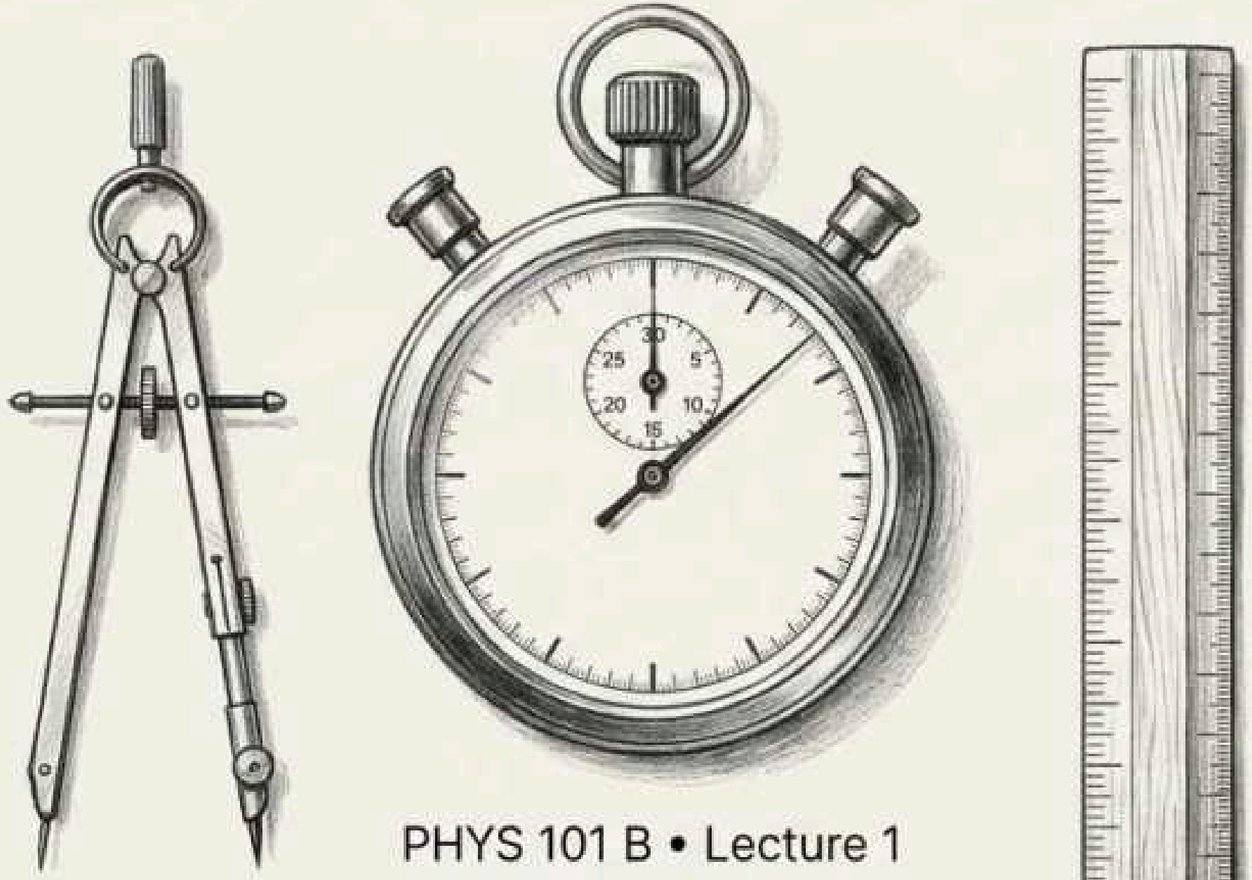
¶ 1.1

Describing Motion.

Position, Velocity, and Acceleration.



PHYS 101 B • Lecture 1

The Vocabulary of Motion.

