

2 Kinematics – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English	Write it 3 times (English)		
gradient	_____	_____	_____
tangent	_____	_____	_____
projectile	_____	_____	_____
Horizontal	_____	_____	_____
Vertical	_____	_____	_____

Recall

In **Part 1** you used the four equations of motion and read velocity–time graphs. Keep these ready:

- A **vector** has size *and* direction; free fall has acceleration $g = 9.8 \text{ m s}^{-2}$ downward.
- On a velocity–time graph, the gradient is the acceleration and the area is the displacement.

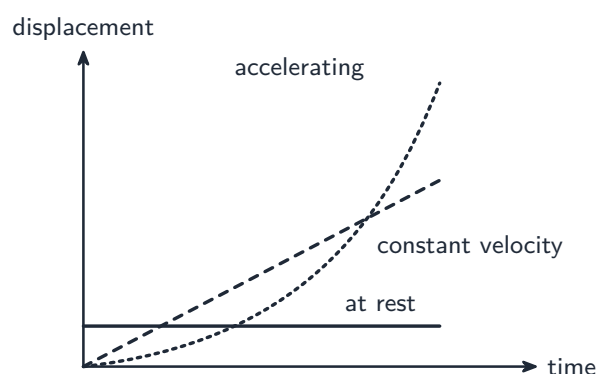
Part 2 looks at motion graphs more closely, and at motion in **two directions** at once.

New ideas

■ 1 Displacement–time graphs

On a displacement–time graph the **gradient** (steepness) is the **velocity**.

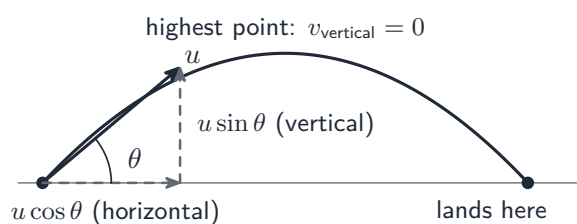
- a straight slope $\rightarrow$ constant velocity;
- a flat line $\rightarrow$ at rest (not moving);
- a curve $\rightarrow$ changing velocity. The velocity at one instant is the gradient of the **tangent** (a straight line just touching the curve) at that point.



■ 2 Projectile motion

A **projectile** moves horizontally and vertically at the same time. The trick: treat the two directions **separately**, sharing the same time t .

- **Horizontal** : no force, so the velocity stays constant – distance = $u_x t$.
- **Vertical** : free fall, so use the equations of motion with $a = g$.

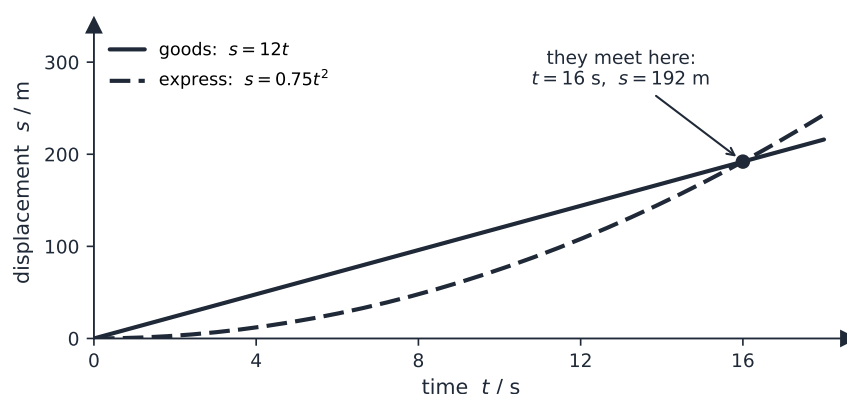


Worked example. A ball is thrown horizontally at 5.0 m s^{-1} from a height of 1.8 m .
Vertical: $1.8 = \frac{1}{2}gt^2 \Rightarrow t = \sqrt{2(1.8)/9.8} = 0.61 \text{ s}$. *Horizontal:* range = $u_x t = 5.0 \times 0.61 = 3.0 \text{ m}$.

Watch out: the horizontal and vertical parts are independent – they share only the *time*. The horizontal speed never changes how fast the projectile falls.

■ 3 Two objects meeting

When two objects move along the same line, write a displacement equation for **each**, then set them equal to find when they meet.



Worked example. Car A starts from rest-point 0 at 20 m s^{-1} . Car B is 100 m ahead going 12 m s^{-1} the same way. A catches B when $20t = 100 + 12t$, so $8t = 100$, $t = 12.5 \text{ s}$ (at 250 m).

Practice

2.1 A displacement–time graph is a straight slope for 5 s, then a flat horizontal line. State what the object does in (a) the first 5 s, (b) after 5 s. [2]

2.2 A stone is thrown horizontally at 8.0 m s^{-1} from a cliff 20 m high ($g = 9.8 \text{ m s}^{-2}$). (a) Find the time to reach the ground. (b) Find how far from the cliff base it lands. [4]

2.3 A ball rolls off a table 0.80 m high at 2.0 m s^{-1} . Find the time it takes to hit the floor. [2]

2.4 Runner A passes a post at 6.0 m s^{-1} . At the same moment runner B is 30 m ahead going 4.0 m s^{-1} the same way. After what time does A catch B? [2]

2.5 Challenge. Two balls leave a table at the same instant – one is simply dropped, the other is rolled off fast. Explain why they hit the floor at the same time. [2]