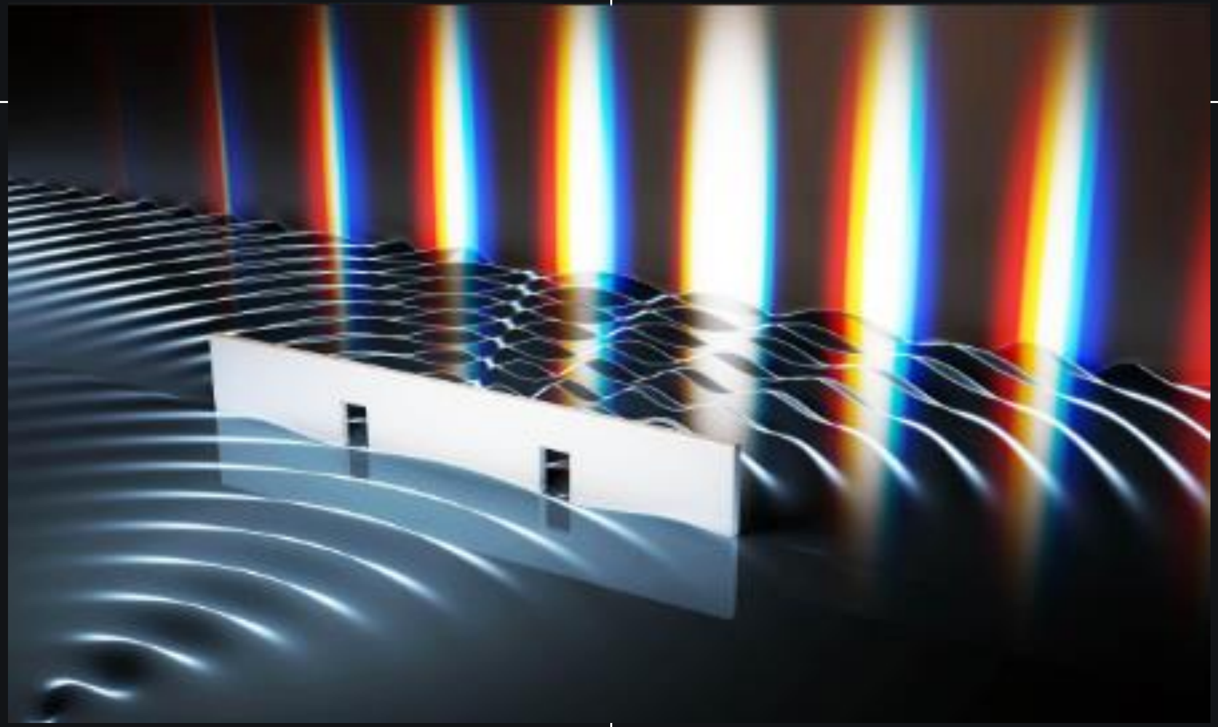
Physics for Physics Teacher 1



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PHYSICS LECTURE SERIES

Momentum and Collision

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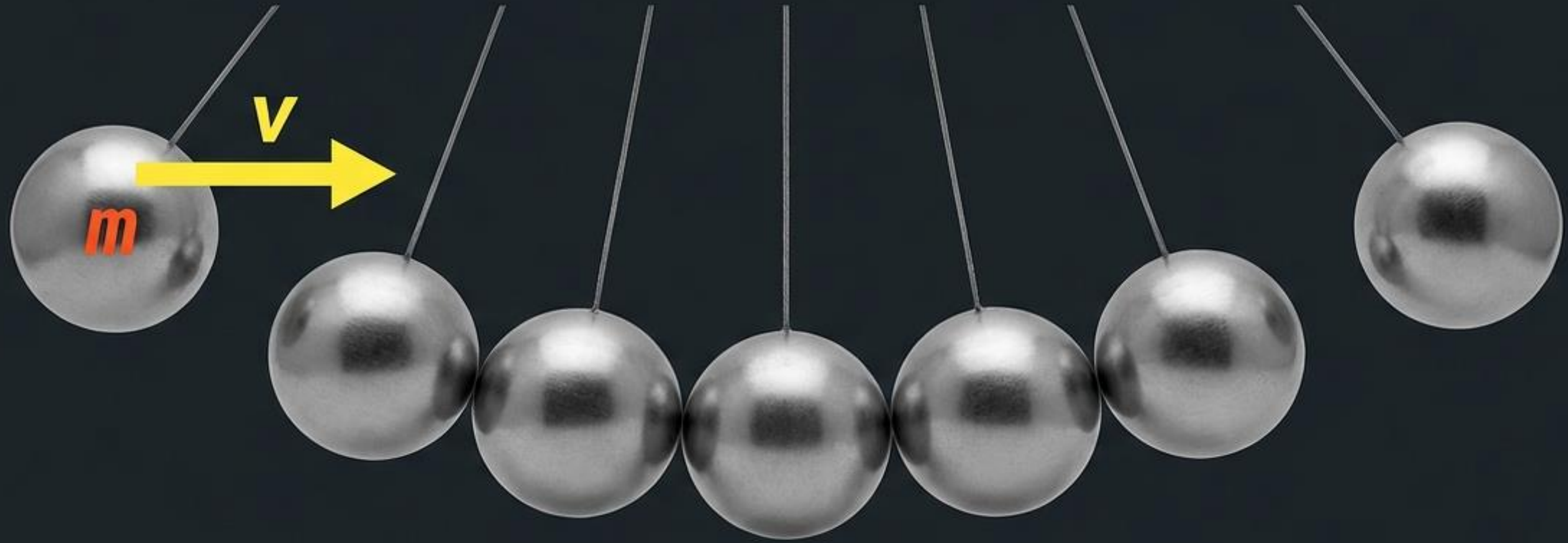
COORD: 13.7563° N, 100.5018° E // REF: PHYS_MOD_06

Momentum & Collisions

From the properties of a single object
to the laws of interacting systems.

