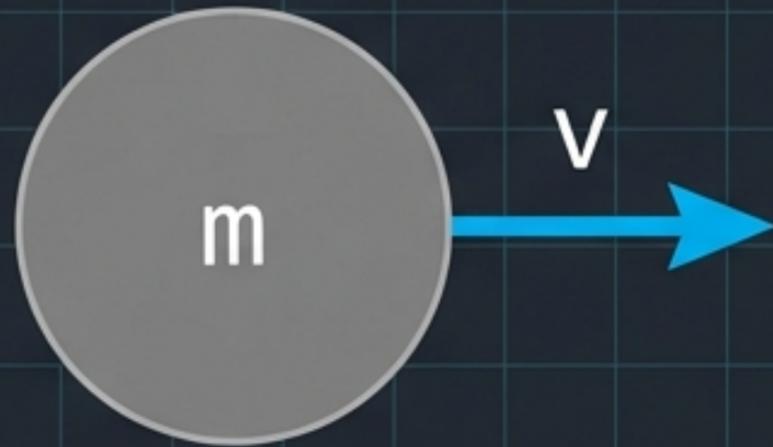


# Mechanics Playbook: Momentum & Impulse

A visual toolkit for cracking collisions, rebounds, and jerks.

# The Currency and The Transaction

(+) --->



Momentum ( $p$ )

The “currency” of motion.

$$p = mv$$

Units:  $\text{kg m s}^{-1}$  or  $\text{N s}$



Impulse ( $I$ )

The “transaction” that changes motion.

$$I = Ft$$

Units:  $\text{N s}$

# The Core Formula Map

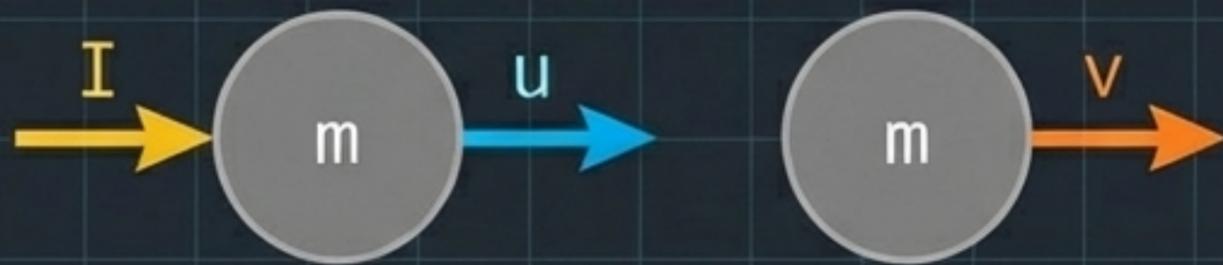
(+) --->

$$p = mv$$

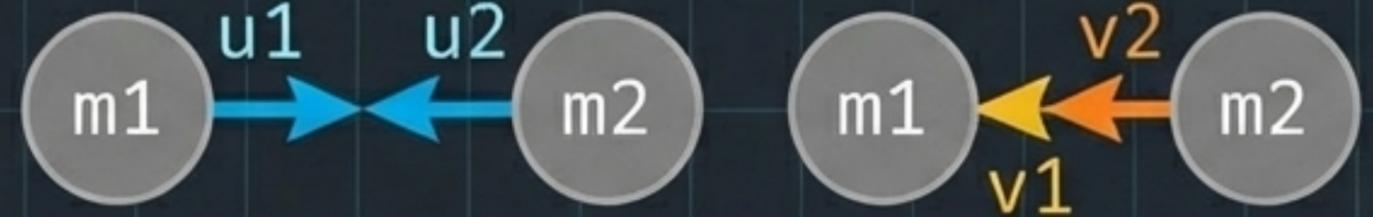
Impulse-Momentum Principle

$$I = mv - mu$$

Conservation Principle

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$


For tracking a single particle acting against an external force.

