Suvat equations

1. $v = u + at$
2. $s = \left(\frac{u+v}{2}\right)t$
3. $v^2 = u^2 + 2as$
4. $s = ut + \frac{1}{2}at^2$
5. $s = vt - \frac{1}{2}at^2$

Data Booklet

These Kinematics equations (suvat) can only be applied in cases where the acceleration is constant in both magnitude + direction.

Example:

A car travelling at 15 ms^{-1} (u) accelerates by 1.2 ms^{-2} (a) for 10s (t). What is its final velocity (v)?

Given { $u = 15 ms^{-1}$, $a = 1.2 ms^{-2}$, $t = 10 s$

Required { $v = ?$

Analysis { $v = u + at$ ← Δv (1)

Solution {
$V = 15ms^{-1} + (1.2ms^{-2})(10s)$
$v = 15ms^{-1} + 12 ms^{-1}$
$v = 27 ms^{-1}$

Paraphrase { The final velocity is 27 ms^{-1}

GRASP

Example

How far does a bird travel if it accelerates by 0.15 ms^{-2} from a speed of 3.0 ms^{-1} to a speed of 5.0 ms^{-1}?

(s, a, u, v)

$a = 0.15\ ms^{-2}$
$u = 3.0\ ms^{-1}$
$v = 5.0\ ms^{-1}$
$s = ?$

(3)

$$v^2 = u^2 + 2as$$

$$v^2 - u^2 = 2as$$

$$s = \frac{v^2 - u^2}{2a}$$

$$s = \frac{(5.0\ ms^{-1})^2 - (3.0\ ms^{-1})^2}{2(0.15\ ms^{-2})}$$

$$s = \frac{25\ m^2s^{-2} - 9.0\ m^2s^{-2}}{0.30\ ms^{-2}}$$

$$s = \frac{16\ m^2s^{-2}}{0.30\ ms^{-2}}$$

$$s = 53\ m$$

The bird travelled 53 m.

Example

An electron travelling at 2.0 x 10^7 ms^{-1} accelerates uniformly to a speed of 3.0x10^7 ms^{-1} in a time of 5.0 ns. How far does the electron travel?

(u, v, t, s; n = x10^{-9})

$u = 2.0 \times 10^7\ ms^{-1}$
$v = 3.0 \times 10^7\ ms^{-1}$
$t = 5.0 \times 10^{-9}\ s$ (n)
$s = ??$

(2)

$$s = \left(\frac{u+v}{2}\right)t$$

$$s = \left(\frac{2.0\times10^7\ ms^{-1} + 3.0\times10^7\ ms^{-1}}{2}\right)(5.0\times10^{-9}\ s)$$

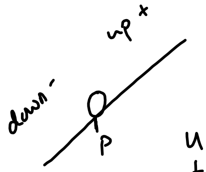
$$s = (2.5\times10^7\ ms^{-1})(5.0\times10^{-9}\ s)$$ (v_{av})

$$s = 1.2\times10^{-1}\ m \quad (0.12\ m)$$

The electron travelled 0.12 m.

Example

A ball starts at a point P and is rolled up an incline with an initial speed of 2.5 ms⁻¹ (u). Over a period of 4.0 s (t) its acceleration down the incline is 1.8 ms⁻² (a). What is the balls final displacement (s) from P?



define up as positive
down as negative.

$u = +2.5\,ms^{-1}$
$t = 4.0\,s$
$a = -1.8\,ms^{-2}$
$s = ?$

$$s = ut + \frac{1}{2}at^2 \quad (4)$$

$$s = (+2.5ms^{-1})(4.0s) + \frac{1}{2}(-1.8ms^{-2})(4.0s)^2$$

$$s = 10\,m - 14.4\,m$$

$$s = -4\,m$$

The ball finishes 4 m below P (downhill from P)

Example

A driver in her car slows down and stops (v) at the traffic lights. The deceleration of the car is 1.4 ms⁻² (a) and travels 25 m (s) before it stops. How long (t) does it take to stop?

$V = 0$
$S = 25m$
$a = -1.4\,ms^{-2}$
$t = ?$

$$s = vt - \frac{1}{2}at^2 \quad (5) \qquad (v = 0)$$

$$s = -\frac{1}{2}at^2$$

$$-2s = at^2$$

$$t^2 = \frac{-2s}{a}$$

$$t = \sqrt{\frac{-2s}{a}}$$

$$t = \sqrt{\frac{-2(25m)}{-1.4ms^{-2}}}$$

$$t = \sqrt{\frac{50m}{1.4ms^{-2}}} \qquad \frac{m}{ms^{-2}} \to s^2$$

$$t = 6.0\,s$$

It takes the driver 6.0 s to stop.

Galileo's Experiment

- all objects, regardless of their mass, falling near the Earth's surface in a vacuum, have the same acceleration
  - acceleration of gravity (g) or acceleration free fall
  - near the Earth's surface $g = 9.81 ms^{-2}$
  - g varies slightly on the Earth's surface.
  - decreases as you get further away from the center

$g = 9.81 ms^{-2}$ acceleration of free fall

$g = 9.81 Nkg^{-1}$ gravitational field strength.

Acceleration due to gravity ($g = 9.81 ms^{-2}$)

Example up is (+) down is (−)

A ball is thrown vertically upwards with a speed of 5.0 ms^{-1}. Ignoring air friction, calculate how high it goes.

u a = $-9.81 ms^{-2}$ s

$u = +5.0 ms^{-1}$

$v = 0$

$a = -9.81 ms^{-2}$

$S = ?$

$$v^2 = u^2 + 2as$$

$$v^2 - u^2 = 2as$$

$$s = \frac{v^2 - u^2}{2a}$$

$$s = \frac{0 - (5.0 ms^{-1})^2}{2(-9.81 ms^{-2})}$$

$$s = \frac{-25 m^2 s^{-2}}{-19.62 ms^{-2}}$$

$$s = 1.3 m$$

The ball reaches a height of 1.3m.

Example

A horse falls from the edge of a cliff to the ground 25m below. How long before it hits the ground? s (Neglecting air resistance)

$S = -25m$ (up is (+), down is (−))

$u = 0$

$a = -9.81 ms^{-2}$

$t = ?$

$$S = ut + \frac{1}{2}at^2 \quad (ut = 0)$$

$$S = \frac{1}{2}at^2$$

$$2s = at^2$$

$$t^2 = \frac{2s}{a}$$

$$t = \sqrt{\frac{2s}{a}}$$

$$t = \sqrt{\frac{2(-25m)}{-9.81 ms^{-2}}}$$

$$t = 2.3s$$

It takes 2.3s for the horse to fall to the ground below.

Find your reaction time by using a ruler:

$s = $? (the distance the ruler falls)

$u = 0$

$a = 9.81 ms^{-2}$ (down is +)

$t = ?$

Popper Physics

- measure the height of the "pop" → 5 → mean.