

CHAPTER 4 • LAWS OF MOTION

Newton's First Law Of Motion

The foundational blueprint of inertia, rest, and uniform motion.

The Law Of Inertia

Every body continues to be in its **state of rest** or of **uniform motion** in a straight line unless compelled by some **external force** to act otherwise.

LOGICAL
TRANSLATION

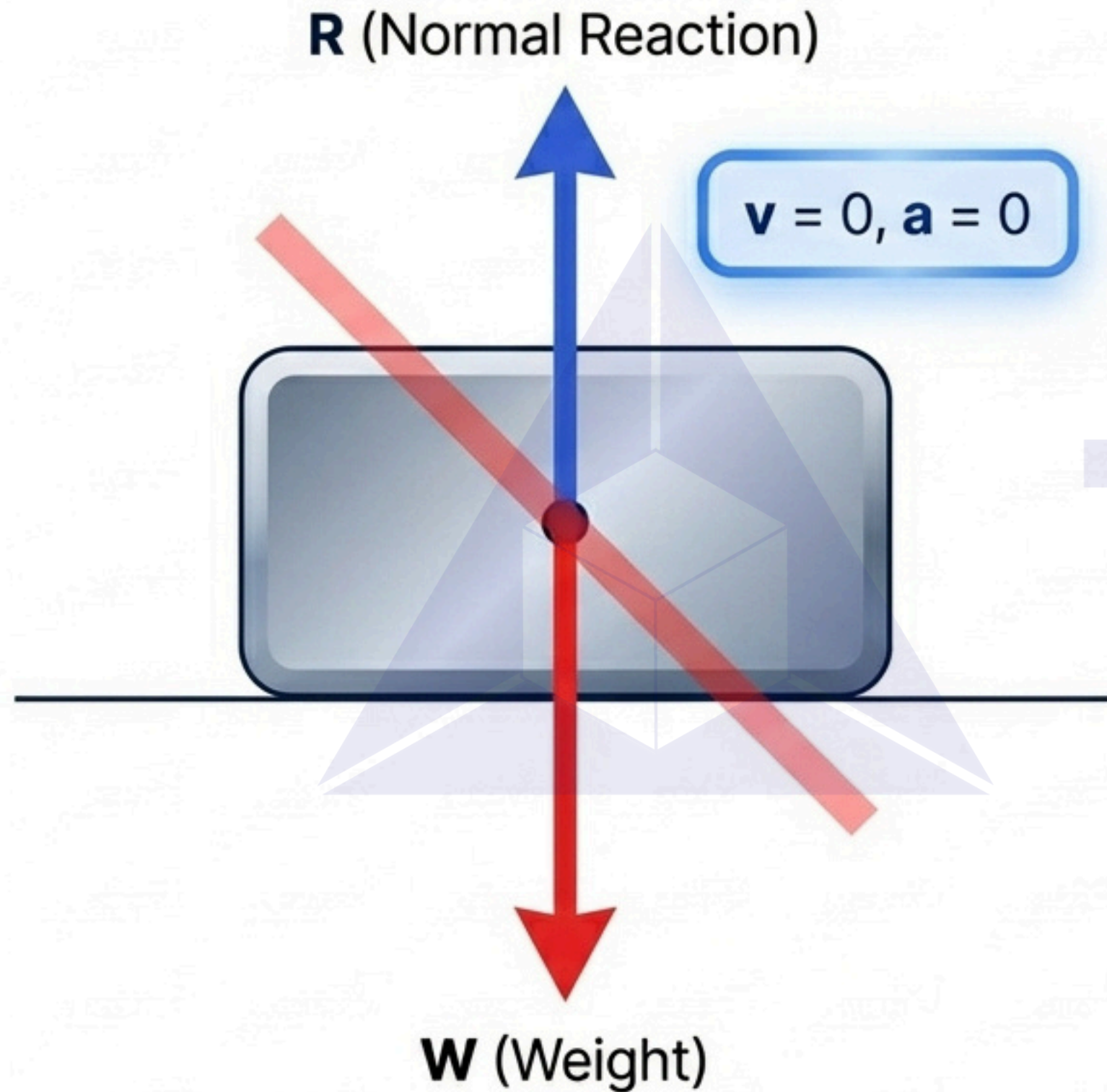
$$\sum F_{\text{ext}} = 0 \iff a = 0$$

Exam Tip

Acceleration is zero ONLY if net external force is zero.