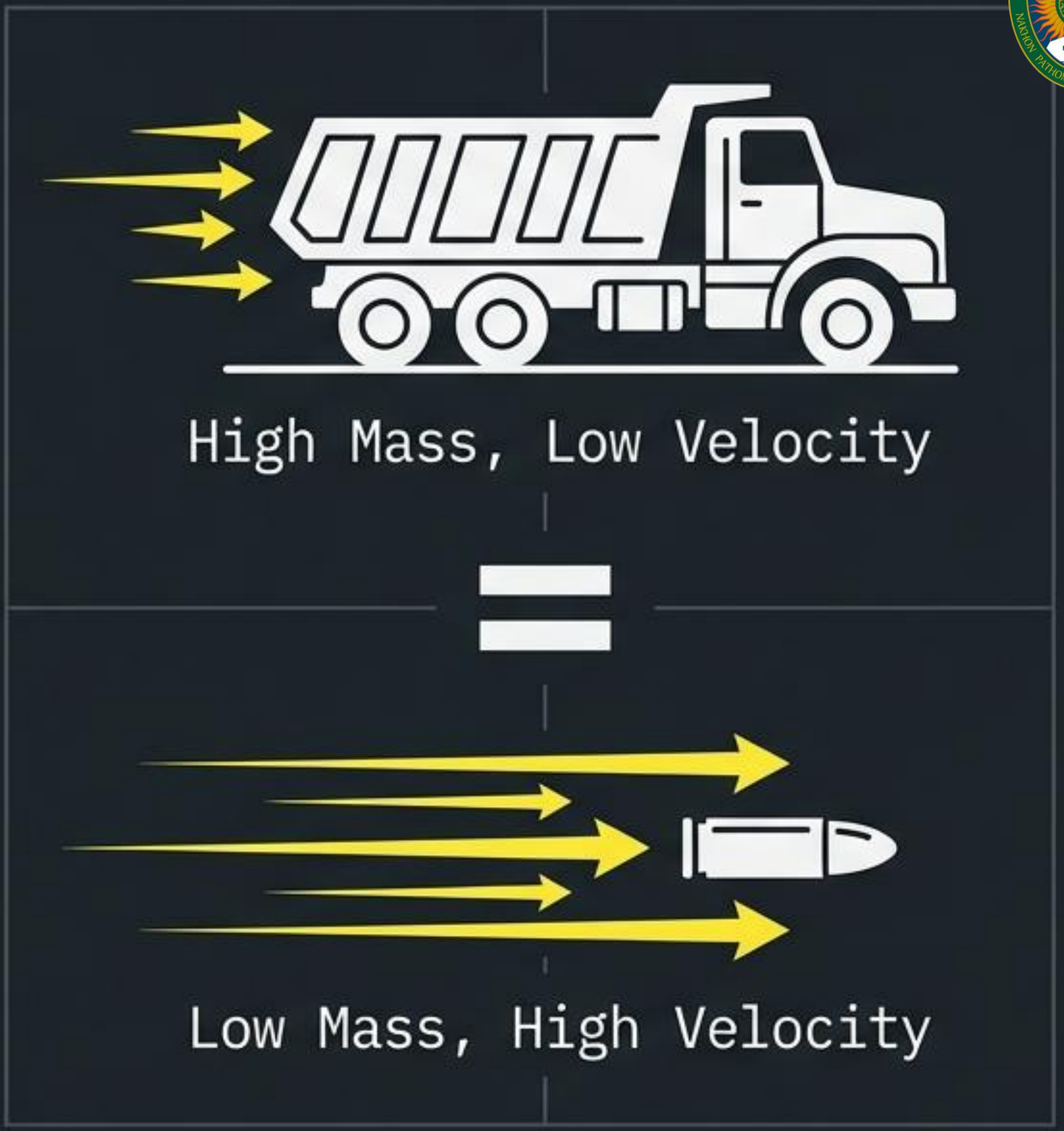


$$\vec{p} = m\vec{v}$$

DEFINITION: Mass in Motion

UNIT: kg·m/s

NOTE: Vector Quantity.
Direction is critical.



Vector Alert: Velocity to the right is (+). Velocity to the left is (-).

