How to solve problems using the kinematic equations:

GUESS Method

Given: list all of the information provided in problem statement as well as assumed values

Unknown: list of value(s) you want to solve for.

Equation: list of equations you need to solve for unknown(s)

Substitute/ Solve: Plug in given values into appropriate equation(s) to solve for unknown(s).

Kinematic Equation Chart

① $s = \frac{(u+v)}{2}t$ ② $v = u + at$ ③ $s = ut + \frac{1}{2}at^2$ ④ $v^2 = u^2 + 2as$

$\bar{v} = \frac{s}{t}$ (avg. vel/speed) $a = \frac{v-u}{t}$

Eqn #1	s	u	v	a	t
①	✓	✓	✓	✗	✓
②	✗	✓	✓	✓	✓
③	✓	✓	✗	✓	✓
④	✓	✓	✓	✓	✗

$s \Rightarrow$ displacement (m)

$u \Rightarrow$ initial velocity (ms^{-1})

$v \Rightarrow$ final velocity (ms^{-1})

$a \Rightarrow$ acceleration (ms^{-2})

$t \Rightarrow$ time interval (s)

$\frac{m}{s^2} \Rightarrow ms^{-2}$

Examples:

A car in front of the school goes 30.0 m in 2.35 seconds. What is its speed?

Given:

$s = 30.0\ m$

$t = 2.35\ s$

Unknown:

$v = \_\_\_\ ms^{-1}$

Equation:

$$v = \frac{s}{t}$$

Substitute/Solve:

$$v = \frac{30.0\ m}{2.35\ s}$$

$$v = 12.8\ ms^{-1}$$

What speed must you average to go 280 km in 3.0 hours?

Given:

$s = 280\ km$

$t = 3.0\ h$

Unknown:

$v = \_\_\_\ ms^{-1}$

Equation:

$$v = \frac{s}{t}$$

Substitute/Solve:

$$v = \frac{280{,}000\ m}{10{,}800\ s}$$

$$v = 25.9\ ms^{-1}$$

$$v = 26\ ms^{-1}$$

Conversions:

$280\ km \times \frac{1000\ m}{1\ km} = 280000\ m$

$3.0\ h \times \frac{3600\ s}{1\ h} = 10800\ s$

A car accelerates from rest to 27 ms^{-1} in 3.0 seconds. What is its acceleration?

Given

$t = 3.0\ s$

$u = 0.0\ ms^{-1}$

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

Unknown:

$a = \_\_\_\ ms^{-2}$

Equation:

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

Sub./Solve:

$$a = \frac{27 - 0}{3}$$

$$a = 9.0\ ms^{-2}$$

A rocket accelerates at a rate of 190 ms^{-2} for 2.4 seconds from rest. What is its final speed?

Given:

$a = 190\ ms^{-2}$

$t = 2.4\ s$

$u = 0.0\ ms^{-1}$

Unknown:

$v = \_\_\_\ ms^{-1}$

Equation:

$$v = u + at$$

Sub./Solve:

$$v = 0 + (190)(2.4)$$

$$v = 456\ ms^{-1}$$

$$v = 460\ ms^{-1}$$

A car has a velocity of 15 ms^{-1}. It then accelerates at a rate of 3.5 ms^{-2} for the next 5.0 seconds. What is its final velocity?

Given:
$u = 15\ ms^{-1}$
$a = 3.5\ ms^{-2}$
$t = 5.0\ s$

Unknown:
$V = \_\_\ ms^{-1}$

Equation:
$V = u + at$

Sub./Solve:
$V = 15 + (3.5)(5)$
$V = 32.5\ ms^{-1}$
$V = 33\ ms^{-1}$

What distance will a train stop in if its initial velocity is 23 ms^{-1} and its acceleration is -0.25 ms^{-2}?

Given:
$u = 23\ ms^{-1}$
$a = -0.25\ ms^{-2}$
$V = 0.0\ ms^{-1}$

Unknown:
$S = \_\_\ m$

Equation:
$V^2 = u^2 + 2as$

Sub./Solve:
$(0)^2 = (23)^2 + 2(-.25)s$
$0 = 529 - .5s$
$-529 \quad -529$
$-529 = -.5s$
$\frac{-529}{-.5} = \frac{-.5s}{-.5}$
$S = 1058\ m$
$S = 1100\ m$

What distance will a car cover accelerating from 12 ms^{-1} to 26 ms^{-1} in 14 seconds?

G:
$t = 14\ s$
$u = 12\ ms^{-1}$
$V = 26\ ms^{-1}$
U:
$S = \_\_\ m$

E:
$S = \frac{(u+v)}{2}t$

S/S:
$S = \frac{(12+26)(14)}{2}$
$S = 266\ m$
$S = 270\ m$ 2 SF!

A train traveling 12 ms^{-1} stops in a distance of 541 m. What was its acceleration?

G:
$S = 541\ m$
$u = 12\ ms^{-1}$
$V = 0\ ms^{-1}$
U:
$a = \_\_\ ms^{-2}$

E:
$V^2 = u^2 + 2as$

S/S:
$(0)^2 = (12)^2 + 2a(541)$
$0 = 144 + 1082a$
$-144 \quad -144$
$\frac{-144}{1082} = \frac{1082a}{1082}$
$a = -.133\ ms^{-2}$
$a = -.13\ ms^{-2}$

A person starts at rest and accelerates at 3.2 ms^{-2} for 3.0 seconds.
(a) What is their final velocity?
(b) What is their average velocity?
(c) What distance do they cover in that time?