CONDITION 1

The State Of Rest



- An object at rest is NOT free of forces. Gravity is always acting.
- Rest simply means the net external force cancels out to exactly zero.

EXAM TRICK

"We don't say "**W** = **R**, so the book is at rest."
We say "The book is at rest, therefore
 $\mathbf{F}_{\text{net}} = 0$, which means **R** must equal **W**."



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$$E=mc^2$$



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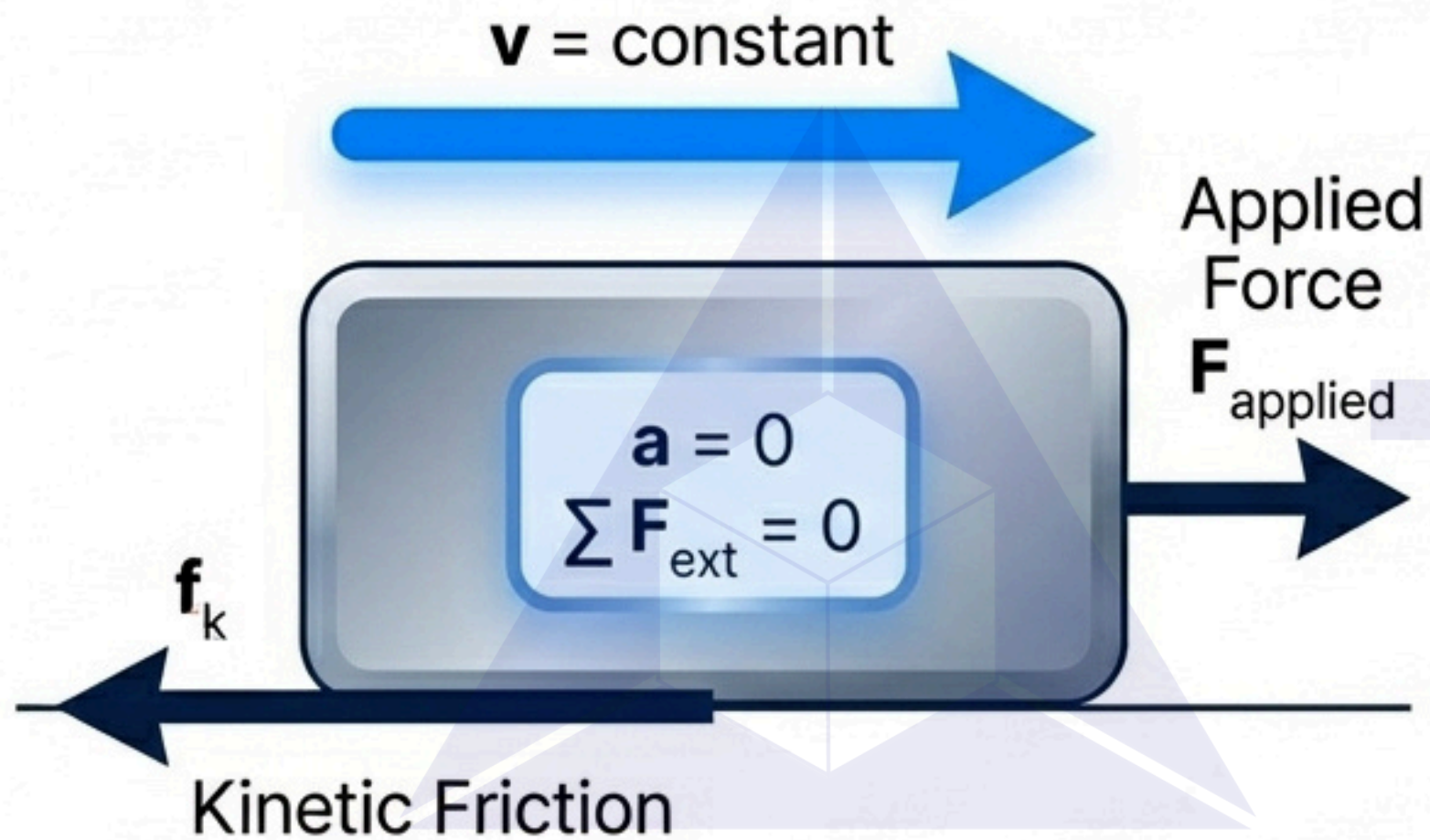


