Equations of Motion (constant acceleration)

Starter

1. Given that $v^2 = u^2 + 2as$, find the possible values of v when $u = -3$, $a = 5$ and $s = 4$.

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

$$v^2 = (-3)^2 + 2 \times 5 \times 4$$
$$v^2 = 49$$
$$v = \pm\sqrt{49} = \pm 7$$

The values of v could be ± 7.

2. Rearrange the formula $s = ut + \frac{1}{2}at^2$ to make a the subject.

Working:

$$s = ut + \frac{1}{2}at^2$$

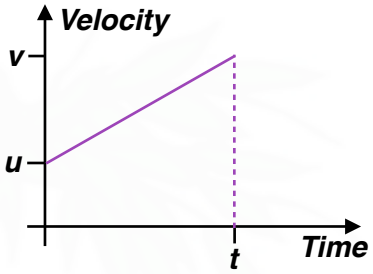
Subtract ut from both sides:
$$s - ut = \frac{1}{2}at^2$$

Multiply both sides by 2:
$$2(s - ut) = at^2$$

Divide both sides by t^2:
$$\frac{2(s - ut)}{t^2} = a$$

Write the new subject on the left:
$$a = \frac{2(s - ut)}{t^2}$$

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



(a) 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.

(b) 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:
$$at = v - u$$
Make v the subject:
$$v = u + at$$
No s

(b) ***Using Area of trapezium $= \frac{1}{2}(a + b)h$:***

Area under the line $\equiv s = \frac{1}{2}(u + v)t$

Splitting into a rectangle and triangle:

Area of rectangle $= ut$

Area of triangle $= \frac{t(v - u)}{2} = \frac{vt}{2} - \frac{ut}{2}$

$$s = ut + \frac{vt}{2} - \frac{ut}{2}$$

Collecting like terms:
$$s = \frac{ut}{2} + \frac{vt}{2}$$

Factorising:
$$s = \frac{1}{2}(u + v)t$$

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.

Working:

Substituting in $s = \frac{1}{2}(u + v)t$***:*** $s = \frac{1}{2}(u + u + at)t$

Collect like terms in the bracket: $s = \frac{1}{2}(2u + at)t$

Expand the brackets: $s = ut + \frac{1}{2}at^2$ No v

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 $\Rightarrow$ $v = u + at$

(b) No t $\Rightarrow$ $v^2 = u^2 + 2as$

(c) No v $\Rightarrow$ $s = ut + \frac{1}{2}at^2$

(d) No v $\Rightarrow$ $s = ut + \frac{1}{2}at^2$

(e) No t $\Rightarrow$ $v^2 = u^2 + 2as$

(f) 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***:*** $v^2 = u^2 + 2as$

Substitute the values: $v^2 = 4^2 + 2 \times 5 \times 2$

$v^2 = 36$

$v = 6$

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

Working:

Write down the letters you know: $u = 20, v = 35, t = 3, a = ?$

No s so choose the equation without s: $v = u + at$

Substitute the values: $35 = 20 + 3a$

Solve the equation $15 = 3a$

$a = 5$

The acceleration is 5 m/s^2.

E.g. 6 A car has initial velocity 30 km/h and accelerates at 4 m/s^2 for 12 seconds. Find the distance travelled.

Working:

Convert the initial speed to m/s.

$30 \text{ km/h} \equiv 30 \times 1000 \text{ m/h} = \dfrac{30 \times 1000}{60} \text{ km/s} = \dfrac{30 \times 1000}{60 \times 60} \text{ m/s}$

$30 \text{ km/h} \equiv 8\dfrac{1}{3} = \dfrac{25}{3} \text{ m/s}$

Write down the letters you know: $u = \dfrac{25}{3}, a = 4, t = 12, s = ?$

No v so choose the equation without v: $s = ut + \dfrac{1}{2}at^2$

Substitute the values: $s = \dfrac{25}{3} \times 12 + \dfrac{1}{2} \times 4 \times 12^2$

$s = 388 \text{ m}$

The distance travelled is 388 m.

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