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

(① – ④: 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:
- $u = 15\,ms^{-1}$
- $a = 1.2\,ms^{-2}$
- $t = 10s$

Required: $v = ?$

Analysis: $v = u + at$ ← Δv (1)

Solution:

$v = 15\,ms^{-1} + (1.2\,ms^{-2})(10s)$

$v = 15\,ms^{-1} + 12\,ms^{-1}$

$v = 27\,ms^{-1}$

Paraphrase: The final velocity is $27\,ms^{-1}$

GRASP

Example s

How far does a bird travel if it accelerates by 0.15 ms⁻² (a) from a speed of 3.0 ms⁻¹ (u) to a speed of 5.0 ms⁻¹ (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 $2.0 \times 10^7\,ms^{-1}$ (u) accelerates uniformly to a speed of $3.0 \times 10^7\,ms^{-1}$ (v) in a time of 5.0 ns (t; n = $\times 10^{-9}$). How far (s) does the electron travel?

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

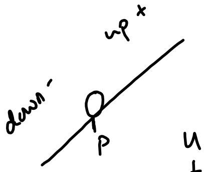
(2)

$$s = \left(\frac{u+v}{2}\right)t$$
$$s = \left(\frac{2.0\times10^7\,ms^{-1} + 3.0\times10^7\,ms^{-1}}{2}\right)(5.0\times10^{-9}\,s)$$
$$s = (2.5\times10^7\,ms^{-1})(5.0\times10^{-9}\,s)$$
(Vav)
$$s = 1.2\times10^{-1}\,m \quad (0.12\,m)$$

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.

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

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

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

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

$$s = -4\,m$$

The ball finishes 4m 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 25m (s) before it stops. How long (t) does it take to stop?

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

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

(v = 0)

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

$$-2s = at^2$$

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

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

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

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

$$t = 6.0\,s$$

It takes the driver 6.0s 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.