Force is the Rate of Change

Step 1: $F = ma$ Newton's Second Law

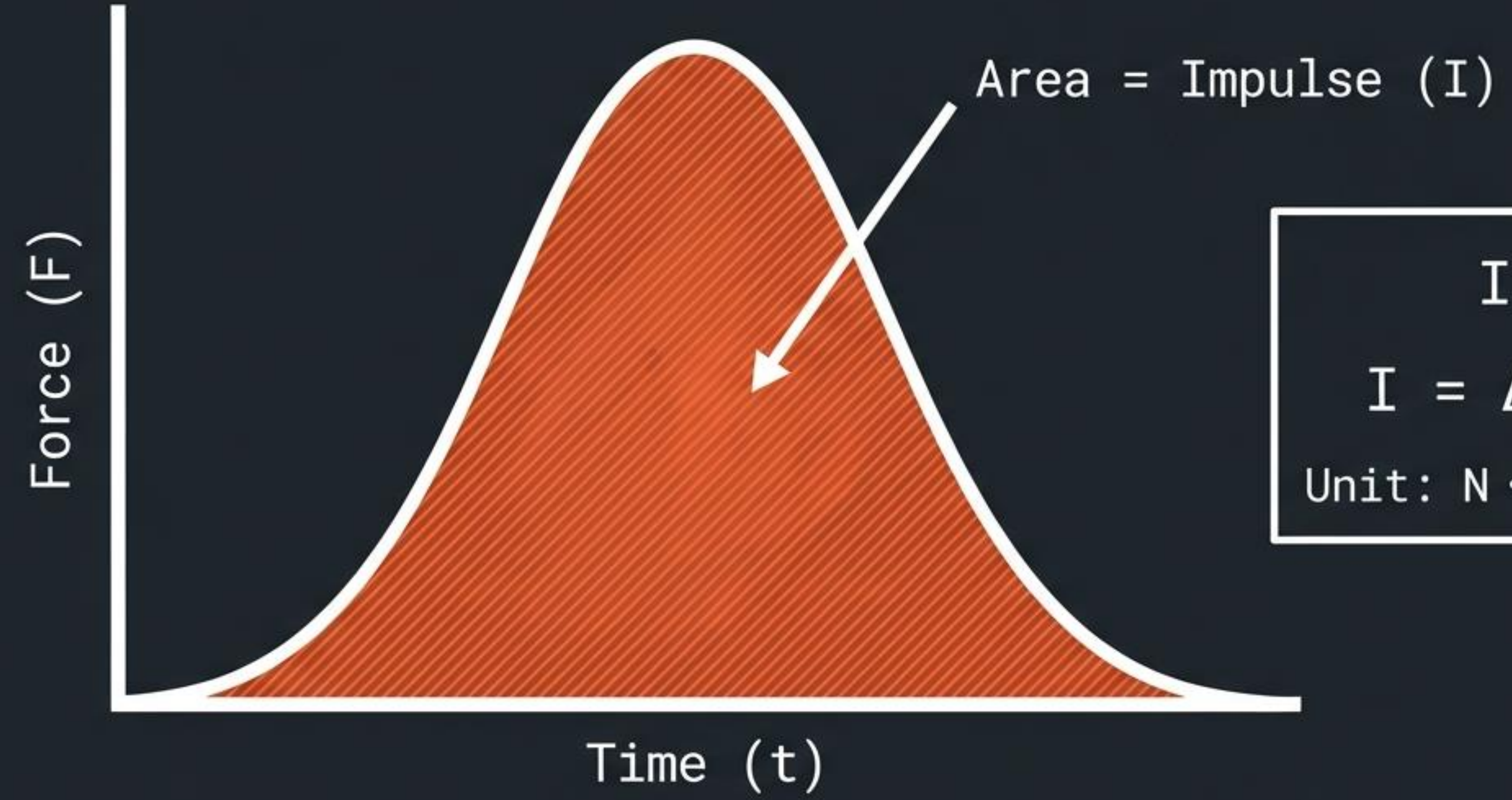
Step 2: $F = m\left(\frac{\Delta v}{\Delta t}\right)$ Acceleration is change in velocity over time

Step 3: $F = \frac{m\Delta v}{\Delta t}$

$$\boxed{F = \frac{\Delta p}{\Delta t}}$$

To change momentum quickly, you need a large Force.