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CONDITION 2

Uniform Motion Needs No Net Force

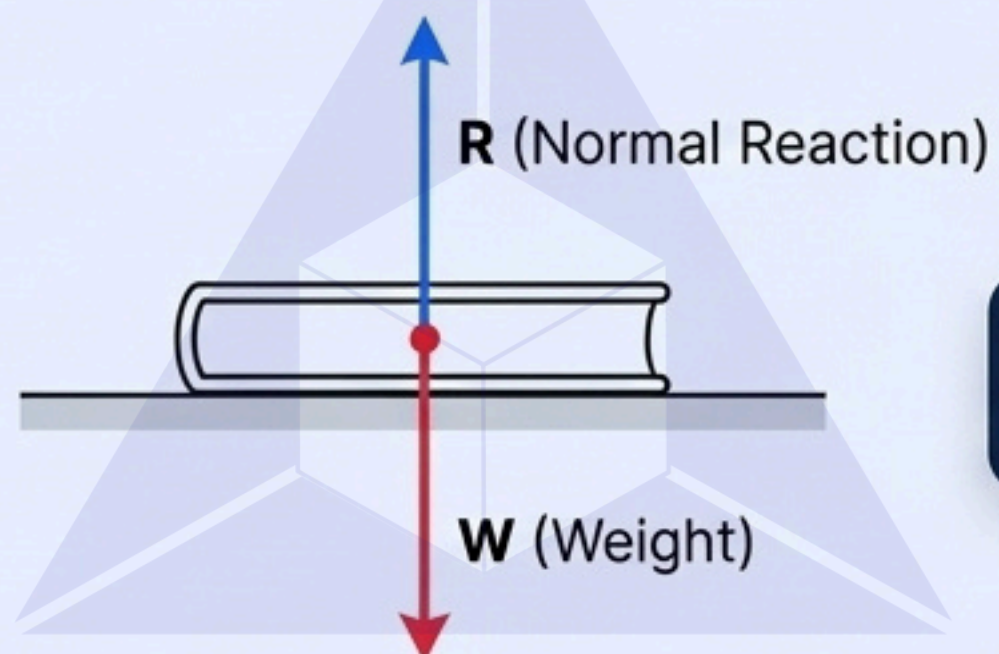
- **Aristotle's Fallacy:** Believing a net force is needed to keep a body moving.
- **The Reality:** We only apply force to counter opposing forces (like friction).
- If friction didn't exist, a moving body would continue forever with zero applied force.

CONCEPT CHECK

Force changes velocity; it is not required to maintain it.

