Basic Kinematics

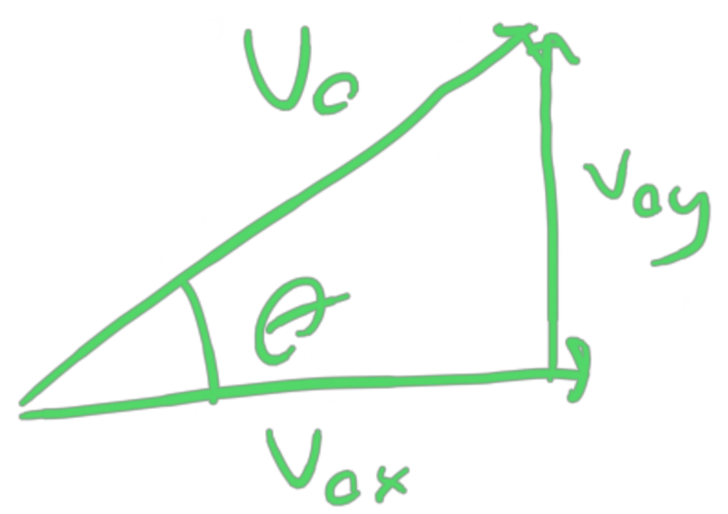
Kinematics is the study of objects in motion *before* we even consider forces (directly). A classic example is a motorcycle jumper, without air resistance.

Ex. motorcycle jumper.

How far away from the ramp will she land?

First, recall that x & y motion can be treated independently. So, we'll look at her vertical motion to see how long she's airborne.

First, split V_0 into components:



$$V_{0y} = V_0 \sin\theta$$

$$V_{0x} = V_0 \cos\theta$$

[remember, e.g. $\cos 0 = 1$ & $\theta = 0 \rightarrow V_{0x} = V_0$]

So, her vertical trajectory is described by

$$y: \quad h + V_{0y} t - \frac{1}{2} g t^2 = 0$$

is a quadratic equation,

$$t = \frac{-V_{0y} \pm \sqrt{V_{0y}^2 - 4h\left(\frac{-g}{2}\right)}}{2\left(\frac{-g}{2}\right)}$$

only one of these solutions is positive.

Take that solution for t, and plug in:

$X: \ X_f = X_0 + V_{0x} t$

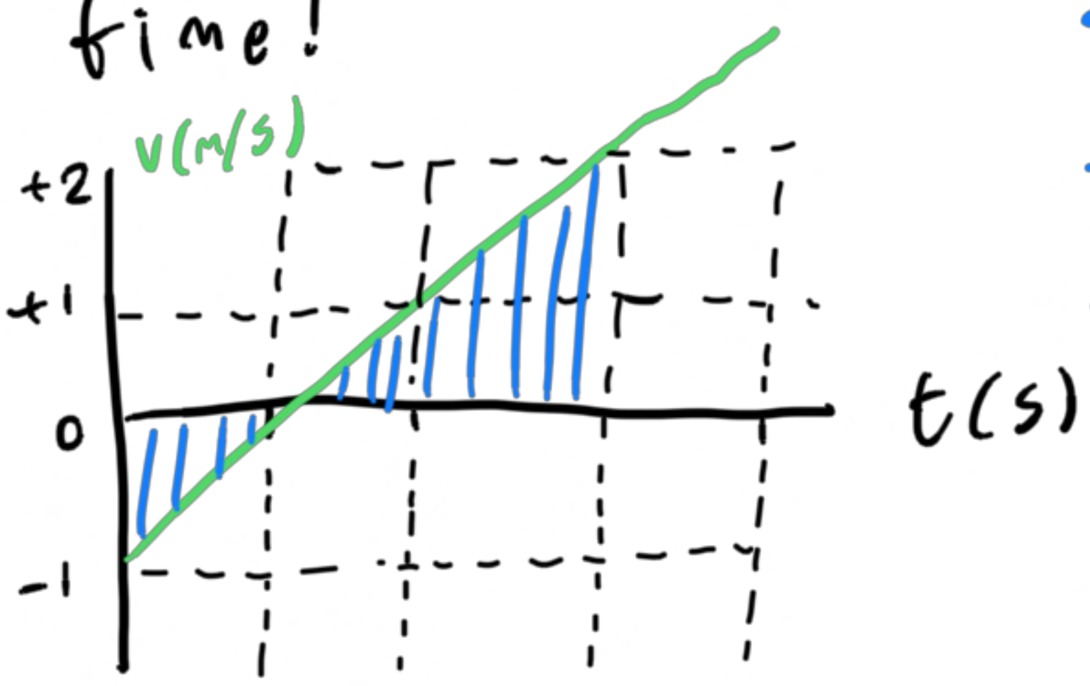
$$X_f = 0 + V_{0x} t$$

Some other handy tricks for kinematics

In the very common plot problems, recall that velocity is the slope (time derivative) of position, and acceleration is the slope of velocity.

In the same vein, position is the area under (integral of) velocity, which is the area under acceleration.

Ex. for this velocity vs. time graph, the object under observation starts at $X_0 = -1.5m$. When does it pass the origin, and what is its acceleration at that time?



the area of the blue region tells us the position at time t by summing the area up to that point. At $t = 1s$, the area is 0.5 below the axis, so $X(t=1) = X_0 - 0.5m = -2m$.

By this logic, the area totals +1.5 at $t=3s$.
So this is when the object passes through $x=0$.

The slope at this time tells us the acceleration.
Velocity is increasing 1 m/s per second.

So, $a(x=0) = a(t=3s) = +1 \, m/s^2$.