Impulse (I): The Interaction



$$I = F_{avg} \cdot \Delta t$$

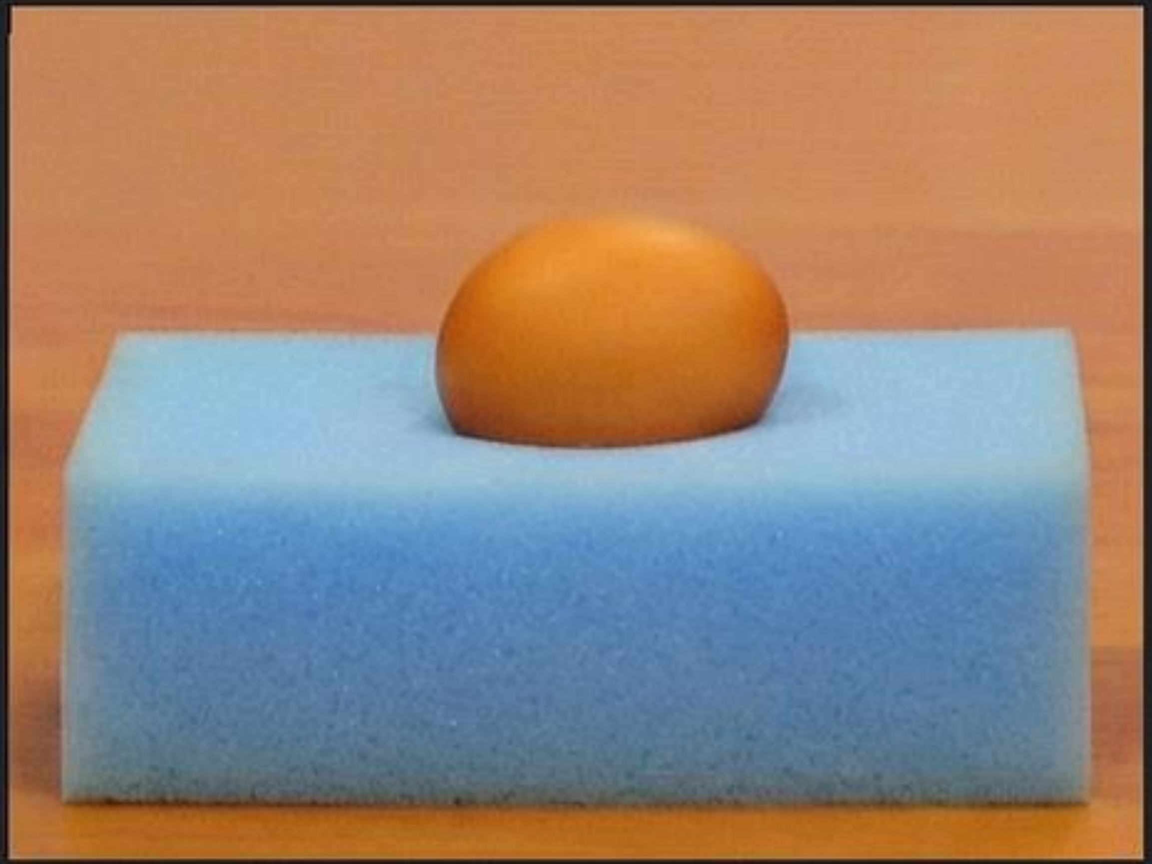
$$I = \Delta p = m(v - u)$$

Unit: N · s (Newton-seconds)

Pro-Tip: A variable force can be averaged (F_{avg}) to simplify calculations.

