Section 2.6: The "Big Three" Kinematics Equations

Whenever an object moves with constant acceleration, there are a number of quantities we might be interested in:

$\vec{v}_f$, $\vec{v}_i$, $\vec{a}$, $\vec{d}$ } vectors (direction matters) (+/- matters)

Δt or t ← scalar!!

There are three VERY POWERFUL equations that relate these variables to each other. They are...

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

Example 1: A police car traveling at 80 km/h east speeds up to 100 km/h east in 1.7 s. What is its acceleration?

$\vec{v}_f$ = 100 km/h (27.7 m/s)

$\vec{v}_i$ = 80 km/h (22.2 m/s)

$\vec{a}$ = ?

$\vec{d}$ = –

t = 1.7 s

$$\vec{v}_f = \vec{v}_i + \vec{a}t$$

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

$$\frac{(27.7)-(22.2)}{(1.7)} = \boxed{3.3\,m/s^2}$$

Example 2: A sprinter, 20 m before the finish line, finds a little extra energy in her legs and accelerates at 0.9 m/s² for the rest of the race. She crosses the finish line going 9.3 m/s. What was her velocity when she started accelerating?

$\vec{v}_f$ = 9.3 m/s

$\vec{v}_i$ = ?

$\vec{a}$ = 0.9 m/s²

$\vec{d}$ = 20 m

t =

$$\vec{v}_f^{\,2} = \vec{v}_i^{\,2} + 2\vec{a}\vec{d}$$

$$\sqrt{\vec{v}_f^{\,2} - 2\vec{a}\vec{d}} = \sqrt{\vec{v}_i^{\,2}}$$

$$\pm\sqrt{\vec{v}_f^{\,2} - 2\vec{a}\vec{d}} = \sqrt{\vec{v}_i}$$

$$\pm\sqrt{(9.3)^2 - 2(0.9)(20)} = \vec{v}_i$$

pick one → $\pm$ 7.1 m/s = $\vec{v}_i$

= +7.1 m/s