¶ 1.2

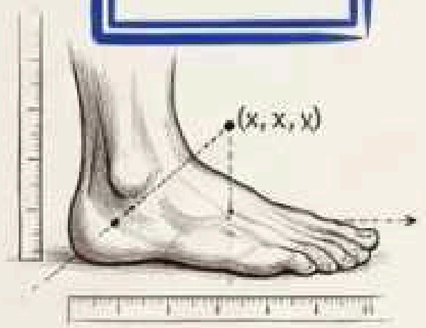
Position

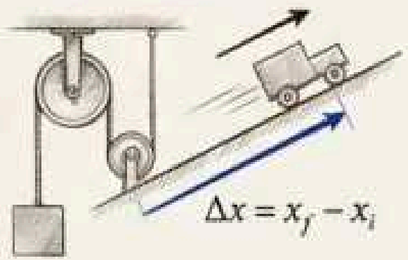
Displacement

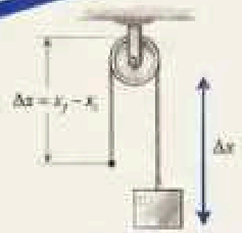
Velocity

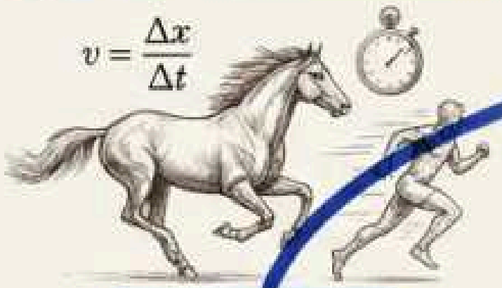
Acceleration

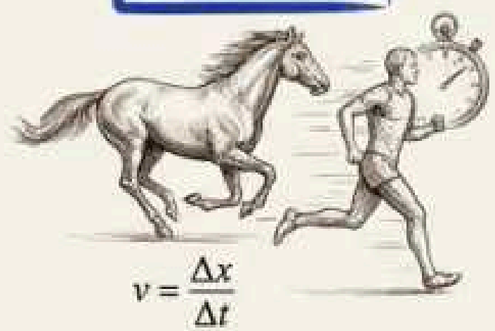
Graphical Translation

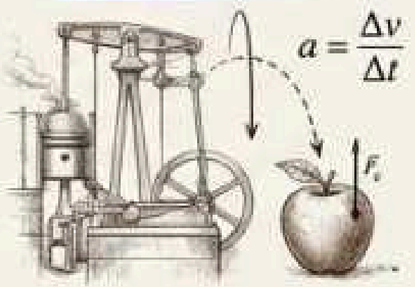


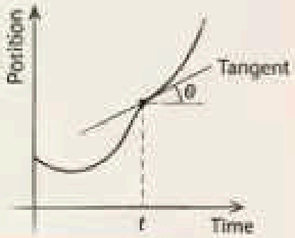


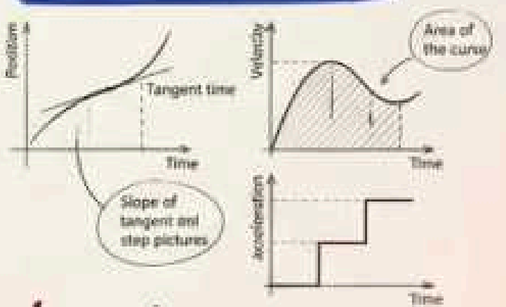










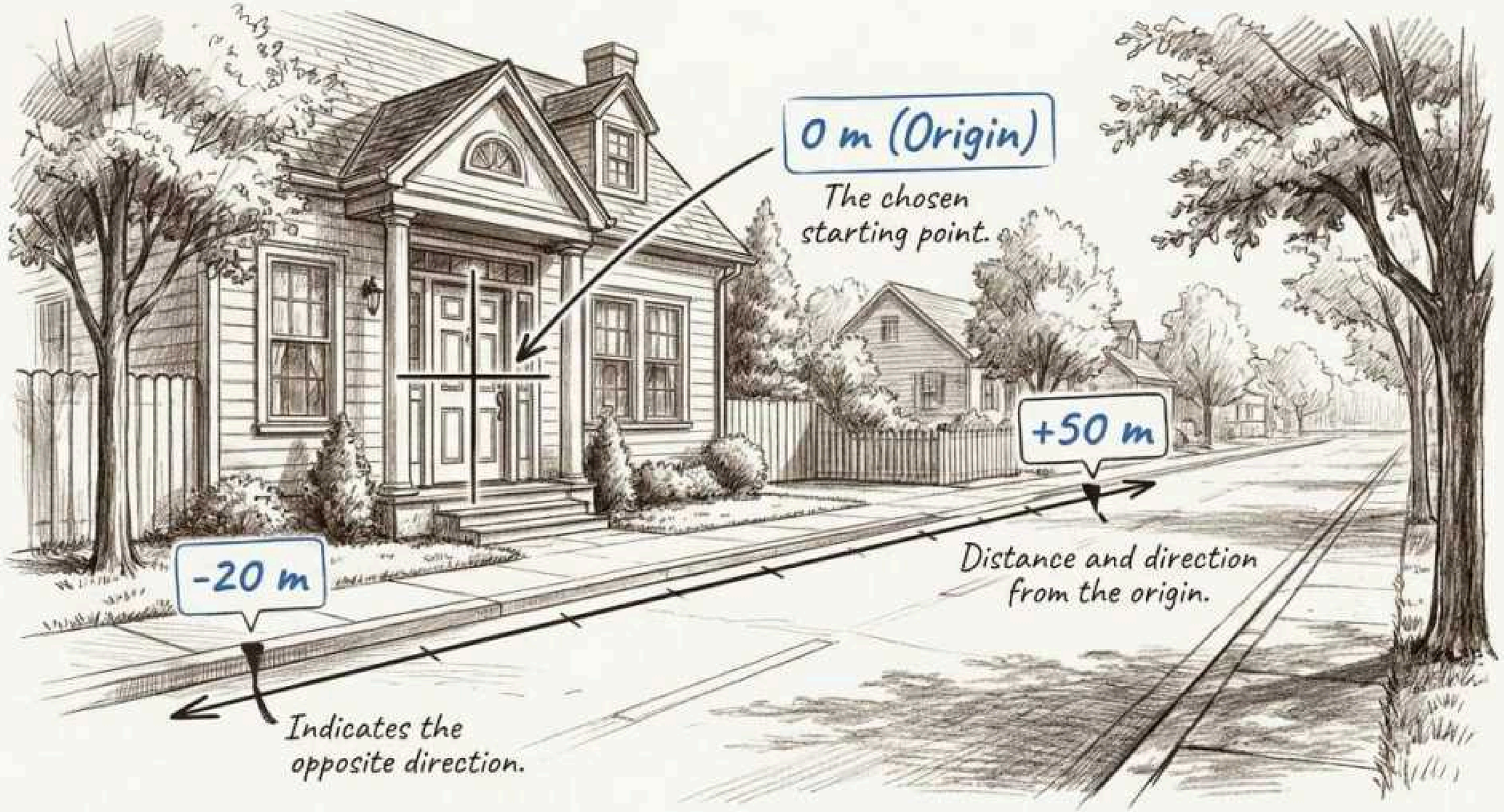


Goal: Describe any straight-line motion in words, numbers, and pictures.

Everything later in the course rests on these four ideas.

Position: Where Are You?

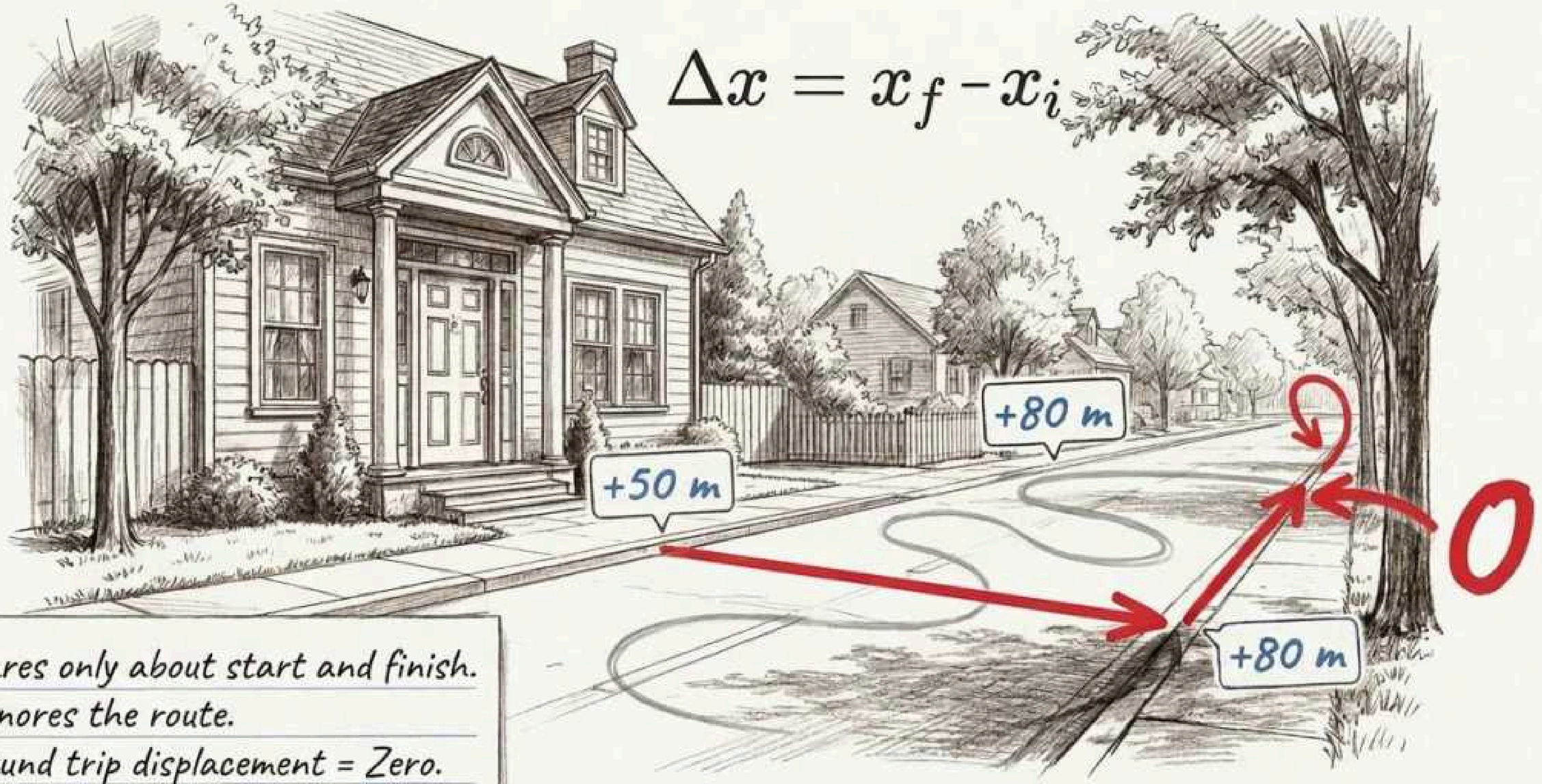
¶1.3



Displacement: The Net Change.

¶1.4

$$\Delta x = x_f - x_i$$

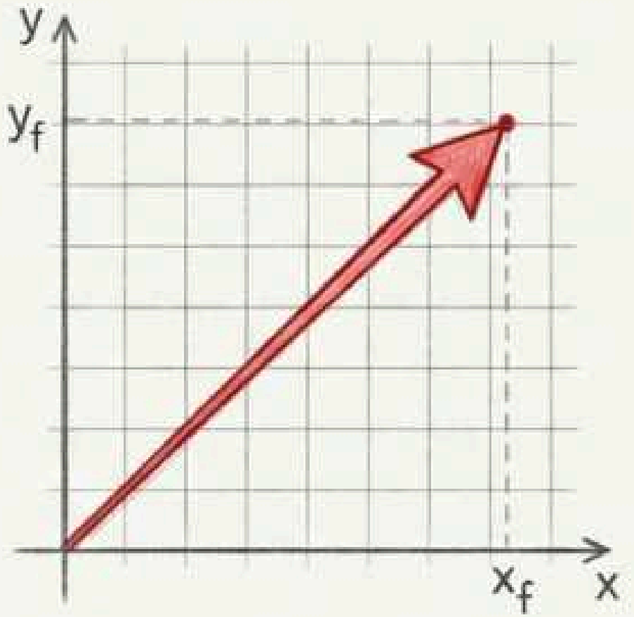


- Cares only about start and finish.
- Ignores the route.
- Round trip displacement = Zero.