The Physics of Safety

$$F = \frac{\Delta p}{\Delta t}$$



Short Δt

Roboto Mono

Small Time = High Impact Force

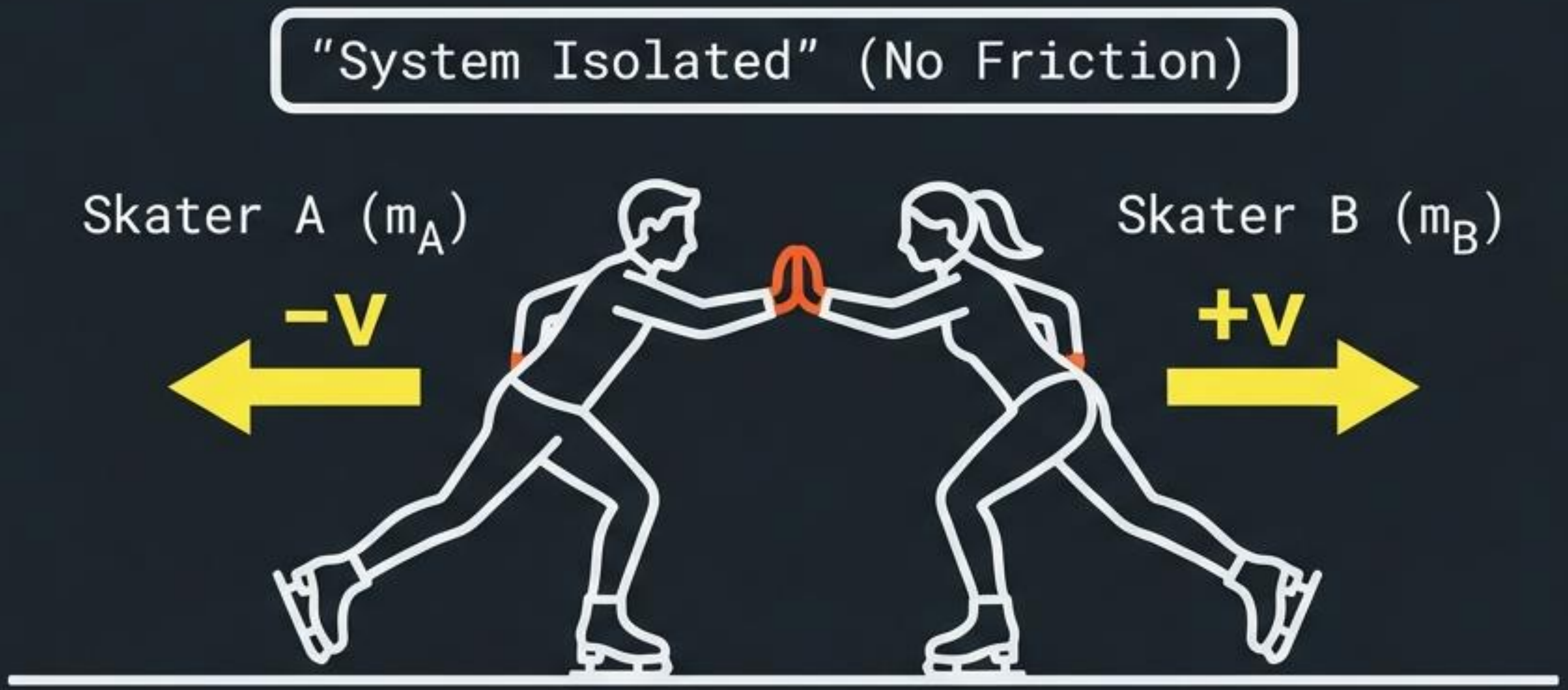
Long Δt

Roboto Mono

Extended Time = Low Impact Force

Airbags, helmets, and sponges work by extending the contact time of a collision.

Law of Conservation of Momentum

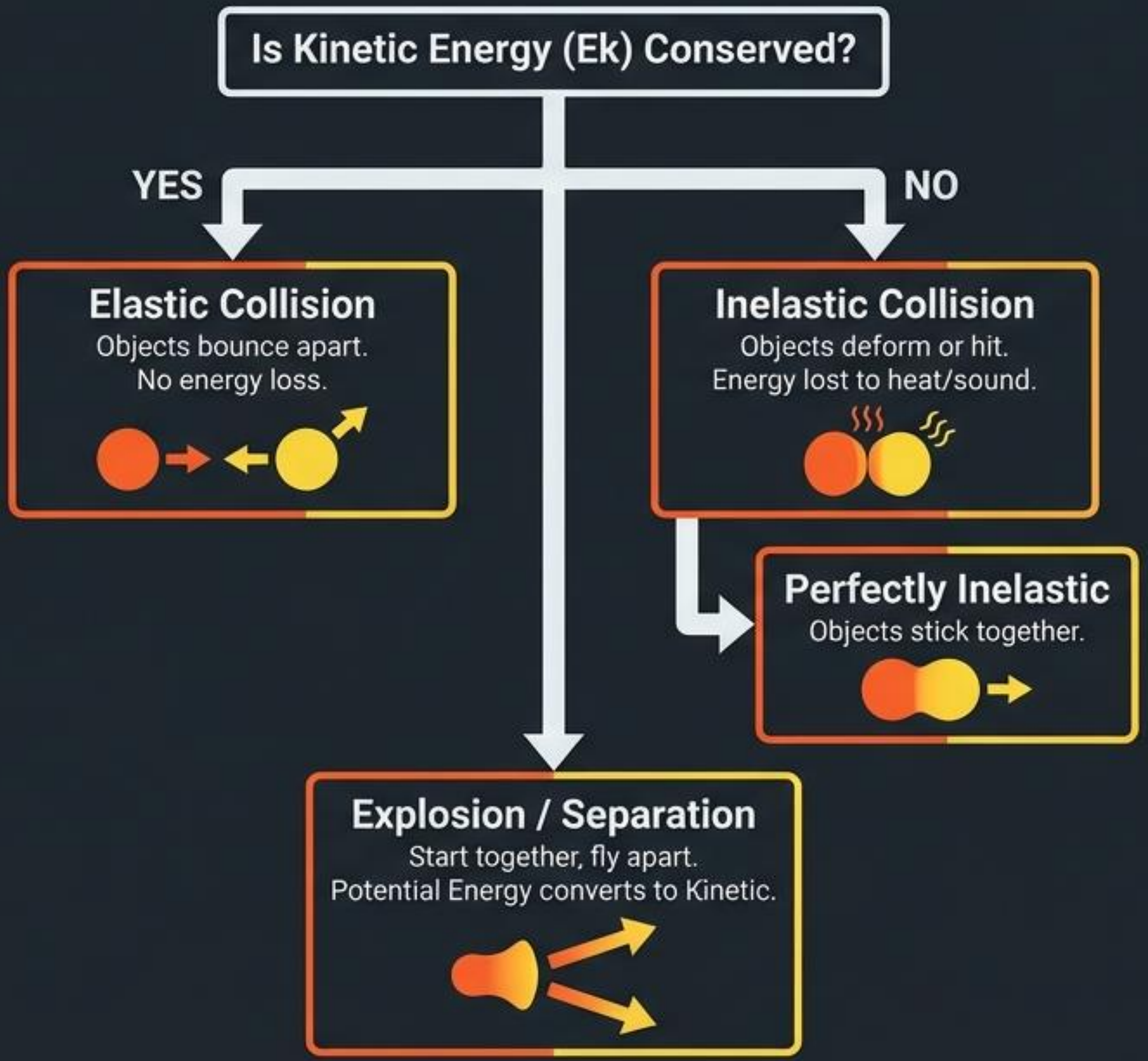


In any interaction between objects in an isolated system, the total momentum remains constant. What one object loses, the other gains.

