Chapter 2
Describing Motion: Kinematics in One Dimension

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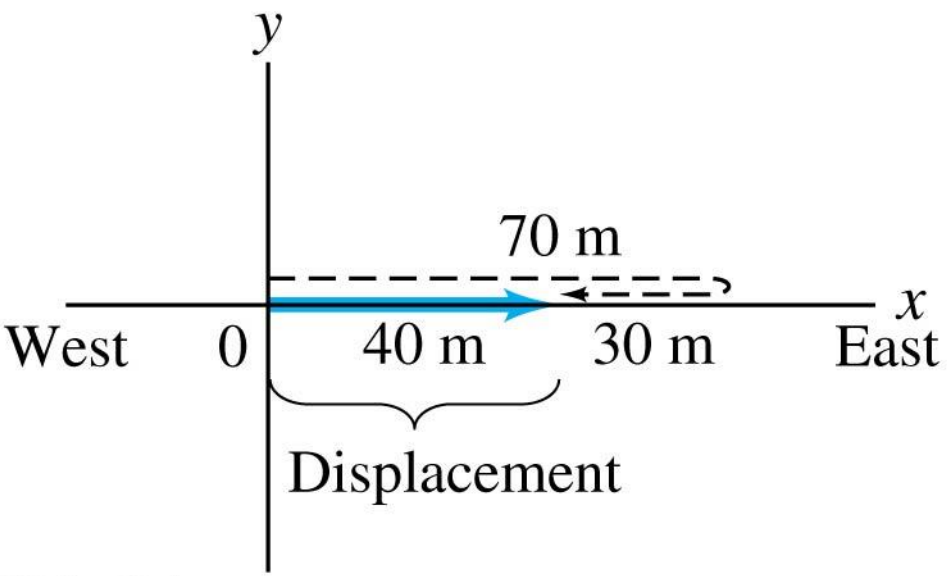
2-1 Reference Frames and Displacement

We make a distinction between distance and displacement.

Displacement (blue line) is how far the object is from its starting point, regardless of how it got there.

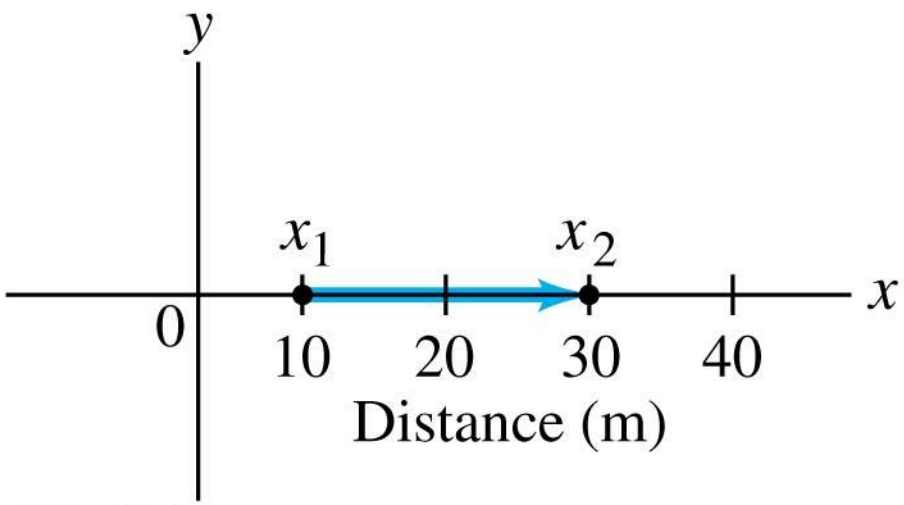
Distance traveled (dashed line) is measured along the actual path.