Distance vs. Displacement

¶ 1.5





Distance

- Total path length
- The Effort
- Never negative, never shrinks

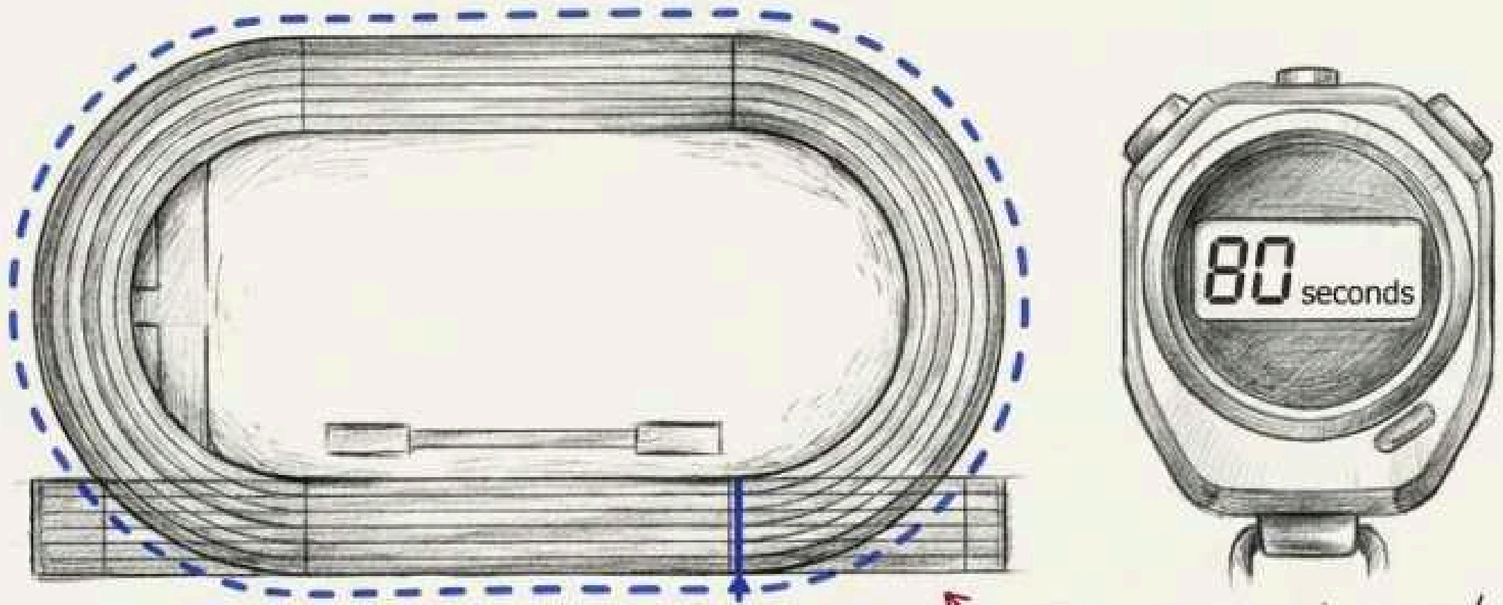
Displacement

- Change in position
- The Net Progress
- Can be positive, negative, or zero

Physicists favor displacement because it carries both size and direction.

Adding Time: Speed vs. Velocity.

¶ 1.6



Average Speed

$$= \frac{\text{Distance}}{\text{Time}} = \frac{400\ \text{m}}{80\ \text{s}} = 5\ \text{m/s}$$

Average Velocity

Displacement = 0 m!

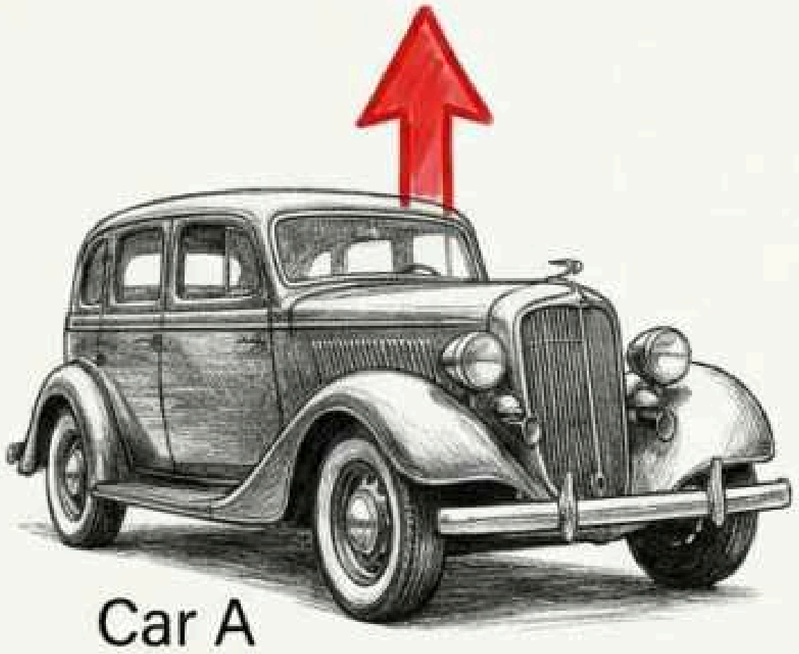
$$= \frac{\text{Displacement}}{\text{Time}} = \frac{0\ \text{m}}{80\ \text{s}} = 0\ \text{m/s}$$

Time = 80 s

The Velocity Vector.

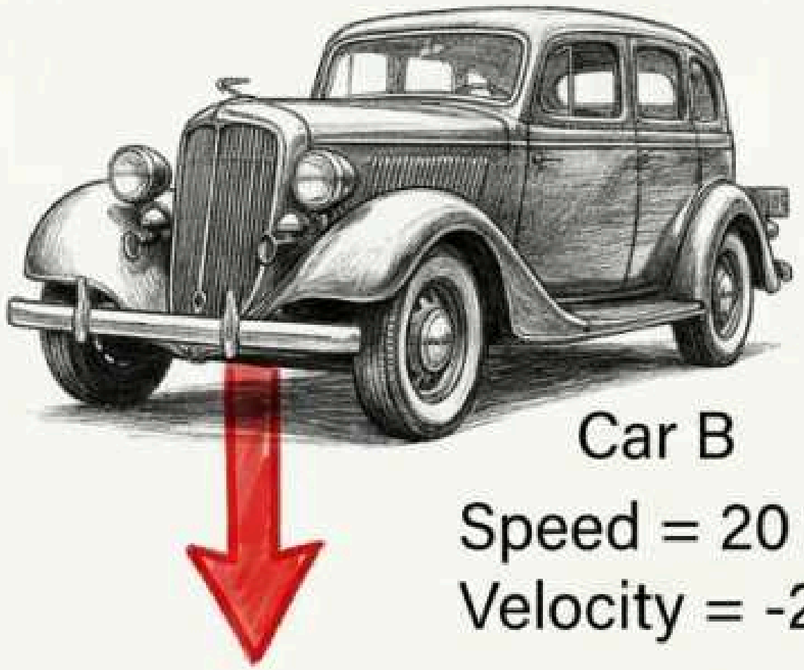
¶ 1.7

Velocity records net progress. Speed records effort.