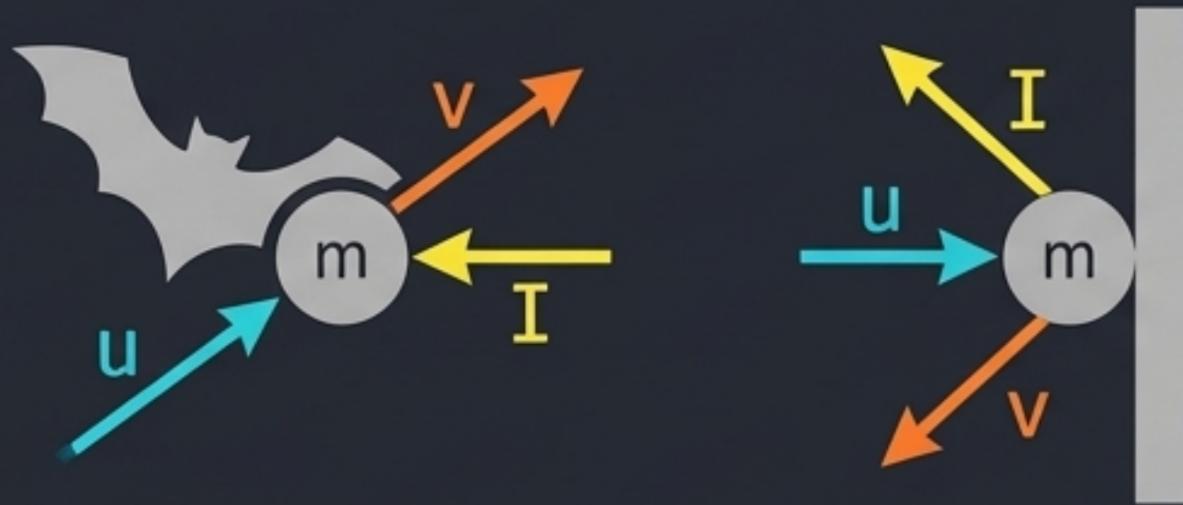


For tracking a closed system of multiple particles interacting.

# The Diagnostic Matrix

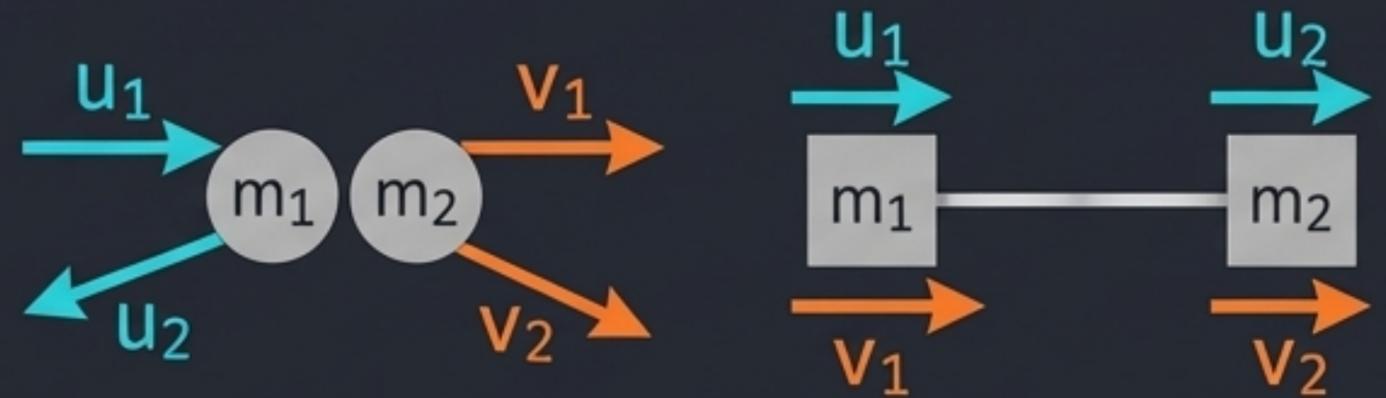
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External Forces  
(Use  $I = mv - mu$ )



- Focuses on one object.
- Involves bats, rackets, or rigid walls.
- Momentum is not conserved for the particle alone.

Internal Forces  
(Use  $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ )

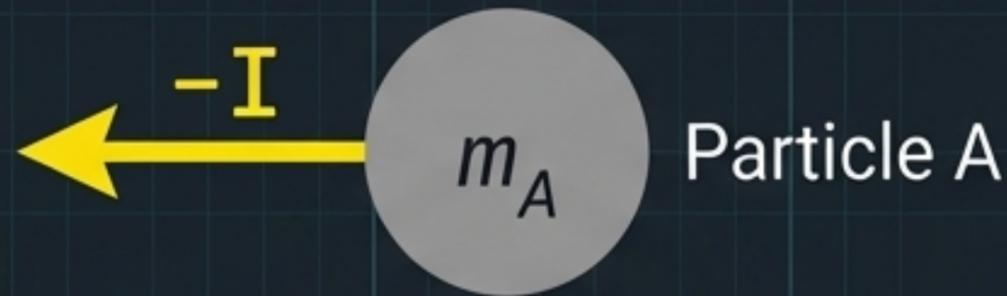


- Focuses on closed systems.
- Involves collisions between free objects or strings jerking taut.
- Total momentum is conserved.