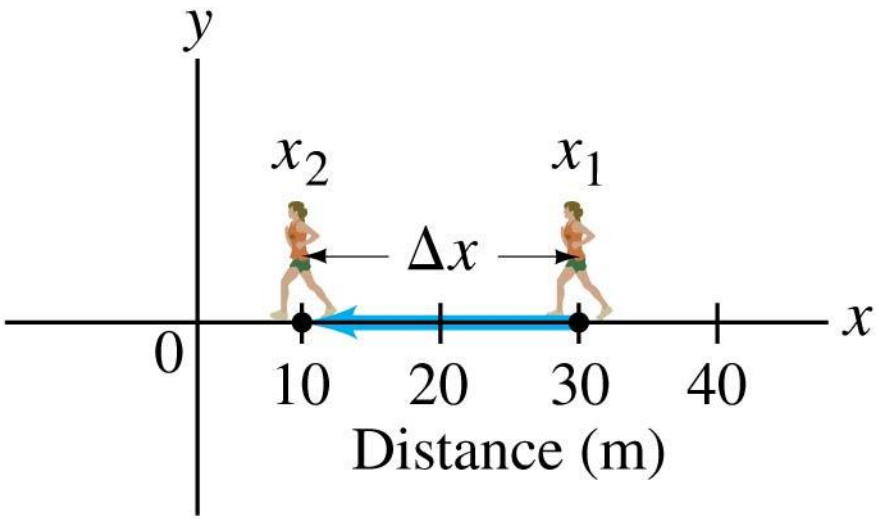


2-1 Reference Frames and Displacement

The displacement is written: $\Delta x = x_2 - x_1$

Left: Displacement is positive. Right: Displacement is negative.





Example

An object started motion along x-axis from x=2m to x=10m. And then back to x=3m, calculate:

a) The distance

b) Displacement

2-2 Average Velocity

Speed: how far an object travels in a given time interval

$$\text{average speed} = \frac{\text{distance traveled}}{\text{time elapsed}} \qquad (2\text{-}1)$$

Velocity includes directional information:

$$\text{average velocity} = \frac{\text{displacement}}{\text{time elapsed}} = \frac{\text{final position} - \text{initial position}}{\text{time elapsed}}.$$

Example

A particle at $t_1 = -2.0$ s is at $x_1 = 4.8$ cm and at $t_2 = 4.5$ s is at $x_2 = 8.5$ cm. What is its average velocity over this time interval? Can you calculate its average speed from these data? Why or why not?

Example

A particle moves from point A toward point B with average speed of 10 m/s, once at arrived at B it returns immediately to point A with average speed of 20 m/s, Calculate:

a) The average velocity of entire trip

b) The average speed of entire trip

Example

A particle position at any instant along x-axis is given as

$$x(t) = 4 - 2t + t^2$$

Calculate

a) The displacement between $t = 2s \; and \; t = 5s$

b) The average velocity between $t = 2s \; and \; t = 5s$

Example

A particle position at any instant along x-axis is given as

$$x(t) = 4 - 2t + t^2$$

Calculate

a) The displacement between $t = 2s \; and \; t = 5s$

b) The average velocity between $t = 2s \; and \; t = 5s$

Example

You are driving home from school steadily at 95 km/h for 180 km. It then begins to rain and you slow to 65 km/h. You arrive home after driving 4.5 h.

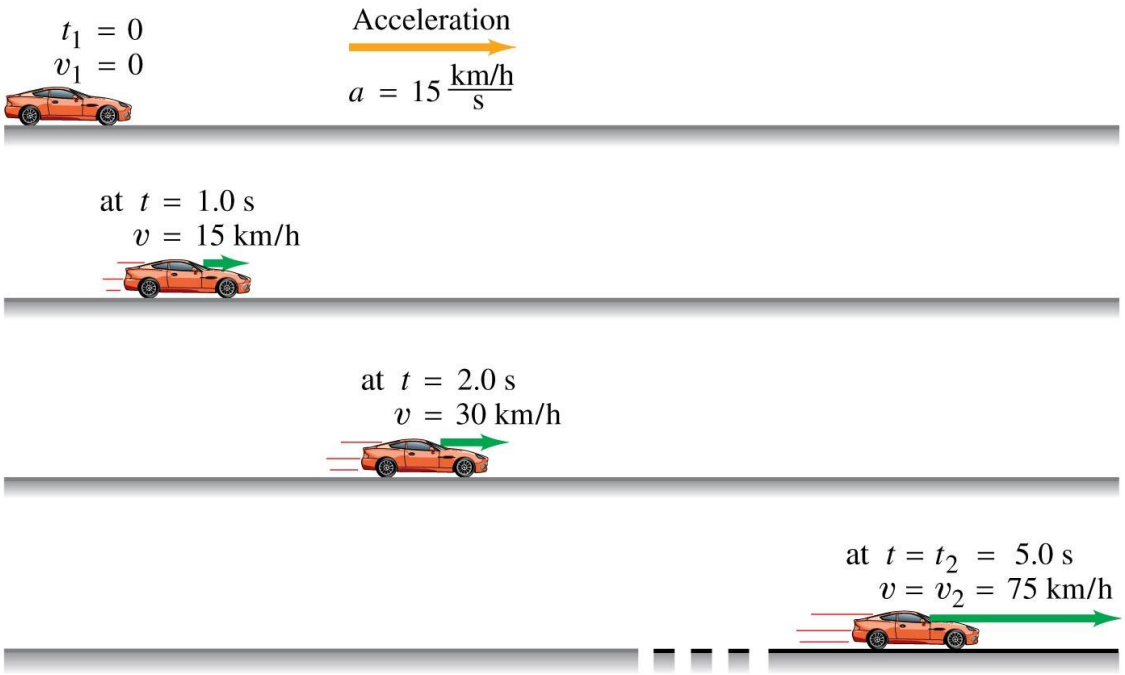
(a) How far is your hometown from school?

