

Acceleration due to Gravity

Also known as acceleration of freefall.

The acceleration of gravity is constant value of $g = 9.81 \text{ ms}^{-2}$ near the Earth's surface.

The distance from the centre of the Earth affects the acceleration due to gravity. Neglecting air resistance, the acceleration of gravity for any falling object is the same.

acceleration due to gravity: $g = 9.81 \text{ ms}^{-2}$
 gravitational field strength: $g = 9.81 \text{ N kg}^{-1}$

is related to the weight of an object

$W = mg$
 weight (N) = mass (kg) \times (N kg⁻¹)

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Example

A ball is thrown upwards with a speed of 50 ms^{-1} . Ignoring air friction, calculate how high it will go.

$u = 50 \text{ ms}^{-1}$ $v^2 = u^2 + 2as$
 $v = 0 \text{ ms}^{-1}$ $v^2 - u^2 = 2as$
 $s = ?$ $s = \frac{v^2 - u^2}{2a}$
 $a = -9.81 \text{ ms}^{-2}$ $s = \frac{0 - (50 \text{ ms}^{-1})^2}{2(-9.81 \text{ ms}^{-2})}$
 $s = 1.3 \text{ m}$

Example

An elephant falls from the edge of a cliff to the ground 25 m below. How long before it hits the ground?

$s = -25 \text{ m}$ $s = ut + \frac{1}{2}at^2$
 $u = 0 \text{ ms}^{-1}$ $s = \frac{1}{2}at^2$
 $a = -9.81 \text{ ms}^{-2}$ $t^2 = \frac{2s}{a}$
 $t = ??$ $t = \sqrt{\frac{2(-25)}{-9.81}}$
 (Assume that the elephant is on the Earth + no air friction)

$\sqrt{5} \times 5 = 5$ $t = 2.35$

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Velocity-Time Graphs

area = displacement

We need to take the sign of the velocity into account

The displacement between 0 and 5s was -5 m
 The displacement between 5 and 10s is 5 m
 includes negative sign. The overall displacement is 0.

For 0-5s, the object is going toward the origin and steadily slowing down.
 For 5-10s, the object is going away from the origin and steadily speeding up.

Calculating using the "suvat" equations in

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Position-Time Graphs

An object starts at a position x_1 and moves with a constant speed in the positive direction until it reaches x_2 after time t .

Average velocity is the slope of the chord

The object is at rest at $x=0$ and increases speed in the positive direction until it reaches x_2 at time t .

Instantaneous velocity is the slope of the tangent at time t .

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Acceleration-Time Graphs

area of rectangle = $l \times w$
 area of rectangle = $a \times t$

Recall: $a = \frac{dv}{dt}$
 $v = a \times t$

area under an a-t graph is $v \therefore \text{Area} = \Delta v$

The object has constant positive acceleration. The area between the line and the time axis is the change in velocity in time Δt .

$d \cdot t$ $v \cdot t$ $a \cdot t$
 area = Δx area = Δv

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Graphs for a ball travelling with a constant velocity to the right starting at x_1 and finishing at x_2 .

area = $a \times t = (x_2 - x_1) a$

slope = acc

Ball starting at x_1 at rest, increasing velocity to the right with constant acceleration, finishing at x_2 .

slope = v_{inst}

slope = acc

area = Δv

area = Δv

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