$$\Sigma p_{initial} = \Sigma p_{final}$$

Total Momentum Before = Total Momentum After

Types of Interactions in 1D



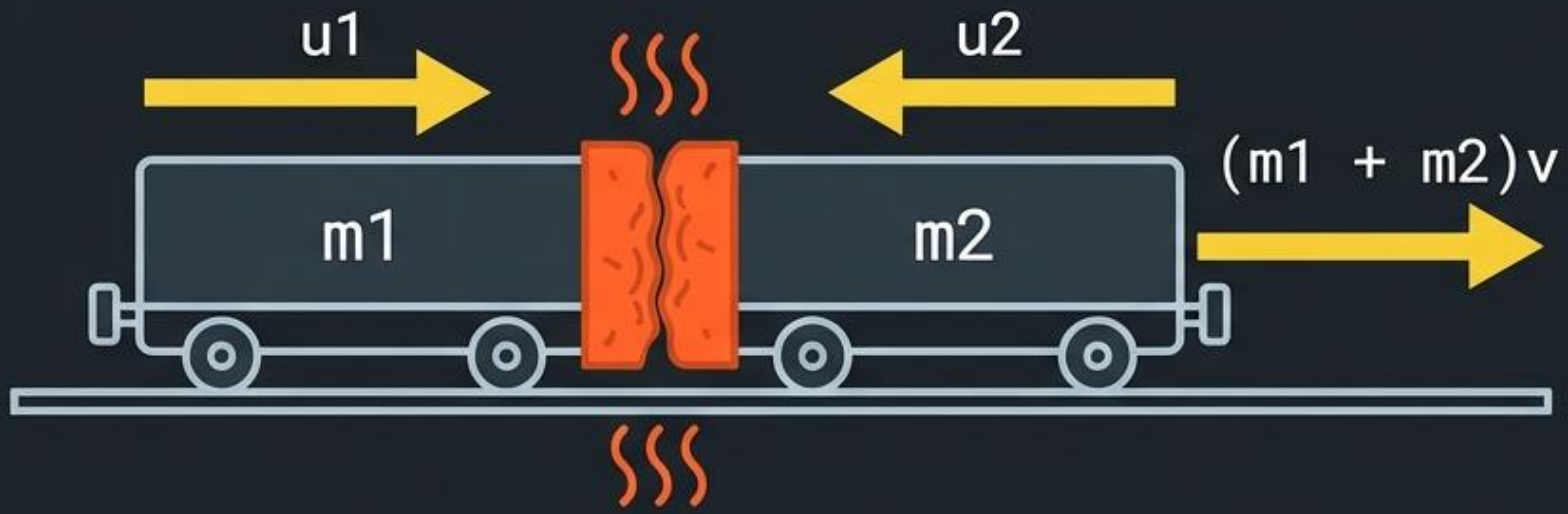
Elastic Collisions

	Momentum (p)
✓	Conserved ($\Sigma\ p_i = \Sigma\ p_f$)
	Kinetic Energy (Ek)
✓	Conserved ($\Sigma\ Ek_i = \Sigma\ Ek_f$)

$$\tfrac{1}{2}\, m1 \cdot u1^2 + 1/2\ m2 \cdot u2^2 = 1/2\ m1 \cdot v1^2 + 1/2\ m2 \cdot v2^2$$

Real World Examples: Ideal gas molecules, hard steel balls.

Inelastic Collisions



Perfectly Inelastic (Objects Stick)

$$m1 \cdot u1 + m2 \cdot u2 = (m1 + m2)v$$

Objects move as one combined mass.

Momentum (p)

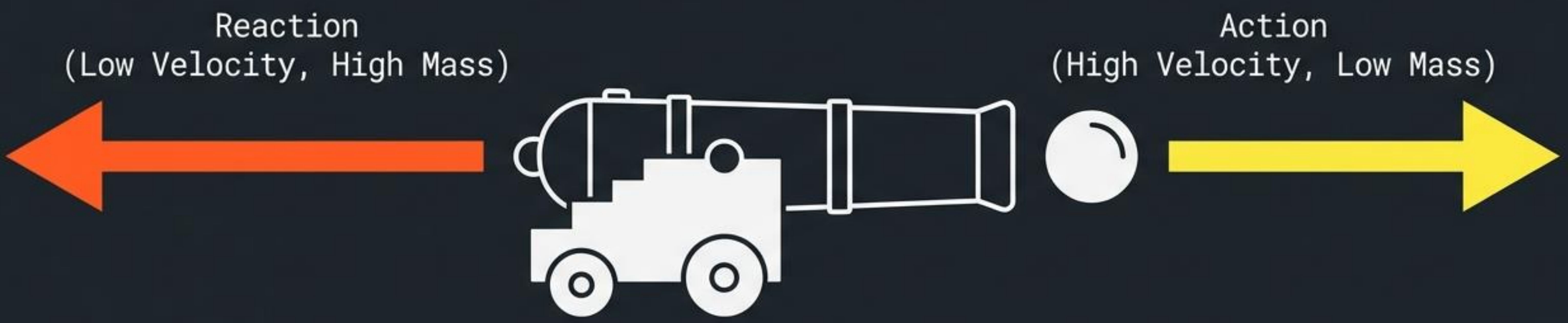
✓ Conserved
$(\sum p_i = \sum p_f)$

Kinetic Energy (Ek)

✗ NOT Conserved
(Energy lost to deformation/heat).

