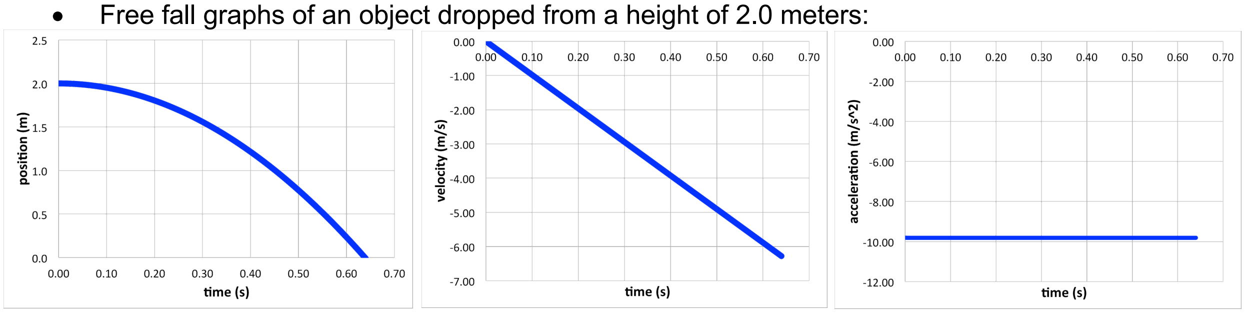
Flipping Physics Lecture Notes:
AP Physics C: Kinematics Review (Mechanics)
https://www.flippingphysics.com/apc-kinematics-review.html

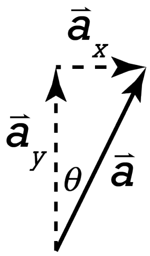
- Dimensions are your friends!!:
  - Be careful with your conversions and give all your answers units (when they have them!).
  - $\rho_{Krypton} = 3.75\frac{g}{cm^3}\left(\frac{100cm}{1m}\right)^3\left(\frac{1kg}{1000g}\right) = \boxed{0.375\frac{kg}{m^3}}$
- Vector vs. Scalar:
  - Vectors have both magnitude and direction.
  - Scalars have magnitude only (no direction) but can be positive or negative.
- Instantaneous velocity is the derivative of position as a function of time: $\vec{v}_{instantaneous} = \frac{d\vec{x}}{dt}$
  - Not to be confused with average velocity: $\vec{v}_{average} = \frac{\Delta\vec{x}}{\Delta t}$
- Instantaneous acceleration is the derivative of velocity as a function of time: $\vec{a}_{instantaneous} = \frac{d\vec{v}}{dt}$
  - Not to be confused with average acceleration: $\vec{a}_{average} = \frac{\Delta\vec{v}}{\Delta t}$
- The derivative represents the slope of the line.
- Uniformly Accelerated Motion or UAM.

AP® Physics C Equation Sheet	*Flipping Physics®*
$v_x = v_{x0} + a_x t$	$v_f = v_i + a\Delta t$
$x = x_0 + v_{xo}t + \frac{1}{2}a_x t^2$	$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$v_x^{\,2} = v_{x0}^{\,2} + 2a_x\left(x - x_0\right)$	$v_f^{\,2} = v_i^{\,2} + 2a\Delta x$
	$\Delta x = \frac{1}{2}\left(v_f + v_i\right)\Delta t$

  - The AP Physics C UAM Equations assume $t_i = 0$; $\Delta t = t_f - t_i = t_f - 0 = t$
  - x_0 means the initial position.
- Free fall is when the only force acting on an object is the Force of Gravity. (No air resistance)
  - $a_y = -g = -9.81\frac{m}{s^2}$ & $g_{Earth} = +9.81\frac{m}{s^2}$
  - This is Uniformly Accelerated Motion where you already know the acceleration!
- Free fall graphs of an object dropped from a height of 2.0 meters:



- Component vectors are the vectors in the x, y (and possibly z) directions that make up a vector.



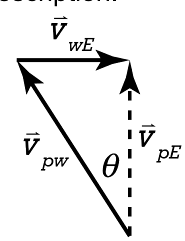
  - $\vec{a} = 2.5\frac{m}{s^2}@26^\circ\, E\, of\, N$
    - $\sin\theta = \frac{O}{H} = \frac{a_x}{a} \Rightarrow a_x = a\sin\theta = 2.5\sin(26) = 1.09593 \approx \boxed{1.1\frac{m}{s^2}}$
    - $\cos\theta = \frac{A}{H} = \frac{a_y}{a} \Rightarrow a_y = a\cos\theta = 2.5\cos(26) = 2.24699 \approx \boxed{2.2\frac{m}{s^2}}$
- Unit Vectors $\hat{i}, \hat{j}, and\ \hat{k}$ are vectors with a value of 1 in the x, y, and z directions respectively.
  - In other words the acceleration in the above example in unit vector form is:

    $\vec{a} = \left[1.1\hat{i} + 2.2\hat{j}\right]\frac{m}{s^2}$ This is the same as $\vec{a} = 2.5\frac{m}{s^2}@26^\circ\, E\, of\, N$
- Vector addition is much easier using Unit Vectors. Example:

  $\vec{A} = \left[1.00\hat{i} + 2.00\hat{j}\right]m;\ \vec{B} = \left[2.50\hat{i} - 1.50\hat{j}\right]m;\ \vec{C} = \left[3.00\hat{i} + 3.50\hat{j}\right]m$

  $\vec{R} = \vec{A} + \vec{B} + \vec{C} = ? = \left[1.00\hat{i} + 2.00\hat{j}\right] + \left[2.50\hat{i} - 1.50\hat{j}\right] + \left[3.00\hat{i} + 3.50\hat{j}\right]$

  $\Rightarrow \vec{R} = \left[1 + 2.5 + 3\right]\hat{i} + \left[2 - 1.5 + 3.5\right]\hat{j} = \left[6.50\hat{i} + 4.00\hat{j}\right]m$
- $\vec{r}$ is generally used as the position vector symbol. This is so you can give the position of an object in 2 (or even 3) dimensions. For example if an object is located -2.0 meters in the x-direction, 7.4 meters in the y-direction and -3.7 meters in the z-direction, we can illustrate its position as $\vec{r} = \left[-2.0\hat{i} + 7.4\hat{j} + -3.7\hat{k}\right]m$.
  - Note: The position vector equation $\vec{r}$ is much shorter than the word description.
- Relative velocity is simply vector addition. $\vec{v}_{pE} = \vec{v}_{pw} + \vec{v}_{wE}$



  - The velocity of the plane with respect to the Earth equals the velocity of the plane with respect to the wind plus velocity of the wind with respect to the Earth.
  - Don't forget it's tip-to-tail vector addition. So $\vec{v}_{pw} + \vec{v}_{wE}$ are drawn "tip-to-tail".
- Projectile Motion is when the only force acting on an object is the Force of Gravity and the object is moving in both the x and y directions. (No air resistance)

x direction	*y direction*
$a_x = 0$	Free-Fall
Constant Velocity	$a_y = -g = -9.81\frac{m}{s^2}$
$v_x = \frac{\Delta x}{\Delta t}$	Uniformly Accelerated Motion
Δt (or t) is the same in both directions because it is a *scalar* and has magnitude only (no direction).	

  - Break the initial velocity into its components.