects within the system is conserved (i.e., remains unchanged).



Before Explosion:
0 kg•m/s + 0 kg• m/s

After Explosion:
-6 kg•m/s + 6 kg•m/s

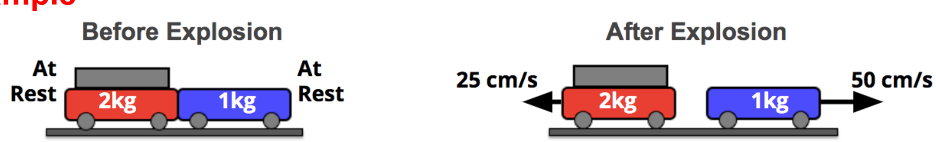
The force propelling the once at-rest carts into motion is an **internal force**. Thus the carts are part of an **isolated system**. Total system momentum is conserved in this explosion.

Tennis Ball Cannon Example

Consider a homemade tennis ball cannon that fires a tennis ball forward at high speed. During the explosion, there is an interaction between the cannon and the ball.

The ball experiences a Δmomentum of +100 units.
The cannon experiences a Δmomentum of -100 units.

Lab Cart Example



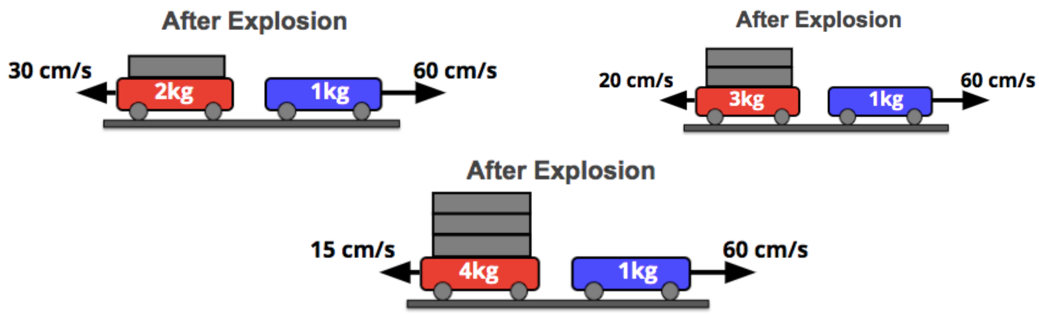
	p Before Explos'n	p After Explos'n	Δp
Red Cart	2•0 = 0 kg•cm/s	2•(-25) = -50 kg•cm/s	-50 kg•cm/s
Blue Cart	1•0 = 0 kg•cm/s	1•(+50) = +50 kg•cm/s	+50 kg•cm/s
System/Total	0 kg•cm/s	0 kg•cm/s	0 kg•cm/s

$p_{total} = p_{total}'$ $\quad\quad$ $\Delta p_1 = -\Delta p_2$

Explosions, Momentum Conservation, and Proportional Reasoning

For the after-explosion system momentum of the two carts to be 0, ….

- … the cart with ½ the mass must be moving with twice the velocity.
- … the cart with ⅓ the mass must be moving with three times the velocity.
- … the cart with ¼ the mass must be moving with four times the velocity.



Example Problem 1

A 54-gram tennis ball is at rest inside a 1300-gram stationary tennis ball cannon. The cannon is fired, causing it to recoil backward at 2.3 m/s. Determine the muzzle velocity of the tennis ball.

Known: m_{ball} = 54 g, m_{cannon} = 1300 g, Δv_{cannon} = -2.3 m/s
Determine v_{ball}

Use $m_{ball} \cdot \Delta v_{ball} = - m_{cannon} \cdot \Delta v_{cannon}$

$(54\text{ g}) \cdot \Delta v_{ball} = - (1300\text{ g}) \cdot (-2.3\text{ m/s})$

$\Delta v_{ball} = - (1300\text{ g}) \cdot (-2.3\text{ m/s}) / (54\text{ g})$

Δv_{ball} = 55 m/s ⇒ v_{ball} = 55 m/s

Example Problem 2

A 62.1-kg male ice skater is facing a 42.8-kg female ice skater, at rest on the ice. They push off each other and move in opposite directions. The female skater moves backwards with a speed of 3.11 m/s. Determine the post-impulse speed of the male skater.

Known: m_{male} = 62.1 kg, m_{female} = 42.8 kg, Δv_{female} = -3.11 m/s
Determine v_{male}

Use $m_{male} \cdot \Delta v_{male} = - m_{female} \cdot \Delta v_{female}$

$(62.1\text{ kg}) \cdot \Delta v_{male} = - (42.8\text{ kg}) \cdot (-3.11\text{ m/s}$

$\Delta v_{male} = - (42.8\text{ kg}) \cdot (-3.11\text{ m/s}) / (62.1\text{ kg})$

Δv_{male} = 2.14 m/s ⇒ v_{male} = 2.14 m/s