Car A

Speed = 20 m/s
Velocity = +20 m/s



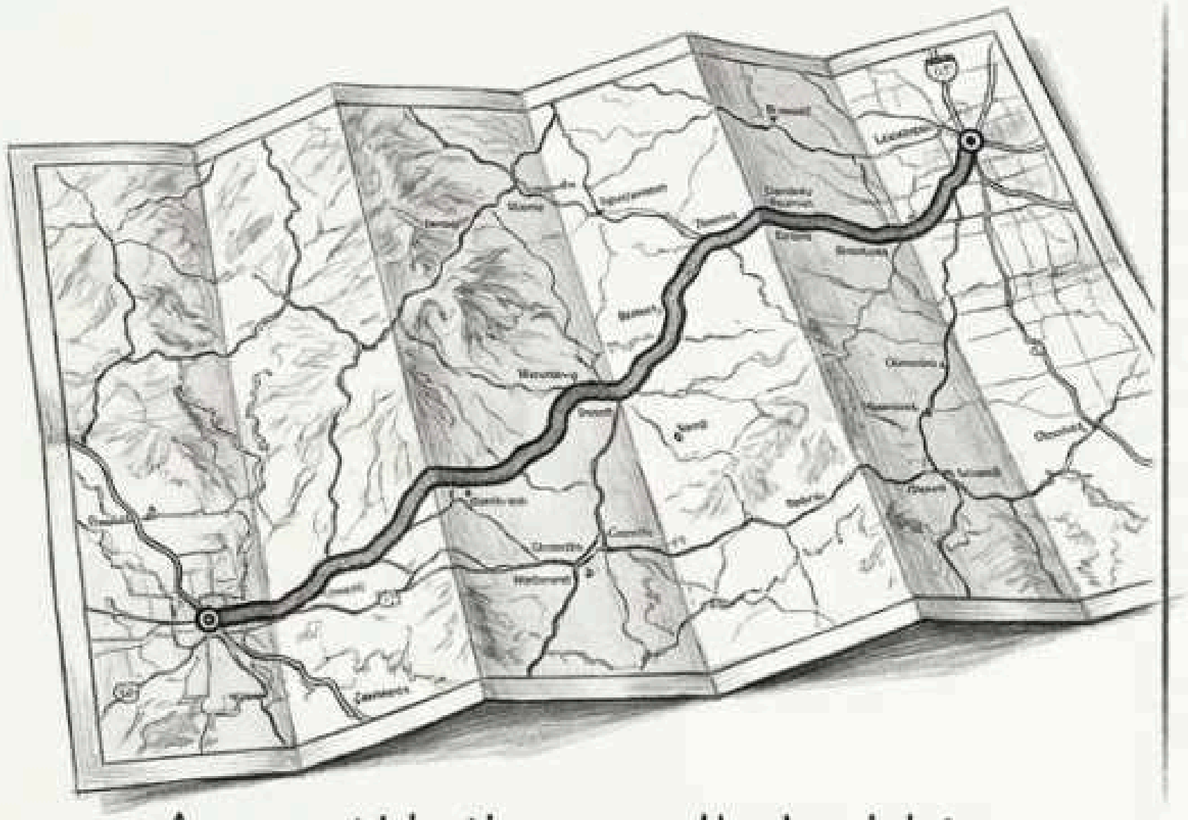
Car B

Speed = 20 m/s
Velocity = -20 m/s

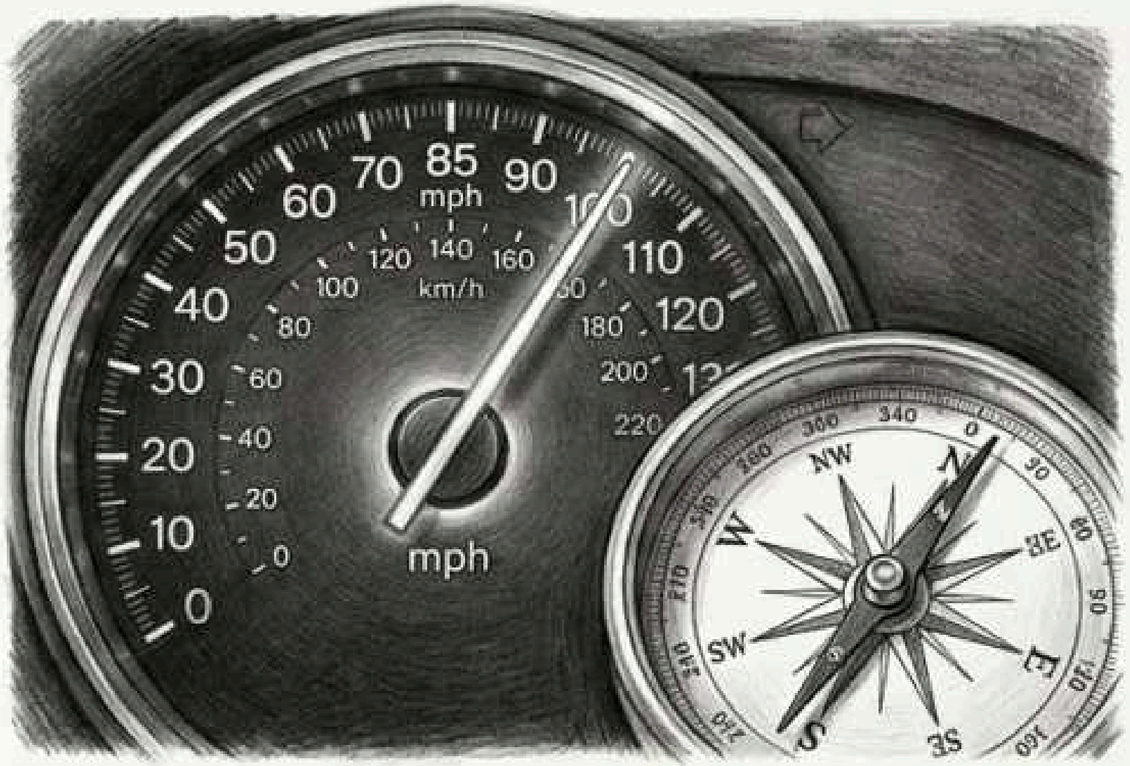
Same speed, opposite velocities.

Average vs. Instantaneous.

¶ 1.8



Average Velocity = smoothed out trip



Instantaneous Velocity = a single instant + direction

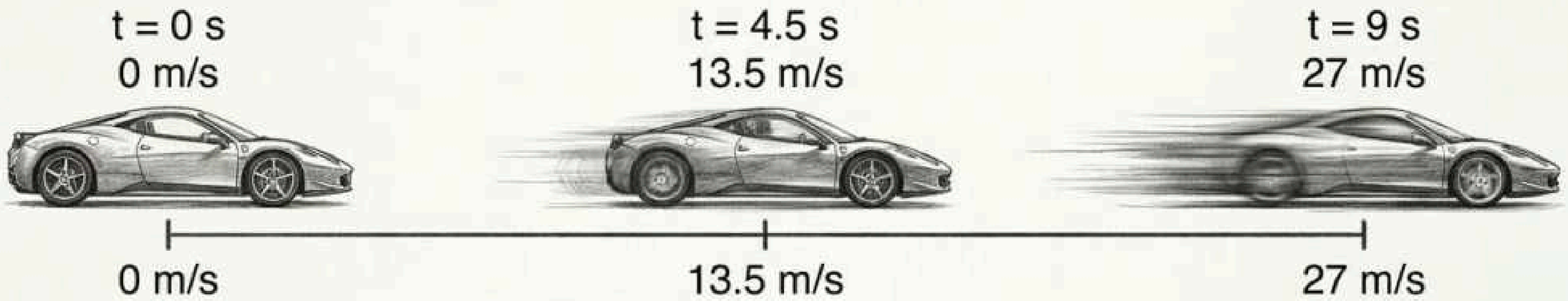
$$\lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = v$$

The seed of calculus

Acceleration: The Rate of Change.

¶ 1.9

$$a = \frac{\Delta v}{\Delta t}$$



0 to 27 m/s in 9 s.

27 / 9 = 3.

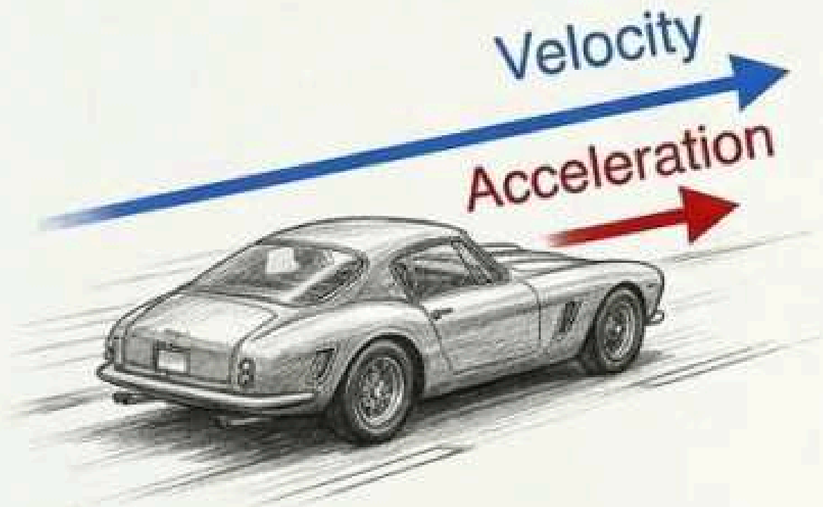
Unit = m/s^2

Read as: 3 meters per second, every second

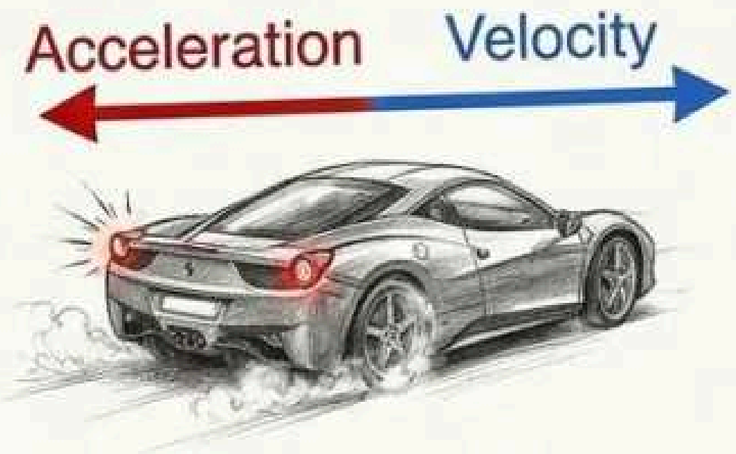
The Physics Definition of Acceleration.

