Kinematics

AP Physics 1 ▪ Unit 1

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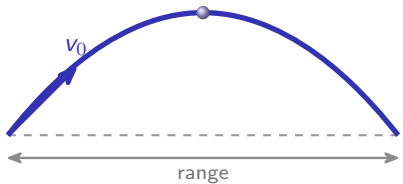
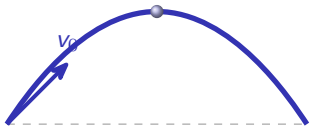


What we will cover

1. Scalars and vectors
2. Displacement, velocity, acceleration
3. Motion graphs and SUVAT
4. Reference frames
5. Projectile motion



Scalars and vectors

- a **scalar** 标量 has only a **magnitude** 大小 – time, mass, speed
- a **vector** 矢量 has magnitude and **direction** 方向 – displacement, velocity, force

In 1-D, pick a **positive direction** 正方向: a − sign is a direction, not "less than nothing".

Speedometers measure magnitude of velocity

From position to acceleration

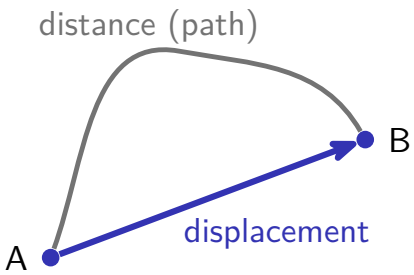
Each quantity is the rate of change of the one before it:

Each has a scalar partner – **distance**, **speed** – with size but no direction.

Distance vs displacement

- **distance** 距离 – the whole path travelled (a scalar)
- **displacement** 位移 $\Delta x = x_f - x_i$ – start to end, *with direction* (a vector)

One full lap of a track: distance is large, displacement is zero.



Velocity and acceleration, defined

Rates of change

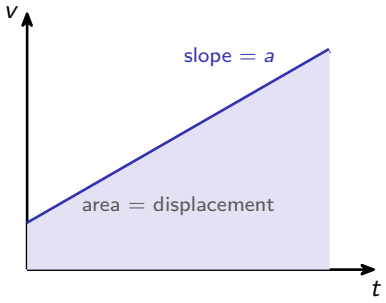
$$v_{avg} = \frac{\Delta x}{\Delta t}, \qquad a_{avg} = \frac{\Delta v}{\Delta t}$$

Instantaneous velocity 瞬时速度 = the slope of the tangent on an x–t graph.

An object slows down whenever a points opposite to v.

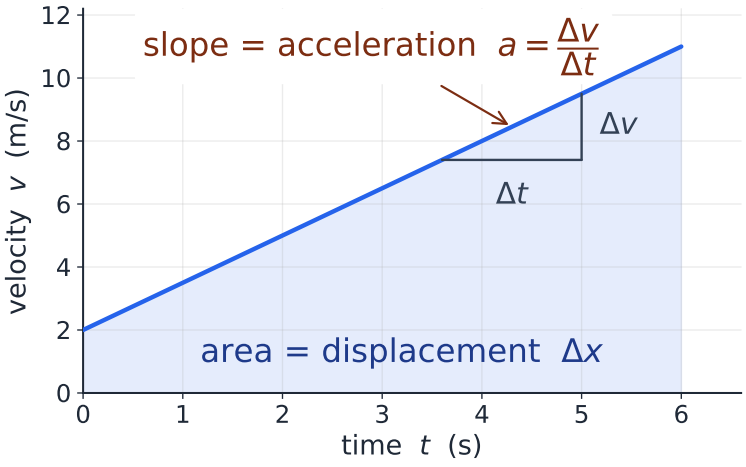
- speeding up, slowing down, *and* turning are all accelerations
- **speed** 速率 is the magnitude of velocity – no direction

Reading motion graphs



Motion graphs describe real journeys

Reading motion graphs



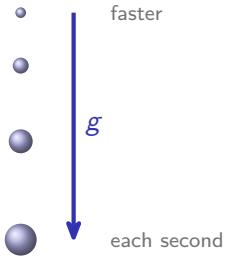
Constant acceleration and free fall

The kinematic equations

$$v = v_0 + at$$

$$x = x_0 + v_0 t + \tfrac{1}{2} a t^2$$

Free fall 自由落体: gravity alone gives $a = g \approx 9.8\,\mathrm{m/s^2}$ downward – the same for every mass.

