The Big 3 Kinematics Equations

If an object is accelerating then the formula:

$\vec{v} = \frac{\vec{\Delta d}}{\Delta t}$ Gives us only the average velocity

We can also find average velocity using:

$\vec{v}_{av} = \frac{\vec{v}_f + \vec{v}_i}{2}$

In order to solve problems with uniform acceleration we need to use 3 formulae. These 3 formulae use the variables:

v_f = final velocity
v_i = initial velocity
a = acceleration
d = displacement
t = time ← scalar

} vectors ... you decide + or − ve

1) $\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$

Ex: A squad car traveling at 7.0 m/s East speeds up to 22.0 m/s East in 1.7 s. What is its acceleration?

Given: $v_i = 7\ m/s\ [E]$ Need: $\vec{a}$
$v_f = 22\ m/s\ [E]$
$\Delta t = 1.7\ s$

$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$

$= \frac{22\ m/s - 7\ m/s}{1.7\ s}$

$\vec{a} = 8.8\ m/s^2\ [E]$

2) $\vec{\Delta d} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2$

Ex: A sprinter starts from rest and accelerates uniformly. He travels 100.0 m south in 9.69 s, what was his average acceleration?

Given: $v_i = 0\ m/s$ Need: $\vec{a}$
$\vec{d} = 100.0\ m\ [S]$
$t = 9.69\ s$

$\vec{\Delta d} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2$

$= 0 + \frac{1}{2}at^2$

$\vec{\Delta d} = \frac{1}{2}\vec{a}t^2$

$\frac{2\vec{\Delta d}}{t^2} = \frac{\vec{a}t^2}{t^2}$

$\vec{a} = \frac{2\vec{\Delta d}}{t^2}$

$= \frac{2(100.0\ m)}{9.69_s^2}$

$\vec{a} = 2.13\ m/s^2\ [S]$

3) $v_f^2 = v_i^2 + 2\vec{a}\vec{\Delta d}$

Ex: A banana boat accelerates from 15.0 km/h at 2.00 m/s^2. How far has it traveled when it reaches 30.0 km/h?

Given: $v_i = \frac{15\ km}{h} \times \frac{1000\ m}{km} \times \frac{1\ h}{3600\ s} = 4.167\ m/s$ Need: $\vec{\Delta d}$

$\vec{a} = 2\ m/s^2$

$v_f = \frac{30\ km}{h}\ (\div 3.6) = 8.333\ m/s$

$v_f^2 = v_i^2 + 2ad$

$\frac{v_f^2 - v_i^2}{2a} = d$

$d = \frac{(8.333\ m/s)^2 - (4.167\ m/s)^2}{2\ (2\ m/s^2)}$

$\vec{d} = 13.0\ m$

Units $\frac{\frac{m^2}{s^2}}{\frac{m}{s^2}} = m$ →

Ex 1: The Rocket Truck is traveling at 16.0 m/s when it is passed by a plane. It immediately hits the jets at accelerates at 14.0 m/s^2 for 3.25 s.

a. What final velocity does it reach?

Given: $V_1 = 16\ m/s$
$a = 14\ m/s^2$
$\Delta t = 3.25\ s$

Need: V_f

$$\vec{a} = \frac{V_f - V_1}{\Delta t}$$

$$V_f = V_1 + \vec{a}t$$

$$= \frac{16\ m}{s} + \frac{14\ m}{s^2}(3.25\ s)$$

$$\vec{V_f} = 61.5\ m/s\ [straight]$$

b. How far does it travel in this time?

Need: $\Delta\vec{d}$

$$V_f^2 = V_i^2 + 2ad$$

$$d = \frac{V_f^2 - V_i^2}{2a}$$

$$= \frac{(61.5\ m/s)^2 - (16\ m/s)^2}{2(14\ m/s^2)}$$

$$\vec{d} = 126\ m\ [straight]$$

Ex 2: An arrow strikes a can at 32.0 m/s and exits at 31.0 m/s. If the arrow is 42 cm long find its acceleration as it pierced the can. Ignore the width of the can.

Given: $V_i = 32\ m/s$
$V_f = 31\ m/s$
$d = 0.42\ m$

$d = 42\ cm = 0.42\ m$

Need: $\vec{a}$

$$V_f^2 = V_i^2 + 2ad$$

$$\vec{a} = \frac{V_f^2 - V_i^2}{2d}$$

$$= \frac{(31\ m/s)^2 - (32\ m/s)^2}{2(0.42\ m)}$$

$$\vec{a} = -75\ m/s^2\ [straight]$$