(b) What was your average speed?

2-4 Acceleration

Acceleration is the rate of change of velocity.

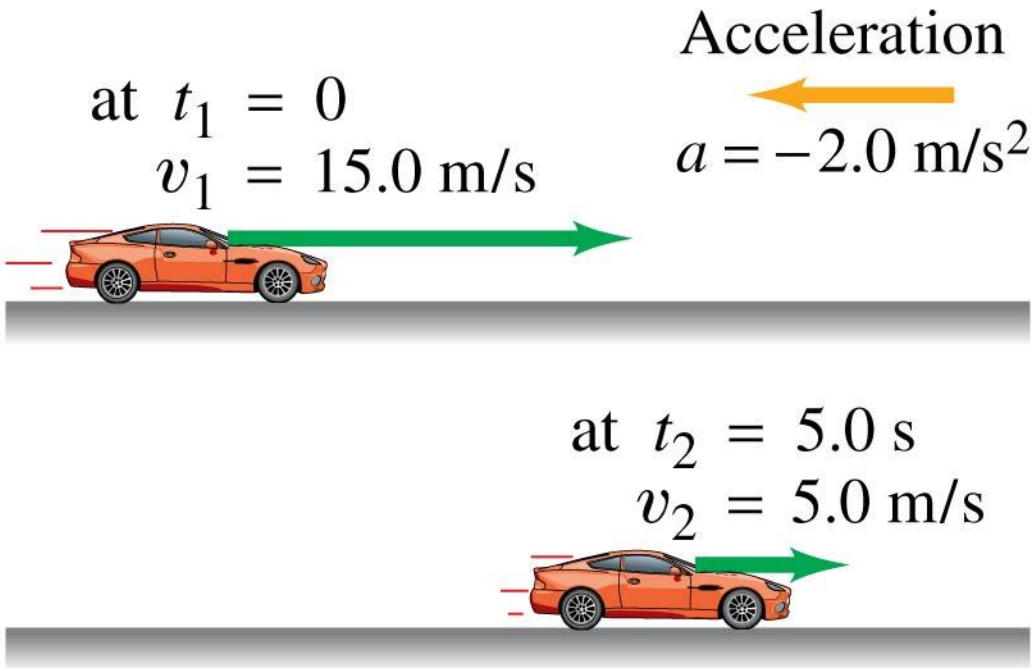
$$\text{average acceleration} = \frac{\text{change of velocity}}{\text{time elapsed}}$$



2-4 Acceleration

Acceleration is a vector, although in one-dimensional motion we only need the sign.

The previous image shows positive acceleration; here is negative acceleration:



Example

A sports car accelerates from rest to 95 km/h in 4.3 s.

What is its average acceleration in m/s^2

Summary of Chapter 2

- Kinematics is the description of how objects move with respect to a defined reference frame.
- Displacement is the change in position of an object.
- Average speed is the distance traveled divided by the time it took; average velocity is the displacement divided by the time.
- Average acceleration is the change in velocity divided by time