¶1.10

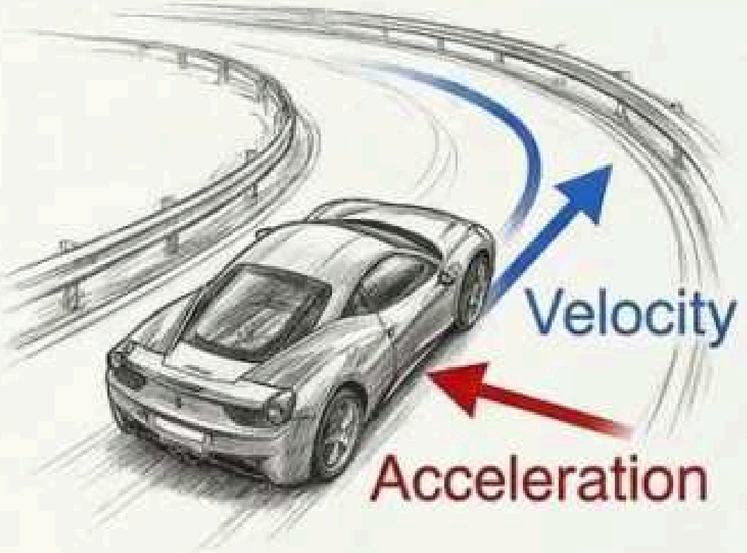
Any change in velocity counts.



1. Speeding Up



2. Slowing Down
(Braking)



3. Turning
(Changing Direction)

Only steady motion in a straight line has zero acceleration.

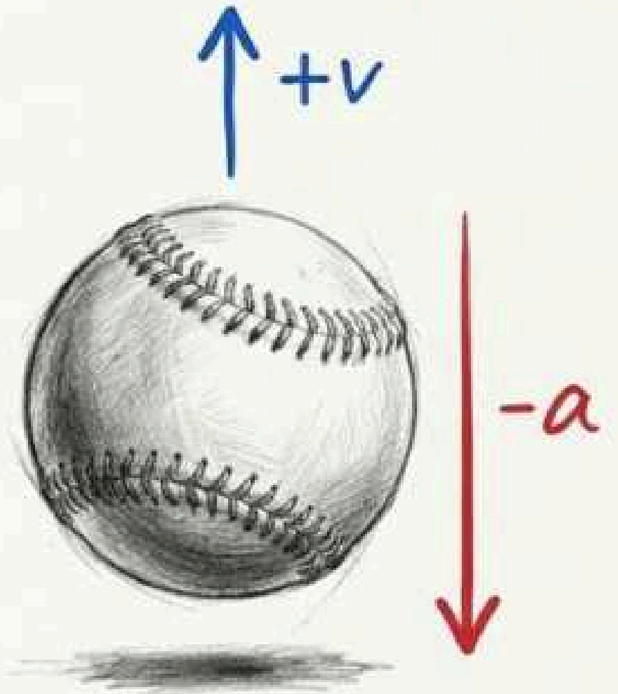
Tracking the Signs.

¶ 1.11

	Acceleration (+)	Acceleration (-)
Velocity (+)	Speeds up	Slows down
Velocity (-)	Slows down	Speeds up

Same signs = Speeds up.

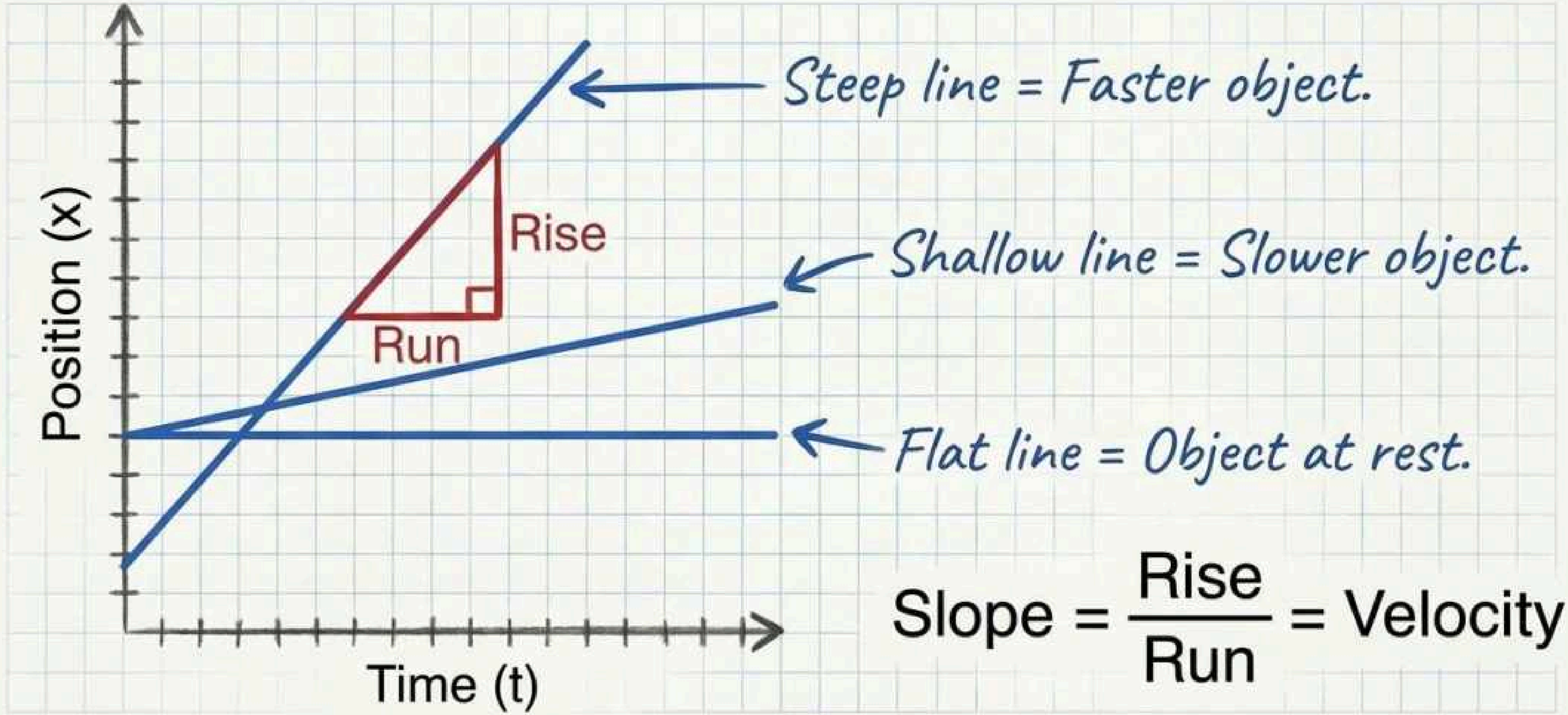
Opposite signs = Slows down.



Upward velocity + downward acceleration = slows, stops, falls.

The Language of Graphs: Position vs. Time.