Unifying Figure 4.2 Examples

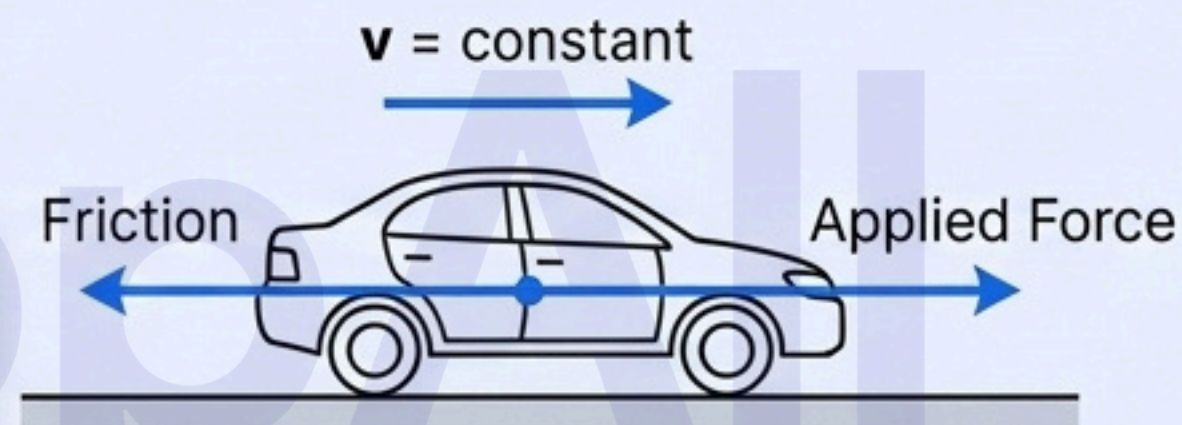
Fig 4.2(a) Book at Rest



Velocity = 0.
Forces strictly balance.
 $W = R$.

PHYSICALLY
EQUIVALENT: $a = 0$

Fig 4.2(b) Car Moving Uniformly



Velocity = Constant
Forces strictly balance.
Drive Force = Friction.

Both cases perfectly satisfy Newton's First Law.