# The Synthesis: Why Momentum is Conserved

(+) ---->

By Newton's 3rd Law, colliding bodies exert equal and opposite impulses. When we look at the whole system, the impulses cancel out perfectly. The net change is zero.



$$-I = m_A v_A - m_A u_A$$



$$+I = m_B v_B - m_B u_B$$

+

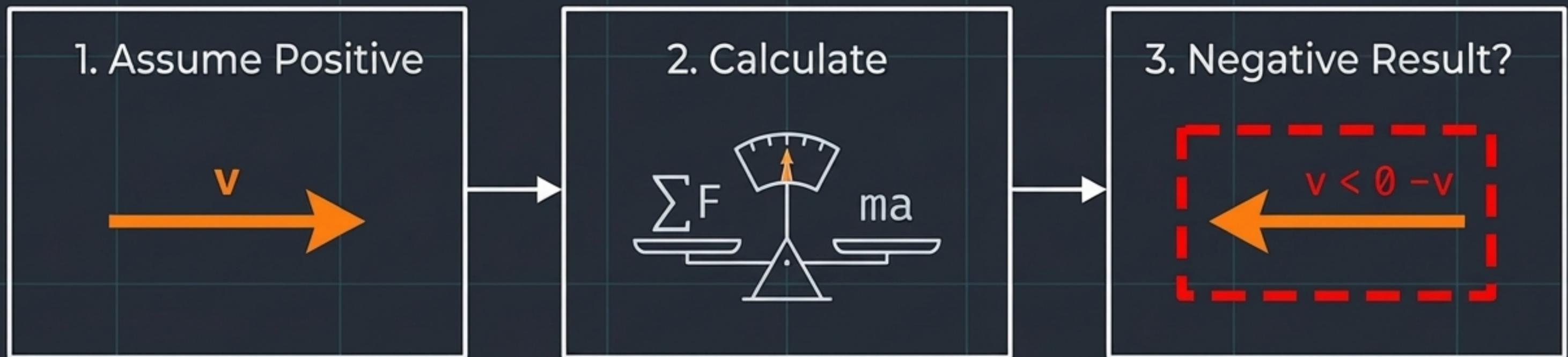


$$0 = (m_A v_A - m_A u_A) + (m_B v_B - m_B u_B)$$

(+) →

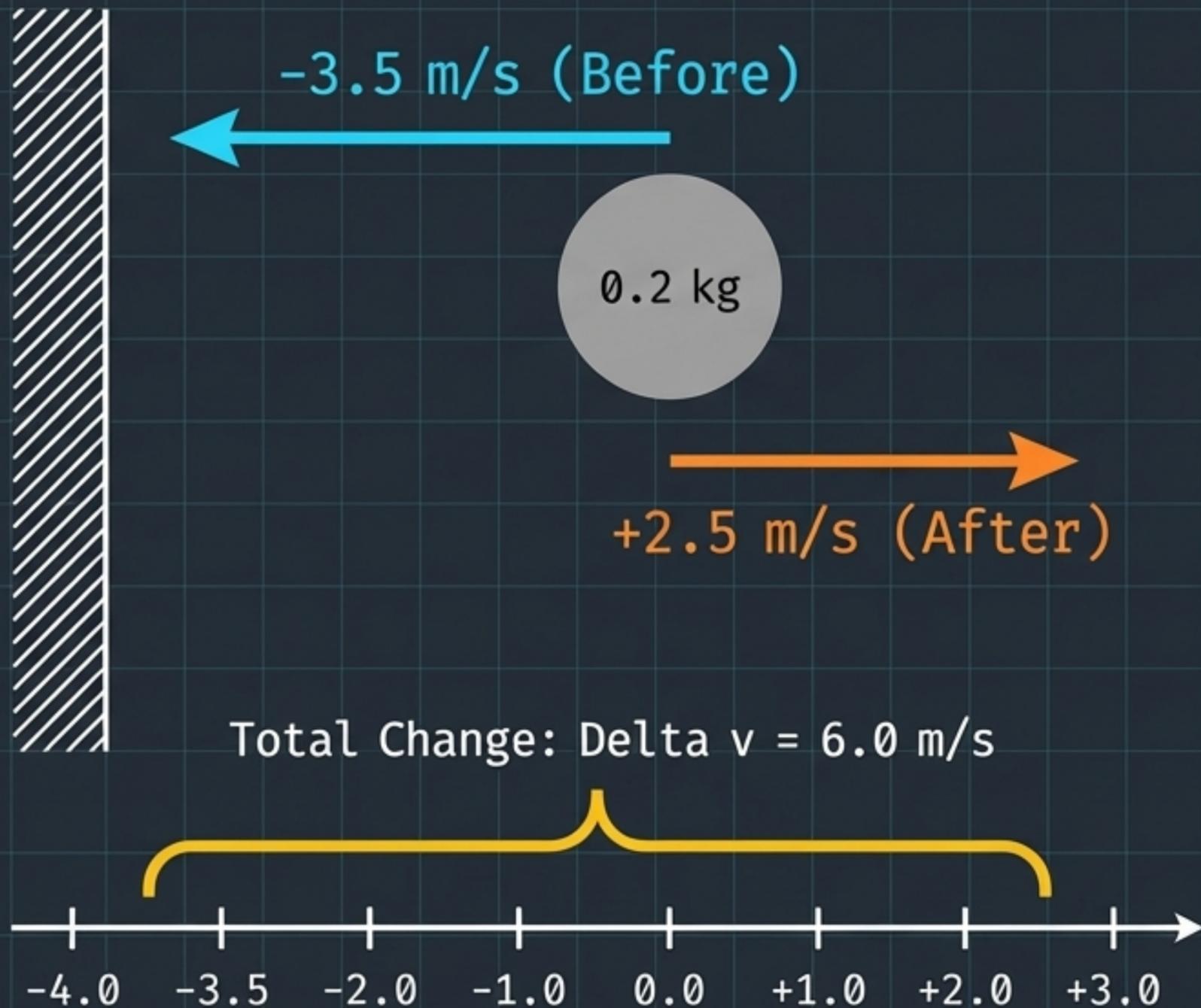
