

# Motion

Patrick Chen

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## Free fall

Motion that is only affected by gravity is called free fall. All objects in free fall move with a constant downward acceleration.

$$a = g \approx 9.8 \frac{m}{s^2}$$

The acceleration is the same for all objects, but the acceleration may differ depending on where you are.

$$\begin{aligned} v &= v_0 + at \rightarrow b = v_0 - gt \\ x &= x_0 + vt + \frac{1}{2}at \rightarrow x = x_0 + vt - \frac{1}{2}gt \end{aligned}$$

Assuming up is positive,

- The position of the thrown object is concave down parabola

$$y = y_0 + v_{0y} + \frac{1}{2}at^2$$

- The velocity of the thrown object is linear with a negative slope

$$v_y = v_{0y} + at$$

- The acceleration of a thrown object is a negative constant.

$$a_y = a$$

At the top of the arc of the thrown object, the velocity is  $0 \frac{m}{s}$  and the acceleration is  $-9.8 \frac{m}{s^2}$ .

## Strategies for solving questions

- If there are separate types of motions, you can break it up into different parts.
- Strategically choose where the origin is.

## Example

$$v_0 = 15m/s$$

$$x_i = 2m$$

$$x_f = 0m$$

$$x_f = x_i + v_0t + \frac{1}{2}at^2$$

$$0 = 2 + 15t + \frac{1}{2}(-9.8)t^2$$

$$0 = -4.9t^2 + 15t + 2$$

$$t \approx 3.189207165165621s \text{ or } t \approx -0.1279826753697030s$$

Since  $t$  cannot be negative

$$t \approx 3.189207165165621s$$

$$v = v_0 + at$$

$$= 15 + (-9.8) \cdot 3.189207165165621$$

$$= -16.25423021862309 \frac{m}{s}$$