

Equations of Motion (constant acceleration)

Starter

- Given that $v^2 = u^2 + 2as$, find the possible values of v when $u = -3$, $a = 5$ and $s = 4$.
- Rearrange the formula $s = ut + \frac{1}{2}at^2$ to make a the subject.

Notes

The equations of motion, where **acceleration is constant**, use the letters u , v , a , s and t .

u = initial velocity

v = final velocity

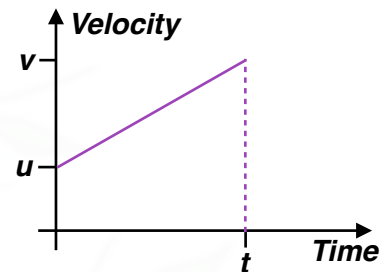
a = acceleration

s = displacement

t = time

E.g. 1 Consider the velocity-time graph.

- Using the fact that the gradient of a line is the acceleration, find an equation involving u , v , a and t .
Rearrange your equation to make v the subject.
- Using the fact that the area under the line is the distance travelled, find an equation involving s , u , v and t .



Working: (a) Gradient $\equiv a = \frac{v - u}{t}$

Multiplying both side by t :

Make v the subject:

$$at = v - u$$

$$v = u + at$$

No s

Further equations can be derived by replacing a letter in $s = \frac{1}{2}(u + v)t$ by an expression from $v = u + at$.

Replacing t

We can rearrange $v = u + at$ to make t the subject:

Subtract u from both sides:

Divide both sides by a :

Replace t by $\frac{v - u}{a}$ in $s = \frac{1}{2}(u + v)t$:

Expand the brackets:

Expand the bracket:

Multiply both sides by $2a$:

Add u^2 to both sides:

$$v = u + at$$

$$v - u = at$$

$$t = \frac{v - u}{a}$$

$$s = \frac{1}{2} \left(\frac{a}{a} \right) \left(\frac{v - u}{a} \right)$$

$$s = \frac{1}{2} \left(\frac{v^2 - u^2}{a} \right)$$

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

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

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

No t

E.g. 2 By replacing v by $u + at$ in $s = \frac{1}{2}(u + v)t$, find a formula for s in terms of a , t and u .

The equations of motion required for GCSE maths are:

$v = u + at$	No s in the equation
$s = ut + \frac{1}{2}at^2$	No v in the equation
$v^2 = u^2 + 2as$	No t in the equation
$s = \frac{1}{2}(u + v)t$	No a in the equation

N.B. The equations of motion are often called the **SUVAT** equations.

Success Criteria

1. Write down which letters you are given and which one you need to find.
2. Write down which letter you do not have/need.
3. Choose the correct equation.
4. Substitute the values you have into the equation and, if necessary, solve the equation to find the required value.

E.g. 3 Choose the correct formula in order to calculate the missing value.

Do not calculate the missing value.

(a) $a = 3, u = 2, v = 9$ find t

(b) $s = 50, v = 11, a = 2$ find u

(c) $u = 1, a = 2.5, t = 6$ find s

(d) $u = 8, t = 6, s = 100$ find a

(e) $u = 3, a = 2, s = 38$ find v

(f) $v = 10, u = 6, a = 1.5,$ find t

Working: (a) No $s \Rightarrow v = u + at$

E.g. 4 Find v given that $a = 5, u = 4$ and $s = 2$

Working: **No t so choose the equation without t :**
Substitute the values:

$$\begin{aligned}v^2 &= u^2 + 2as \\v^2 &= 4^2 + 2 \times 5 \times 2 \\v^2 &= 36 \\v &= 6\end{aligned}$$

E.g. 5 A car accelerates from 20 m/s to 35 m/s in 3 seconds. Find the acceleration.

E.g. 6 A car has initial velocity 30 km/h and accelerates at 4 m/s² for 12 seconds. Find the distance travelled.

Video: [SUVAT equations and examples](#)
Video: [SUVAT examples](#)

[Solutions to Starter and E.g.s](#)

Exercise

9-1 class textbook: p211 E6.12 Qu 1-8, 10
A*-G class textbook: No exercise
9-1 homework book: p76 E6.12 Qu 1-8
A*-G homework book: No exercise

Summary

The equations of motion required for GCSE maths are:

$v = u + at$	No s in the equation
$s = ut + \frac{1}{2}at^2$	No v in the equation
$v^2 = u^2 + 2as$	No t in the equation
$s = \frac{1}{2}(u + v)t$	No a in the equation

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