# The 'Sign Guessing' Algorithm

Don't know which way a particle bounces? Always write the unknown velocity ( $v$ ) as positive in your equation. If the algebra yields a negative number, your particle reversed direction.



# The Arena: The Wall Rebound

(+) →



Equation: Impulse  $I = mv - mu$

$$I = (0.2 * 2.5) - (0.2 * -3.5)$$

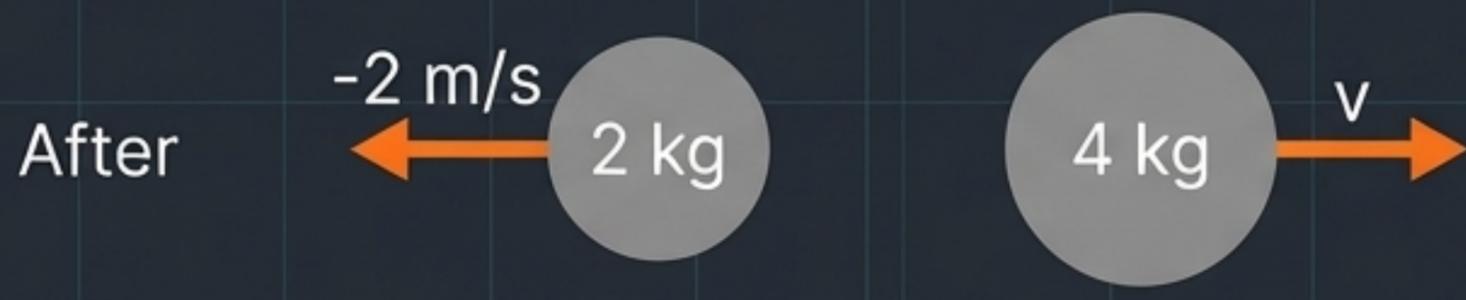
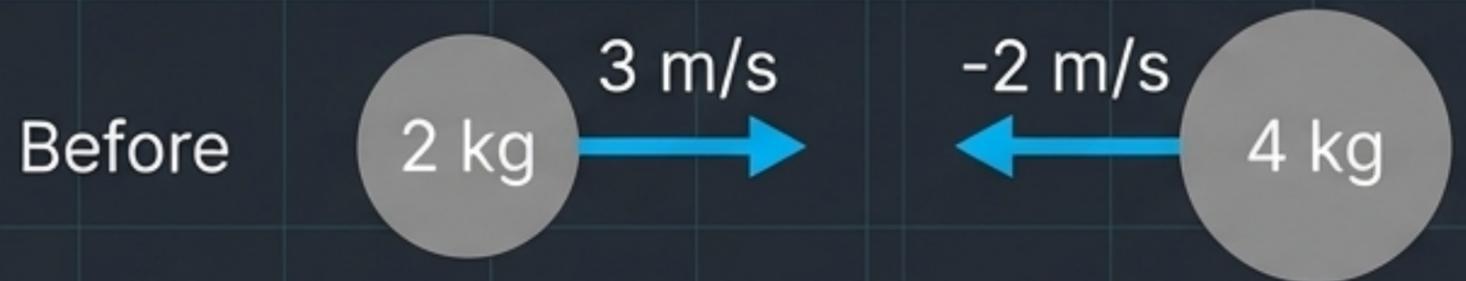
$$I = 0.5 + 0.7$$