G:
$a = 3.2\ ms^{-2}$
$u = 0\ ms^{-1}$
$t = 3.0\ s$

U:
(a) $V =$ ___ ms^{-1}
(b) avg. vel = ___ ms^{-1}
(c) $S =$ ___ m

Eqn (a)
$V = u + at$
S/S (a):
$V = (0) + (3.2)(3.0)$
(a) $V = 9.6\ ms^{-1}$

Eqn (c)
$s = ut + \frac{1}{2}at^2$
$S = (0)(3) + \frac{1}{2}(3.2)(3)^2$
$S = 14.4\ m$
(c) $S = 14\ m$

$S = \frac{(u+v)t}{2}$
$S = \frac{(0+9.6)(3)}{2}$
$S = 14.4\ m$

Eqn (b)
$V = \frac{S}{t}$
$V = \frac{14\ m}{3.0\ s} = 4.7\ ms^{-1}$

Eqn (b)
avg vel $= \frac{(u+v)}{2}$
$= \frac{(0+9.6)}{2}$
avg $= 4.8\ ms^{-1}$

A car skids to a halt at a rate of -9.4 ms^{-2}. The skid marks measure 34 m. What speed was the car going when it slammed on the brakes?

G:
$a = -9.4\ ms^{-2}$
$V = 0\ ms^{-1}$
$S = 34\ m$

U:
$u =$ ___ ms^{-1}

E:
$V^2 = u^2 + 2as$

S/S:
$(0)^2 = u^2 + 2(-9.4)(34)$
$0 = u^2 + (-639.2)$
$+639.2 \quad +639.2$
$\sqrt{639.2} = \sqrt{u^2}$
$u = 25\ ms^{-1}$

A train can accelerate at a rate of 0.15 ms^{-2}. In what distance will it obtain a speed of 25 ms^{-1} if it starts from rest?

G:
$a = 0.15\ ms^{-2}$
$V = 25\ ms^{-1}$
$u = 0\ ms^{-1}$

U:
$S =$ ___ m

E:
$V^2 = u^2 + 2as$

S/S:
$(25)^2 = (0)^2 + 2(.15)S$
$625 = .3S$
$\frac{625}{.3} = \frac{.3S}{.3}$
$S = 2083.3\ m$
$S = 2100\ m$

A drag racer can reach a speed of 53 ms^{-1} over a distance of 120 m.
(a) What is the acceleration of the race car?
(b) Over what distance can it reach a speed of 85 ms^{-1}?

G:
$v = 53\ ms^{-1}$
$s = 120\ m$
$u = 0\ ms^{-1}$

U:
(a) $a =$ ___ ms^{-2}
(b)

E (a):
$v^2 = u^2 + 2as$

S/S (a):
$(53)^2 = (0)^2 + 2a(120)$
$2809 = 0 + 240a$
$\frac{2809}{240} = \frac{240a}{240}$
$a = 11.7041\ ms^{-2}$
$a = 12\ ms^{-2}$ (a)

G:
$a = 12\ ms^{-2}$
$v = 85\ ms^{-1}$
$u = 0\ ms^{-1}$

U:
$s =$ ___ m

E:
$v^2 = u^2 + 2as$
$(85)^2 = (0) + 2(12)s$
$7225 = 24s$
$\frac{7225}{24} = \frac{24s}{24}$
$s = 3.0 \times 10^2\ m$

Light from the sun reaches Earth in 8.3 minutes. The velocity of light is $3.0 \times 10^8\ m\ s^{-1}$. How far is the Earth from the sun?

Given:
$t = 8.3\ min$
$v = 3.0 \times 10^8\ ms^{-1}$

Unknown:
$s =$ ___ m

Equation:
$v = \frac{s}{t}$

Subst./Solve:
$3.0 \times 10^8 = \frac{s}{498}$ * 498
$s = 1.494 \times 10^{11}$
$s = 1.5 \times 10^{11}\ m$

Conversion:
$8.3\ min \left| \frac{60\ s}{1\ min} \right. = 498\ s$

A car is moving down a street at 55 km h^{-1}. A child suddenly runs into the street. If it takes the driver 0.75 seconds to react and apply the brakes, how many meters will the car have moved before it begins to slow down?

Given:

$v = 55\ km\ h^{-1}$

$t = 0.75\ s$

Equation:

$V = \frac{s}{t}$

Subst./Solve

$15.278 = \frac{s}{0.75}$ *.75

$s = 11.458\ m$

$s = 11\ m$

Conversion:

$\frac{55\ km}{h} \left| \frac{1000\ m}{1\ km} \right| \frac{1\ h}{3600\ s}$

$15.278\ m\ s^{-1}$

Unknown:

$s = \_\_\_\ m$

Highway safety engineers build soft barriers so that cars hitting them will slow down at a safe rate. A person wearing a seatbelt can withstand an acceleration of $-3.0 \times 10^2\ m\ s^{-2}$. How thick should the safety barriers be to safely stop a car that hits a barrier at 110 km h^{-1}?

Given:

$a = -3.0 \times 10^2\ m\ s^{-2}$

$u = 110\ km\ h^{-1}$

$v = 0\ km\ h^{-1}$ ($m\ s^{-1}$)

Equation:

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

S/S:

$(0)^2 = (30.556)^2 + 2(-3.0 \times 10^2)s$

$0 = 933.642 + (-600)s$

$-933.642 - 933.642$

$\frac{-933.642}{-600} = \frac{-600s}{-600}$

$s = 1.5561\ m$

Conversion

$\frac{110\ km}{h} \left| \frac{1000\ m}{1\ km} \right| \frac{1\ h}{3600\ s}$

$30.556\ m\ s^{-1}$

$s = 1.6\ m$

Unknown:

$s = \_\_\_\ m$