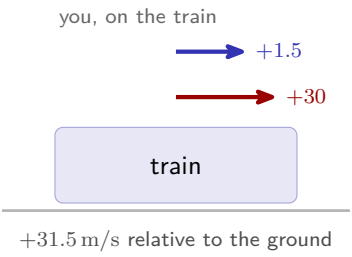


Reference frames and relative motion

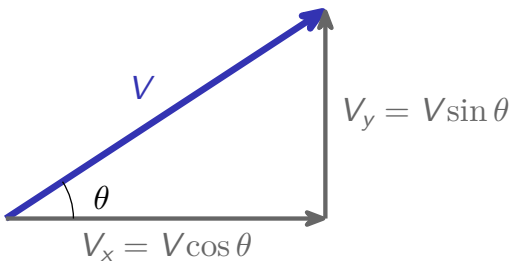
A **reference frame** 参考系 is what you treat as fixed while measuring. Motion is **relative** 相对 to it.

Add velocities as vectors

$$v_{A/C} = v_{A/B} + v_{B/C}$$



Resolving a vector into components



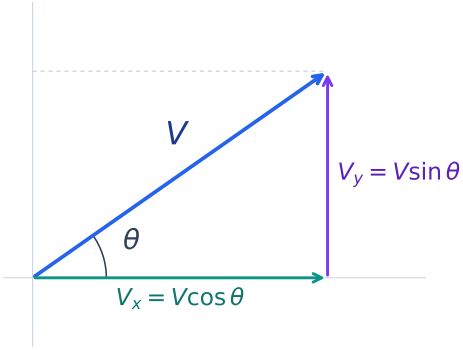
Break each vector into its **components** 分量 on the x- and y-axes.

Back to magnitude and angle

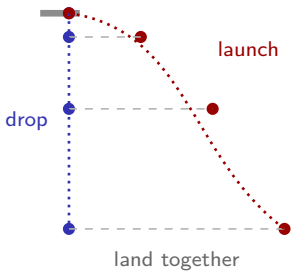
$$V = \sqrt{V_x^2 + V_y^2}, \quad \theta = \tan^{-1}\frac{V_y}{V_x}$$

The x and y motions are independent – they share only the time t.

Resolving a vector into components



Projectile motion

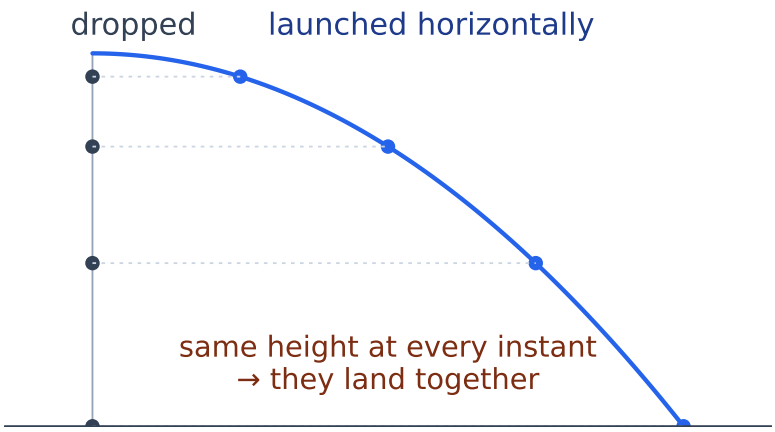


A **projectile** 抛体 has gravity as its only force. Its **trajectory** 轨迹 is a parabola:

- **horizontal**: no force, v_x constant
- **vertical**: free fall at g

A dropped ball and a launched ball fall together – horizontal speed does not change the fall.

Projectile motion



Worked example – a ball off a table

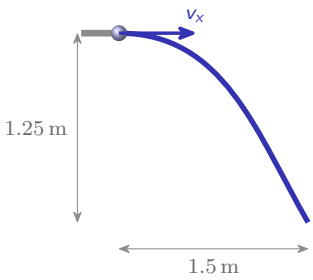
Table $h = 1.25\,\text{m}$, $v_x = 3.0\,\text{m/s}$

Vertical (fall from rest): $h = \frac{1}{2}gt^2$

$$1.25 = \tfrac{1}{2}(9.8)\,t^2 \;\Rightarrow\; t = 0.50\,\text{s}$$

Horizontal (v_x constant):

$$x = v_x t = 3.0 \times 0.50 = 1.5\,\text{m}$$



Unit 1 – key takeaways

1 Vectors

displacement, velocity, acceleration have direction; use signs in 1-D

2 Graphs

x–t slope $= v$; v–t slope $= a$, area = displacement

3 Kinematics

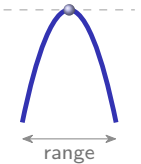
$v = v_0 + at$; $x = x_0 + v_0 t + \frac{1}{2} a t^2$; free fall at g

4 Projectiles

independent x and y motions, joined only by time

Check yourself

1. One full lap of a track – what is the displacement?
2. On a v–t graph, what does the area give?
3. Two balls, one dropped, one launched sideways – which lands first?
4. a points opposite to v: speeding up or slowing down?



Answers **1.** zero **2.** displacement **3.** same time (equal heights) **4.** slowing down