Constant acceleration

1) $v = v_0 + at \rightarrow t = \frac{1}{a}(v - v_0)$

2) $x = x_0 + v_0 t + \frac{1}{2} a t^2$

3) $x = x_0 + \frac{1}{2}(v_0 + v)t$

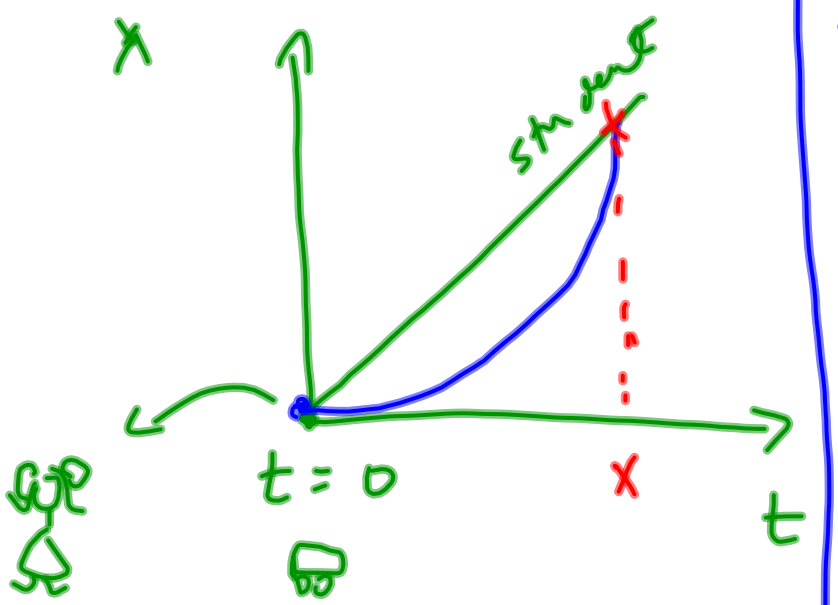
$(v - v_0)(v + v_0)$

$v^2 - v_0^2$

4) $v^2 = v_0^2 + 2a(x - x_0)$

Example

A speeding Phys 121 (2016) student zooms through 50 km/h zone at the speed of 75 km/h without noticing a police car. Police officer heads after a student accelerating at $2.5\ m/s^2$ (the a). When the officer catches up with a student how far down the road are they and how fast is police car going?



$x_{p_0} = 0$

(t), a, v, x = ?

At $t = 0$ $x_{s_0} = 0$

$x_{p_0} = 0$

$t = t$ $x_s = x_p = ?$

$t = 0$ $v_{p_0} = 0$

$v_{s_0} = 75\ km/h$

$= 21\ m/s$

$a_p = 2.5\ m/s^2$

$a_s = 0\ m/s^2$

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$x_s = \frac{2 v_{0s}^2}{a_p} = \frac{2 \cdot 21^2 \, m^2/s^2}{}$$

Student $x_s = x_{0s} + v_{0s} t + \frac{1}{2} a_s t^2 = v_{0s} t$

Police $x_p = x_{0p} + v_{0p} t + \frac{1}{2} a_p t^2 - \frac{1}{2} a_p t^2$

$x_s = x_p$ $\quad v_{0s} t = \frac{1}{2} a_p t^2 \quad | : t$

$t \left(v_{0s} - \frac{1}{2} a_p t \right) = 0$ $\quad t_1 = 0$

$t_2 = \frac{2 v_{0s}}{a_p}$ $\quad v_{0s} = \frac{1}{2} a_p t$

$$x_s = v_{s0} t = \frac{2 v_{s0}^2}{a_p} =$$

$$= \frac{2 \cdot 21 \, m^2/s^2}{2.5 \, m/s^2}$$

$$v_{s0} \cdot \frac{2 \cdot v_{s0}}{a_p} = \frac{2 \cdot v_{s0}^2}{a_p}$$

$$t_2 = \frac{2 v_{s0}}{a_p}$$

$$= 350 \text{ m}$$

$$\frac{2 \cdot 21 \text{ m/s}}{2.5 \text{ m/s}^2} = 16.8 \text{ s}$$

$v_p = ?$

$v_p = \cancel{v_{0p}} + a_p \cdot t = \cancel{a_p} \cdot \frac{2 \cdot v_{s0}}{\cancel{a_p}}$