$$\sum Ek_i > \sum Ek_f$$

Explosions & Recoil



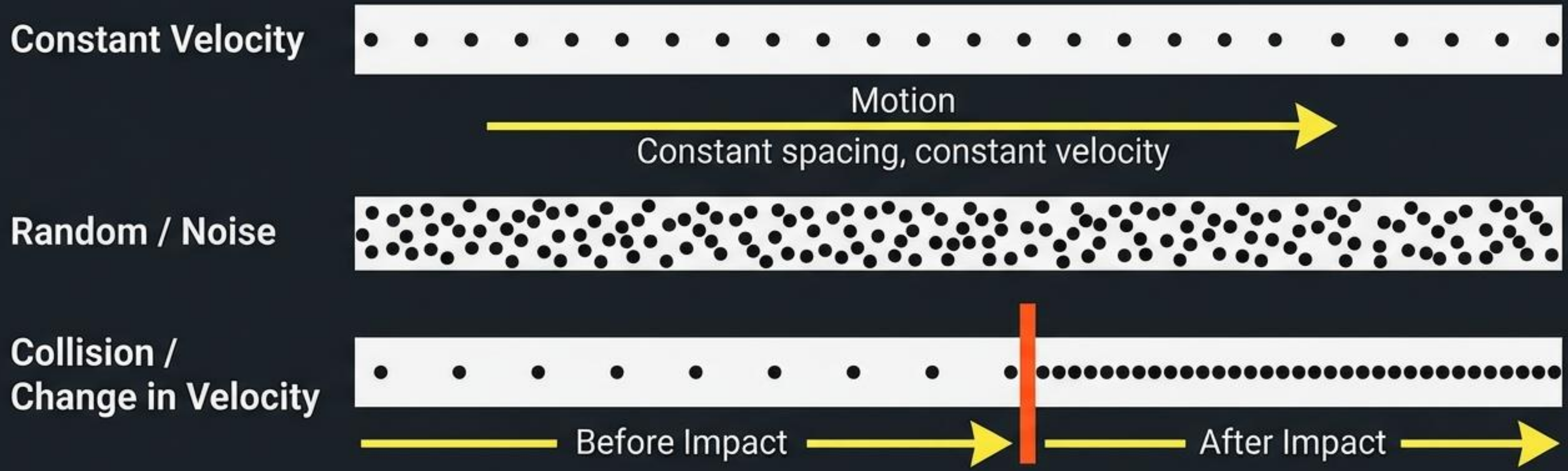
Initial Momentum: 0

Final Momentum: $p_{forward} + p_{backward} = 0$

Therefore: $m_{gun} \cdot v_{gun} = -(m_{bullet} \cdot v_{bullet})$

To launch a small mass forward at high speed, the larger mass must recoil backward to conserve momentum.

Lab Analysis: Reading Ticker Tape



Skill Check

Formula: $v = \Delta x / \Delta t$
Time Interval (Standard Lab Timer): 0.02s (50Hz)
Measure the distance between dots to calculate velocity before and after impact.