Moving Frames And Resistance To Change

INERTIA IN ACTION

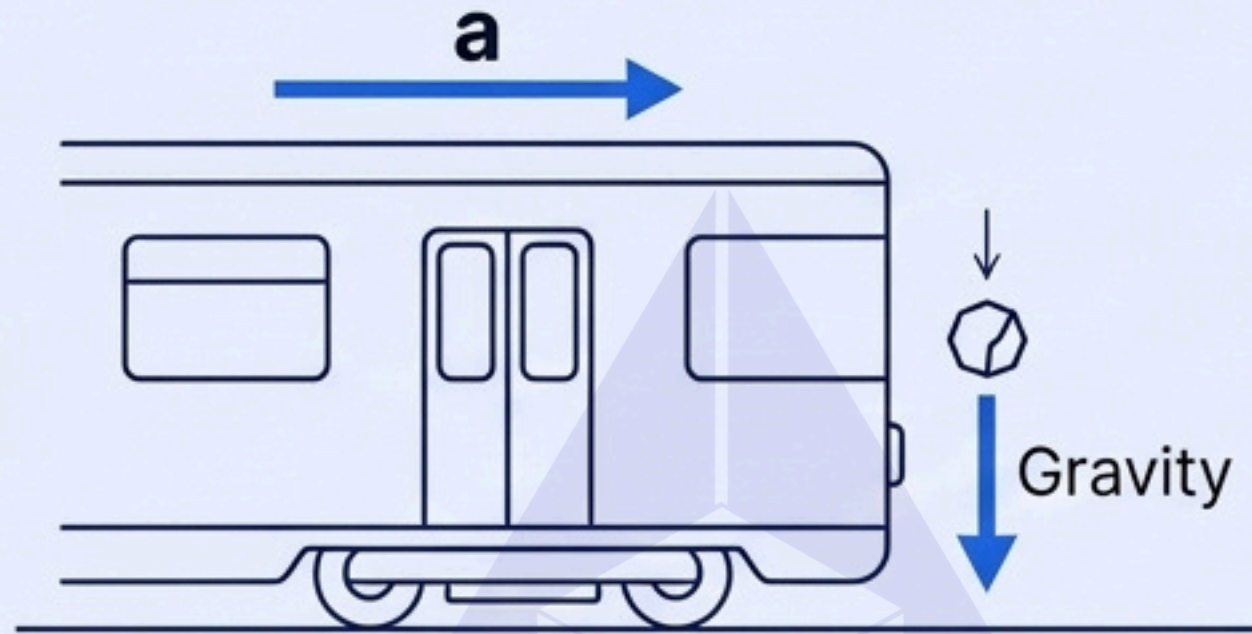
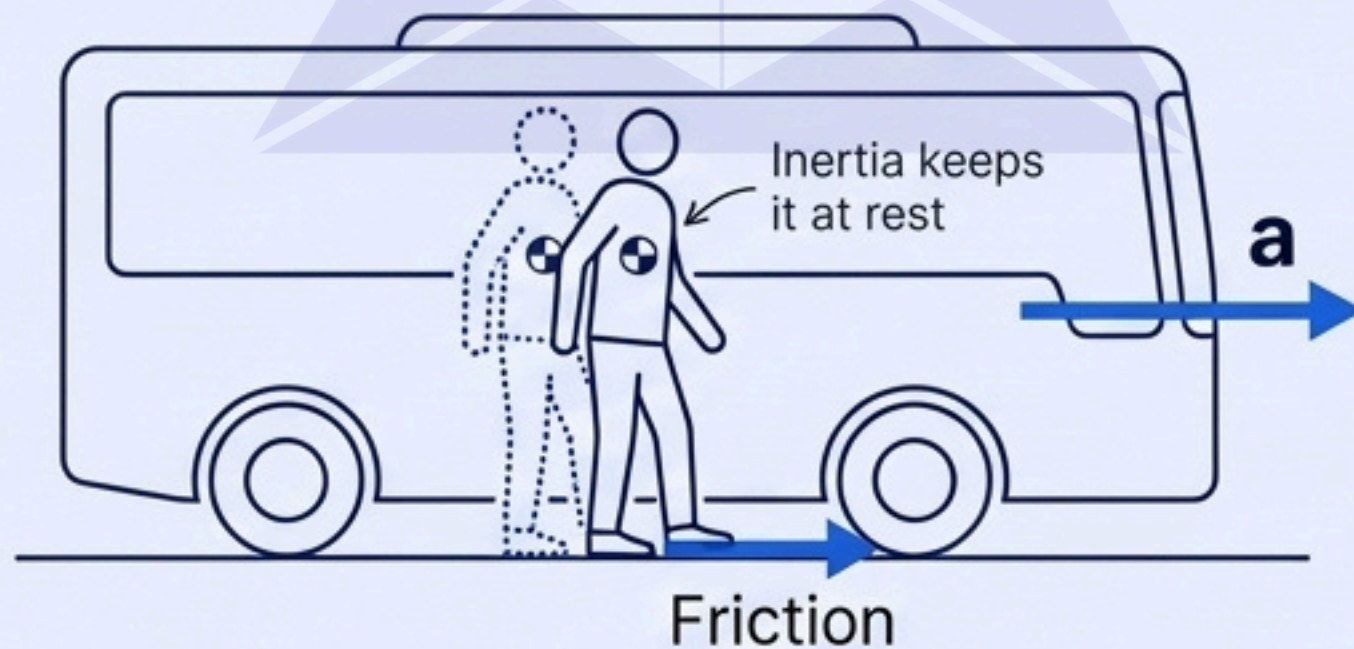


Fig 4.5: The Dropped Stone

Acceleration is determined by forces here and now. The stone carries no memory of the train's horizontal acceleration once dropped.



The Bus Passenger

Inertia means resistance to change. Friction pulls your feet forward with the bus, but your upper body's inertia keeps it at rest, throwing you backward.

CHAPTER 4.4 SUMMARY

Key Takeaways

- 1 Net Force Dictates Acceleration:** If the vector sum of all external forces is zero, acceleration is strictly zero.
- 2 Rest and Uniform Motion are Equivalent:** Both states mean the body is in translational equilibrium ($F_{\text{net}} = 0$).
- 3 Inertia is Resistance:** A body cannot change its state of rest or constant velocity without an unbalanced external force.

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