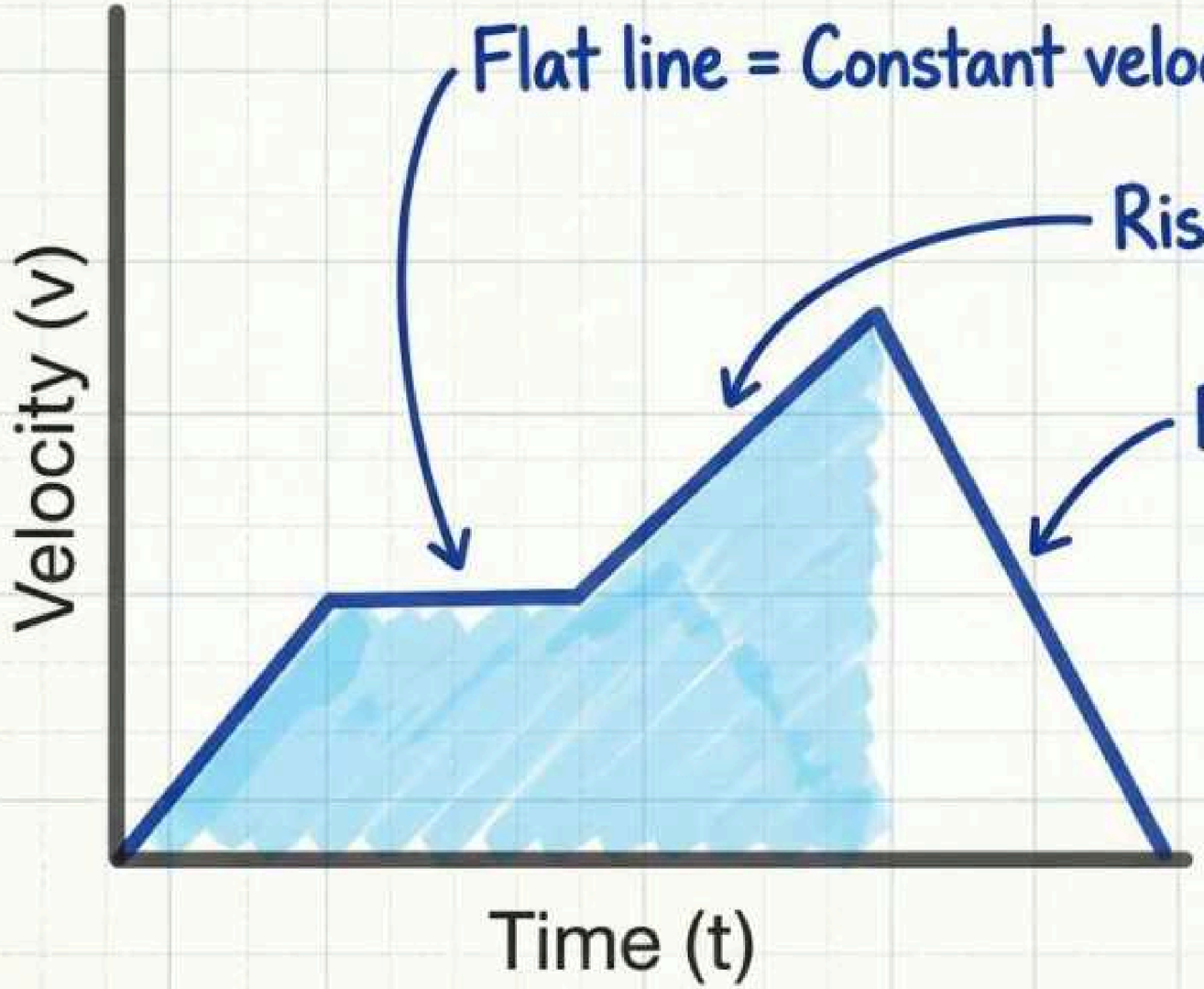
¶ 1.12



$$\text{Slope} = \frac{\text{Rise}}{\text{Run}} = \text{Velocity}$$

Velocity vs. Time Graphs

¶ 1.13



Flat line = Constant velocity (Zero acceleration).

Rising line = Speeding up.

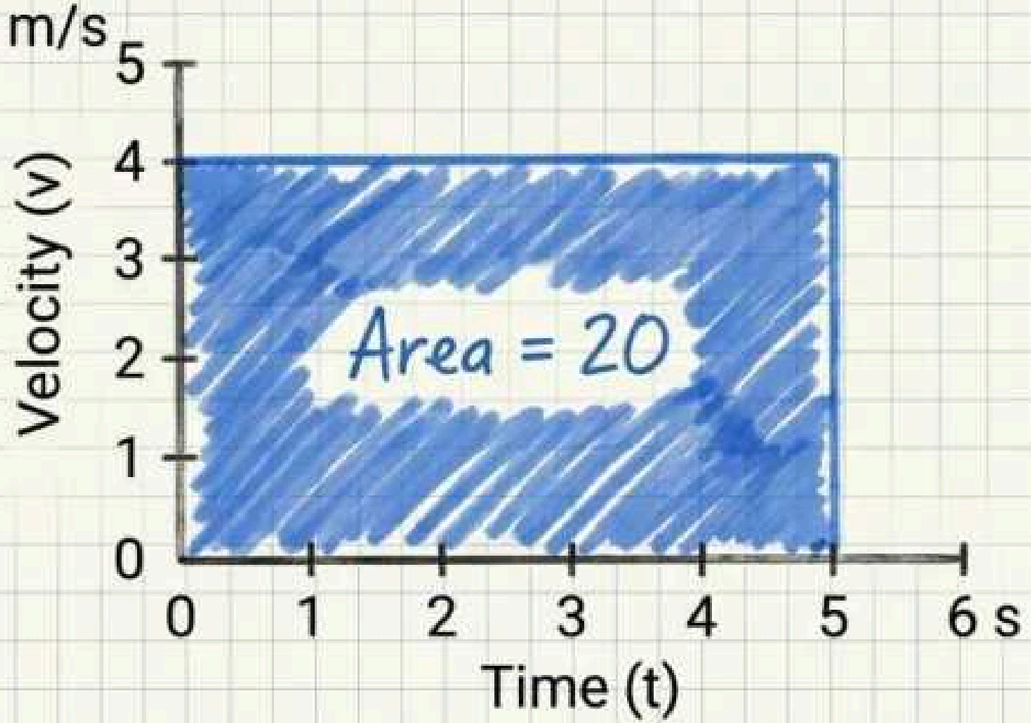
Falling line = Slowing down.

- Slope = Acceleration
- Area under line = Displacement

The Geometry of Motion: Applied.