$$I = 1.2 \text{ N s}$$

**Key Takeaway:** Rebounding requires more impulse than just coming to a dead stop. Watch your negative signs!

# The Arena: Two-Particle Collisions

(+) ---->

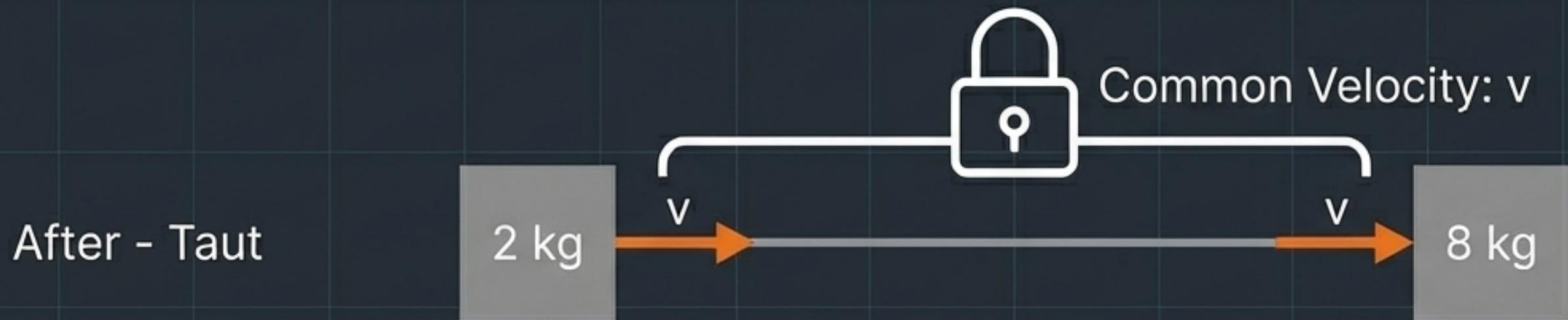
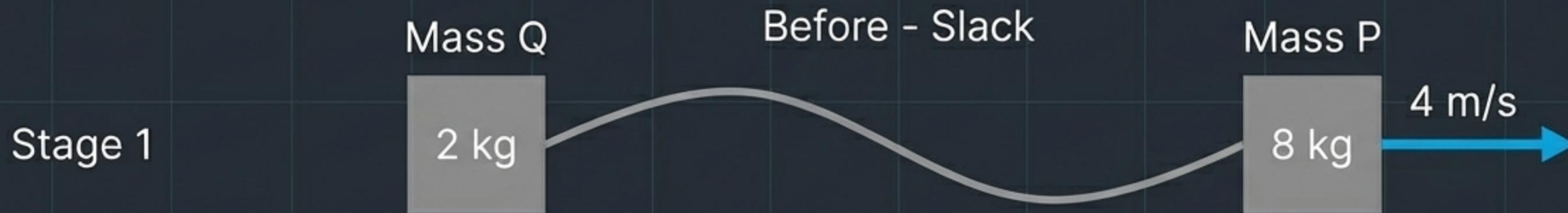


$$m_A u_A + m_B u_B = m_A v_A + m_B v_B$$
$$(2 * 3) + (4 * -2) = (2 * -2) + 4v$$
$$6 - 8 = -4 + 4v$$
$$2 = 4v$$
$$v = 0.5 \text{ m/s}$$

# The Arena: The Jerk String

(+) --->

When an inextensible string goes taut, both particles instantly share the same common velocity ( $v$ ). Lock them together.



$$(2 * 0) + (8 * 4) = 2v + 8v$$

$$32 = 10v$$

$$v = 3.2 \text{ m/s}$$

# The Master Problem-Solver's Workflow

(+) --->