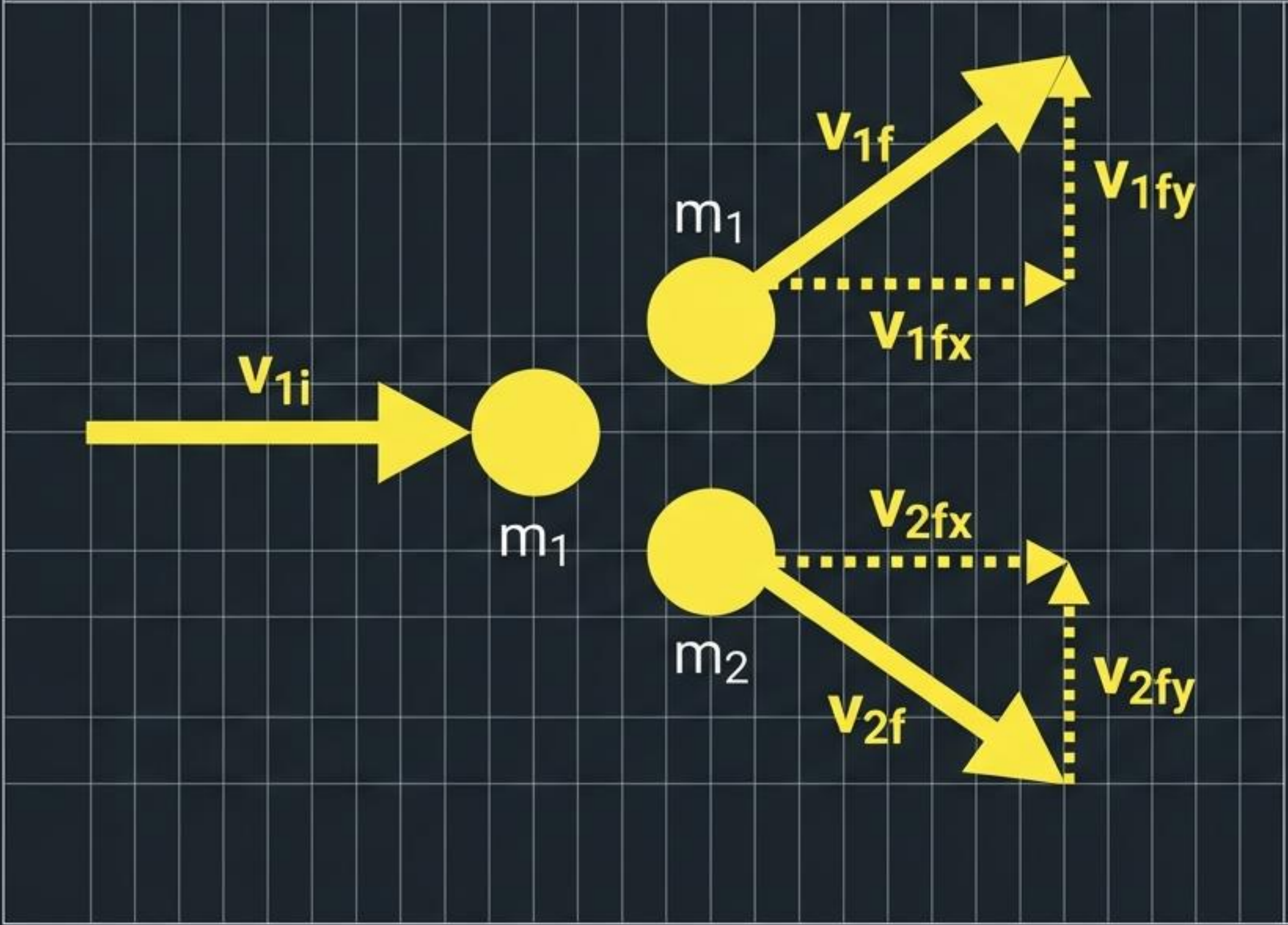
Problem Solving Strategy: 1D Collisions

1. **Sketch:** Draw 'Before' and 'After' states.
2. **Define Direction:** Establish the positive axis.
3. **Choose Law:** Conservation of Momentum (Σp) or Impulse ($F\Delta t$)?
4. **Solve:** Plug in values.

Common Pitfall: Watch the Signs! A ball bouncing BACK has a NEGATIVE velocity. Forgetting the (-) sign is the #1 error.

Helvetica Now Display

2D Collisions: X and Y Independence



Roboto Mono

Momentum is conserved independently in each axis.

X-Axis: $\sum p_{ix} = \sum p_{fx}$

Y-Axis: $\sum p_{iy} = \sum p_{fy}$

Resultant Velocity: Use Pythagoras ($a^2 + b^2 = c^2$) to combine X and Y vectors.

Cheat Sheet: Key Formulas

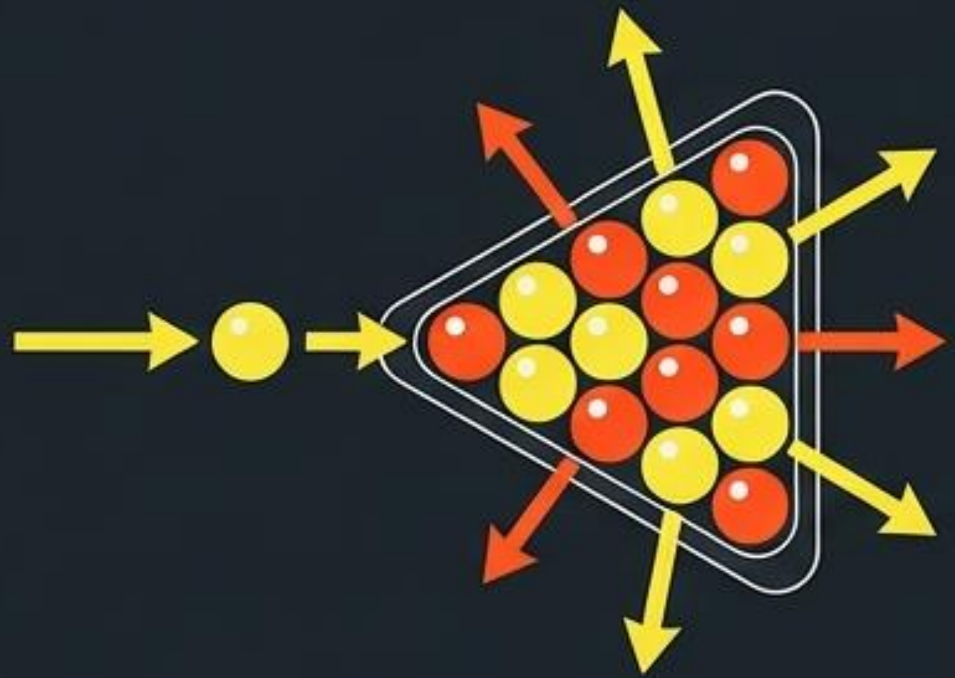
Study Reference

Quantity	Type	Units	Formula
Momentum (p)	Vector	kg · m/s	$p = mv$
Impulse (I)	Vector	N · s	$I = F_{avg} \cdot t = \Delta p$
Kinetic Energy (Ek)	Scalar	Joules (J)	$Ek = \frac{1}{2}mv^2$
Conservation Law	System	-	$\sum p_{before} = \sum p_{after}$

Momentum Explains Interaction

Propulsion/Recoil

Safety/Impulse



Collision/Transfer

Whether engineering safer cars, analyzing sports, or launching rockets, the principle remains: Mass in motion is a quantity that cannot be destroyed, only transferred.