¶ 1.14

Graph 1: The Cyclist

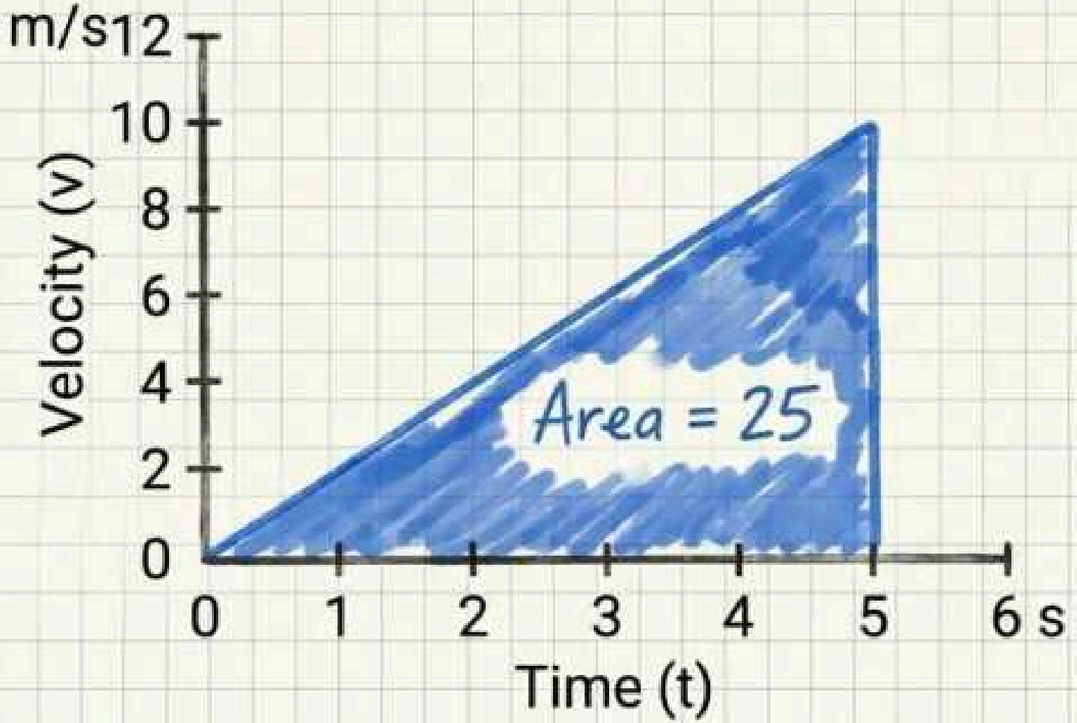


Rectangle

Area = base x height

→ 5 s x 4 m/s = 20 m

Graph 2: The Acceleration



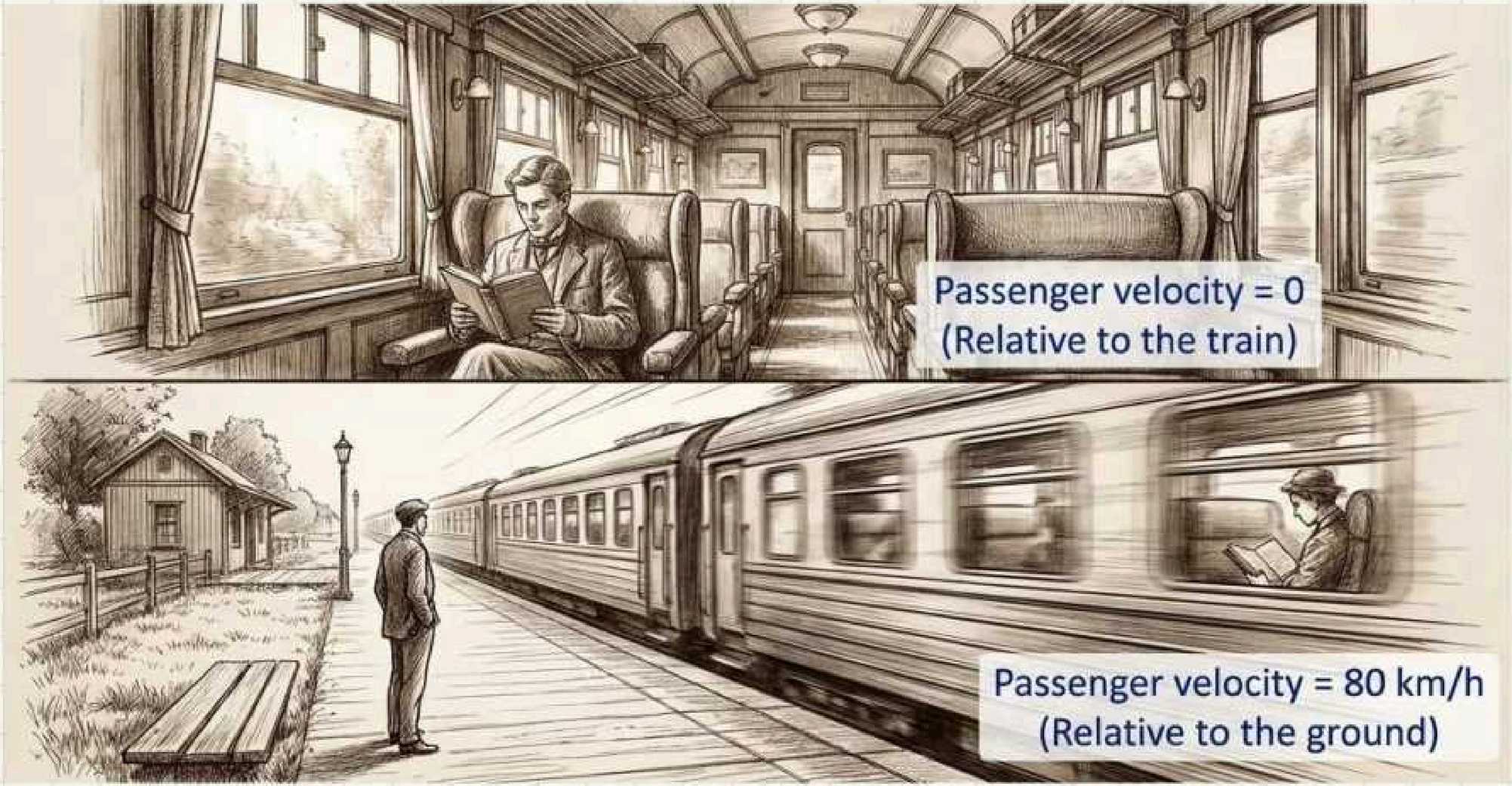
Triangle

Area = Area = 1/2 x base x height

→ 0.5 x 5 s x 10 m/s = 25 m

The Frame of Reference.

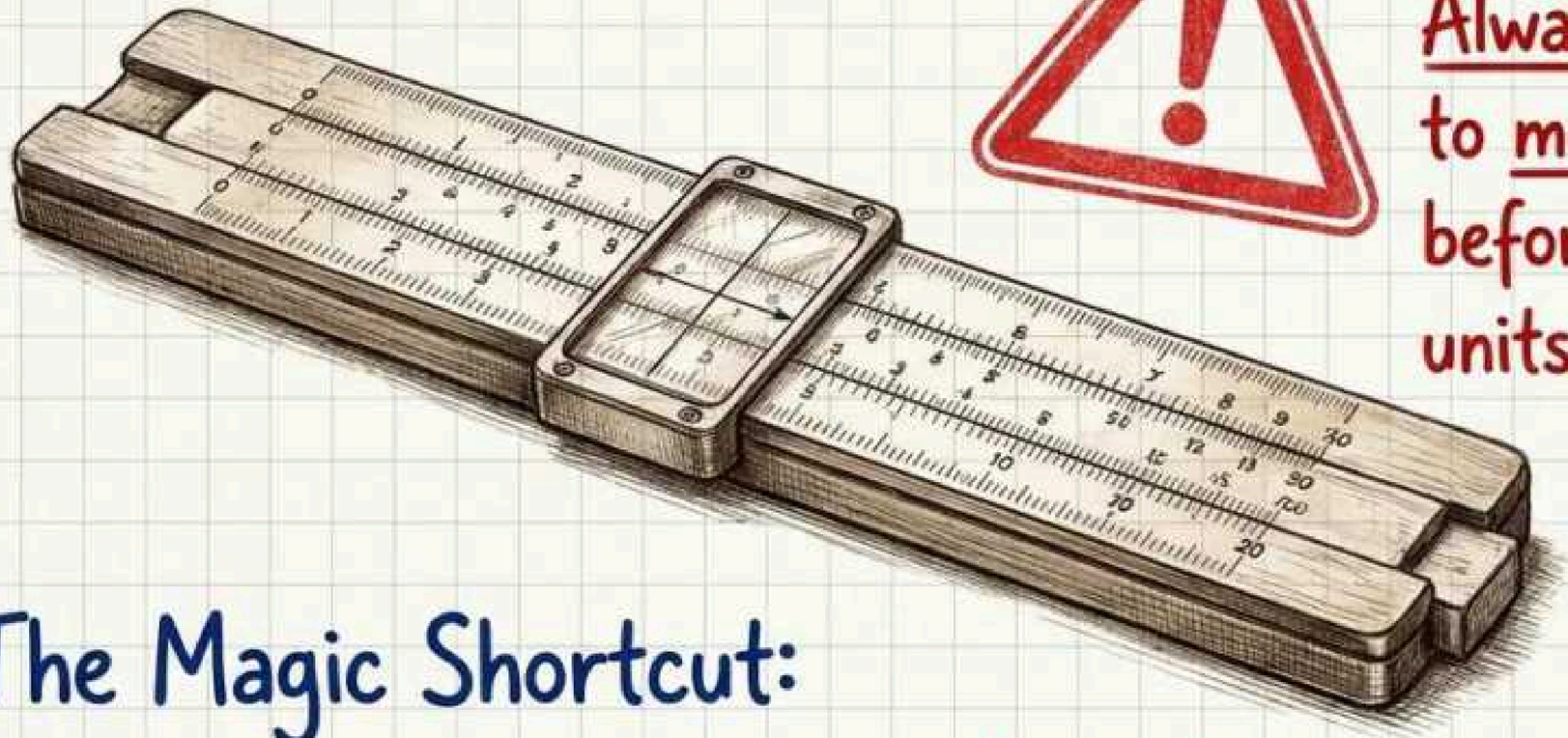
¶ 1.15



Neither is wrong. Choosing the frame is part of describing the motion (we usually choose the ground).

A Word About Units.

¶ 1.16



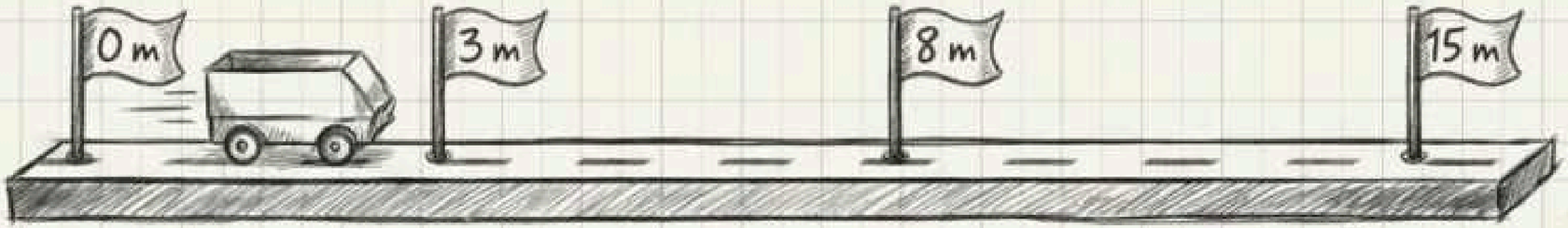
Always convert everything to meters and seconds before calculating! Mixing units causes errors.