$2.5\,m/s^2 \cdot 16.8\,s = 42\,m/s$

$t = \frac{2 v_{s0}}{a_r}$

$\boxed{v_p = 2 \cdot v_{s0}}$

$y = 25\,000 \text{ feet}$

$= 7620 \text{ m}$

$t = 130 \text{ s}$

Freely falling objects & $x \Rightarrow y$

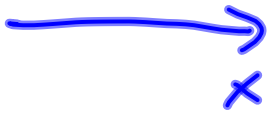
acceleration of gravity $a = -g$

$v = v_0 + at$

$x = x_0 + v_0 t + \frac{1}{2} a t^2$

$x = x_0 + \frac{1}{2} v_0 t + \frac{1}{2} v t$

$v^2 = v_0^2 + 2a(x - x_0)$



$v = v_0 - gt$

$\boxed{y = y_0 + v_0 t - \frac{1}{2} g t^2}$

$y = y_0 + \frac{1}{2} v_0 t + \frac{1}{2} v t$

$v^2 = v_0^2 - 2g(y - y_0)$

$y = y_0 + v_0 t - \frac{1}{2} g t^2$ ($y = 0$, $v_0 = 0$)

$0 = 7620 - \frac{1}{2} \cdot 9.8\, t^2$

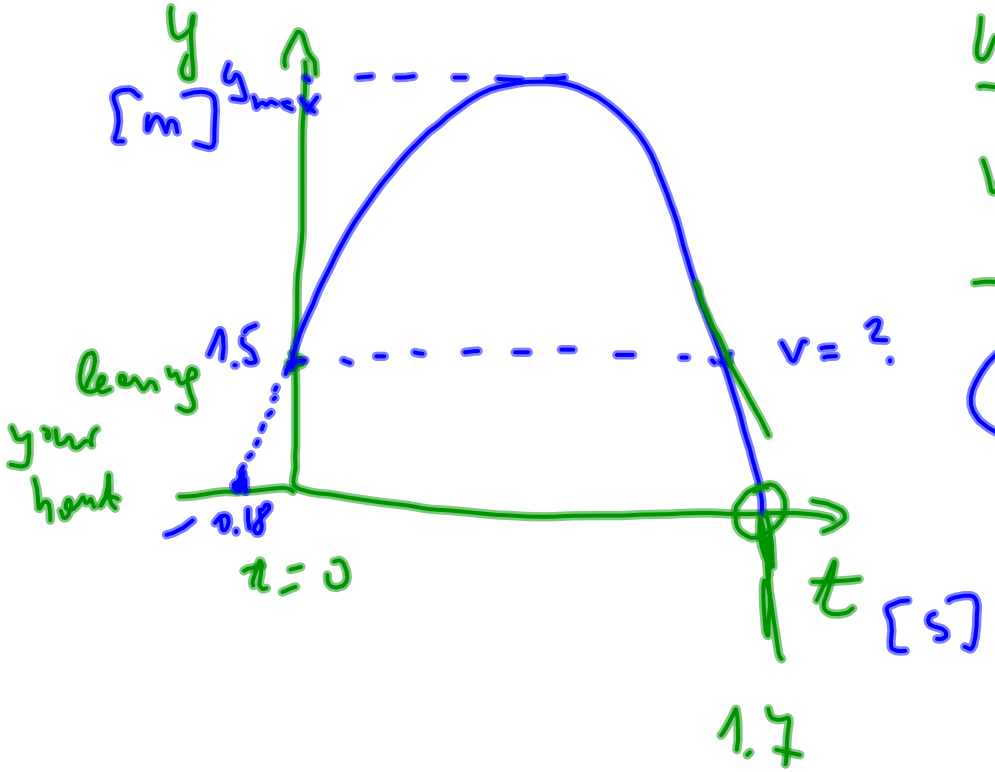
$t^2 = \frac{2 \cdot 7620}{9.8}$

$t \approx 39\ s \neq 130\ s$

duke the jumper

Example

You toss a ball straight up at 7.3 m/s, it leaves your hand at 1.5 m above the floor. Find when it hits the floor, the maximum height it reaches (2) its speed when it passes your hand on the way down.



$y_0 = 1.5\ m$

$v_0 = 7.3\ m/s$

$t = ?$ when $y = 0$

$y_{max} = ?$

$v = ?$

$$y = y_0 + v_0 t - \frac{1}{2} g t^2$$

$t_1 = 1.7 \text{ s}$

$t_2 = -0.18 \text{ s}$

$$0 = 1.5 + 7.3t - \frac{1}{2} 9.8 t^2$$

$$at^2 + bt + c = 0$$

$$t_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$y_{max} = ?$

$v = 0$!

$v^2 = v_0^2 - 2g(y - y_0)$

Please finish this problem