The Magic Shortcut:

90 km/h —/ 3.6→ 25 m/s

Worked Example: Seeing the Rates

¶ 1.17

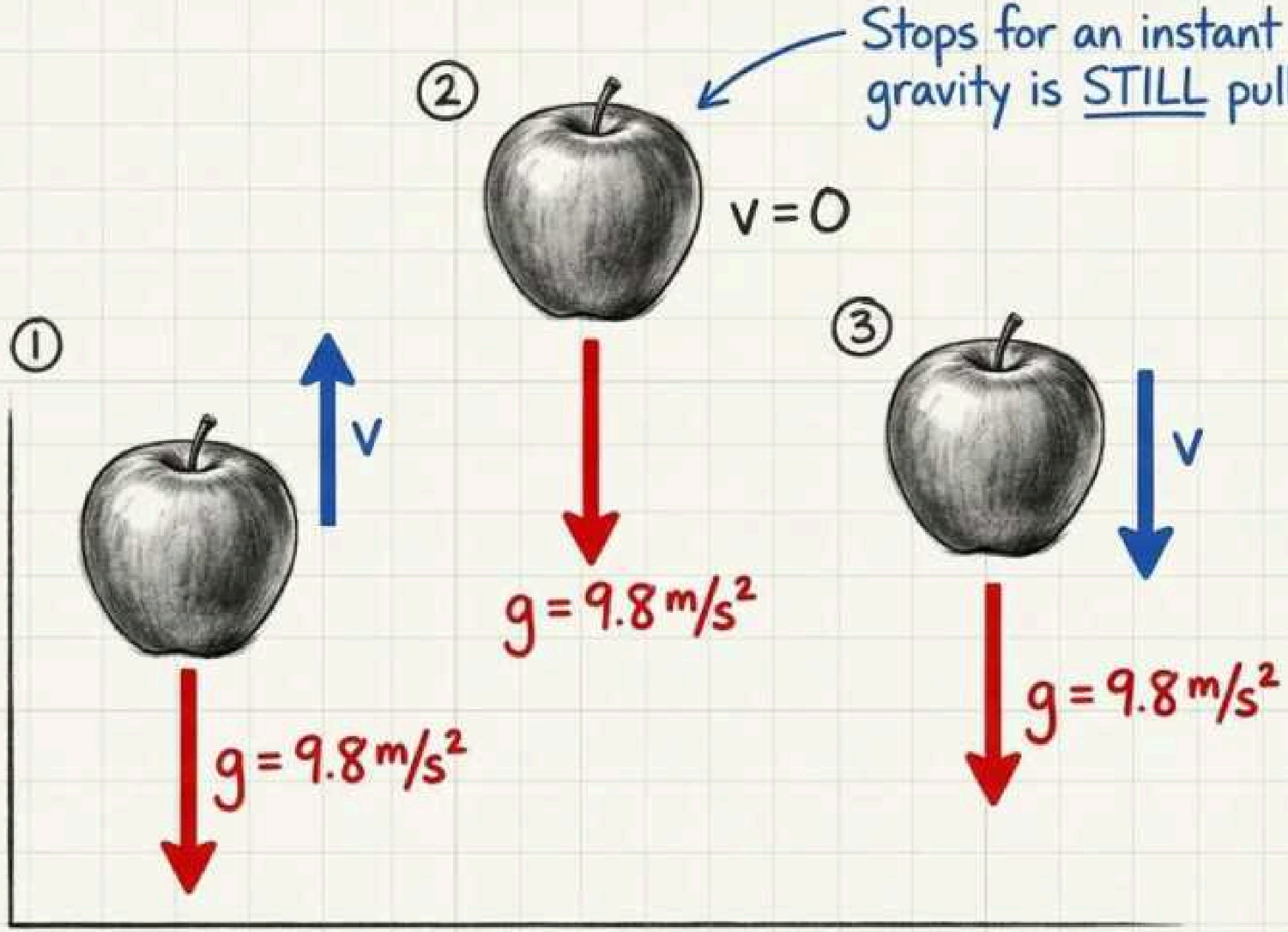


Time (s):	0	1	2	3
Position (m):	0	3	8	15
Velocity (Δx):		+3	+5	+7
Acceleration (Δv):			+2	+2

Average velocity = 15 / 3 = 5 m/s. Acceleration is constant at 2 m/s^2.

The Zero Velocity Paradox

¶ 1.18



- Velocity = How position changes.
- Acceleration = How velocity changes.
- Keep them separate.

Four Hundred Years of Application.

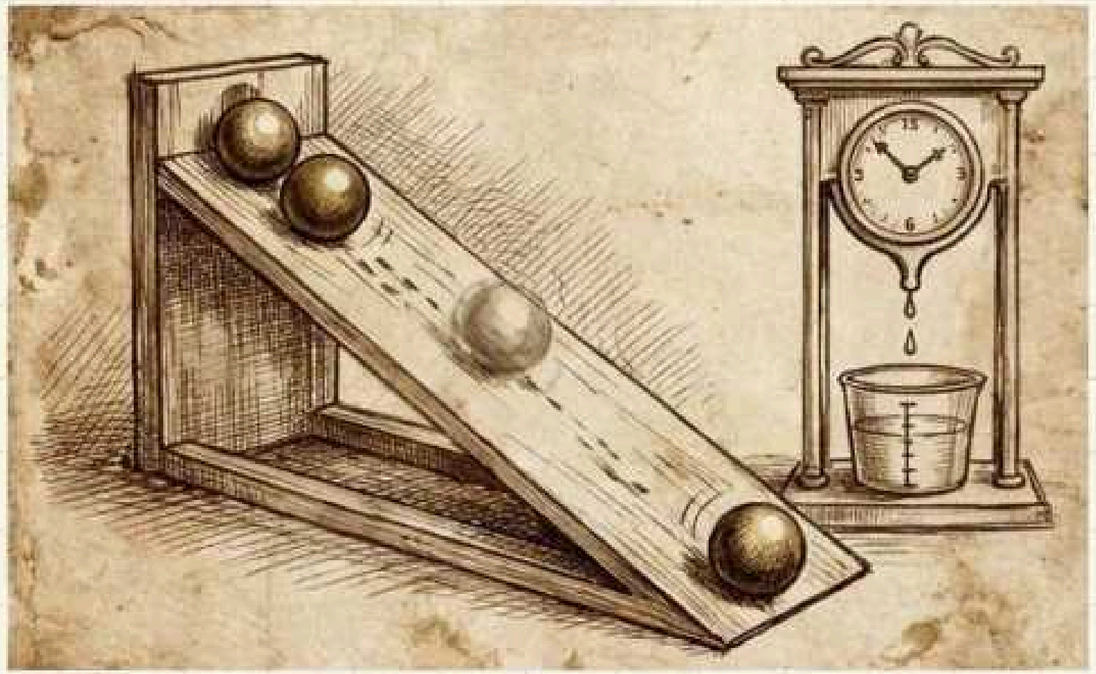
¶ 1.19

Modern Application



Modern Application:
GPS measures position multiple times a second → calculates Velocity → → calculates Acceleration

Historical Root



Historical Root:
Galileo used ramps and a water clock to measure how balls speed up.
The math hasn't changed.

The Lecture Question



Think of a short trip you made today (e.g., walking to a shop).

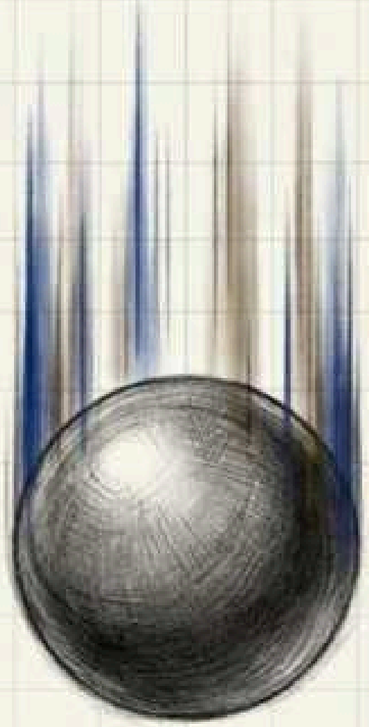
- Estimate your total distance: _____
- Estimate your net displacement: _____
- Calculate your average speed: _____

When during the trip was your acceleration NOT zero? (Hint: Starting, stopping, and turning corners all count).

Looking Ahead.

¶ 1.21

$$x = v_0 t + \frac{1}{2} a t^2$$



$$v = v_0 + at$$

Lecture 2: The Equations of Motion.

Applying steady acceleration to falling objects.