Flipping Physics Lecture Notes:
AP Physics 1 - Unit 1 Review - Kinematics Exam Prep
http://www.flippingphysics.com/ap-physics-1-unit-1-review.html

This lecture is a free part of my AP Physics 1 Ultimate Review Packet. If you find this video useful, I suggest you invest in the rest of the packet.

Before we even begin discussing the topics in this unit, let's talk about 2 things.

1) Significant figures or sig figs. Actually, let's not talk about them. The AP Physics 1 exam basically ignores significant figures, so you can too. My suggestion is to use roughly 3 sig figs and leave it at that.
2) Conversions. Understanding how conversions work does actually help with understanding physics. So, let's do one to make sure you remember how. Convert 8,765 kg/m^3 to g/cm^3.

$$8{,}765\frac{kg}{m^3}\left(\frac{1000g}{1kg}\right)\left(\frac{1m}{100cm}\right)^3 = 8{,}765\frac{kg}{m^3}\left(\frac{1000g}{1kg}\right)\left(\frac{1^3m^3}{100^3cm^3}\right) = 8.77\frac{g}{cm^3}$$

And now, on to AP Physics 1 – Unit 1 – Kinematics Review!

Vectors and Scalars:

- Vectors have magnitude and direction.
- Scalars have magnitude only.
- Examples of vectors are displacement, velocity, acceleration, force, momentum, torque, angular momentum, etc.
- Examples of scalars are time, distance, mass, speed, volume, density, work, energy, rotational inertia, etc.
- Basic ways to illustrate that a variable is a vector. For example, for velocity, v:
    - You can put an arrow over a variable: $\vec{v}$
    - You can give the variable a subscript: v_x
    - Sometimes you will see vectors are illustrated as boldface: **v**
- Often we illustrate vectors using arrows. The longer the arrow, the larger the magnitude of the vector.

Displacement, Velocity, and Acceleration:

- Things to remember about displacement:
    - An object's displacement is the straight-line distance between the object's initial and final points.
    - Displacement is the change in position of an object.
        - $\Delta\vec{x} = \vec{x}_f - \vec{x}_i$
    - If an object stops at the same place it started, it has a displacement of zero.
    - The distance an object travels will always be greater than or equal to the magnitude of the displacement of the object.
        - Magnitude just means the amount of. For example, if someone travels 5 meters North, the magnitude of their displacement is 5 meters.
    - Displacement is a vector. It has both magnitude and direction.
- Average speed is the distance traveled over the time duration of that travel.
    - Typically, the equation for average speed is: $\text{speed}_{avg} = \frac{\text{distance}}{\text{time}}$

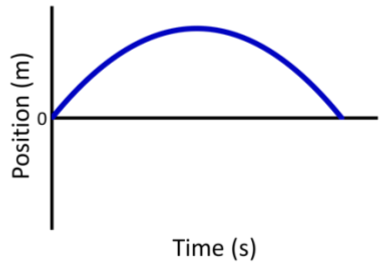
- However, realize the time there is not a specific time, but rather the time duration during which the distance was traveled.

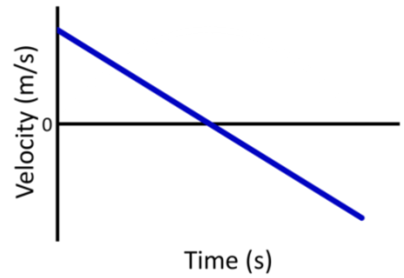
  - Speed is a scalar. It has magnitude only. It does not have direction.

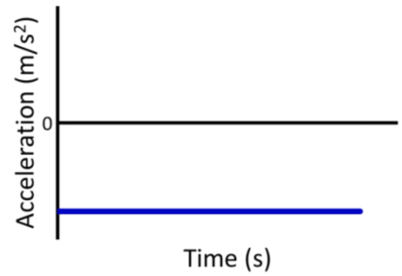
- The equation for average velocity is: $\vec{v}_{avg} = \frac{\Delta \vec{x}}{\Delta t}$
  - Typical units for speed and velocity are meters per second, kilometers per hour, miles per hour, furlongs per fortnight. (maybe not that last one)
  - Velocity is a vector.
  - If the time interval over which the average velocity is taken is very small, then the velocity is considered to be instantaneous velocity. That is, the velocity at a specific time, rather than the velocity over a time period.
- The equation for average acceleration is: $\vec{a}_{avg} = \frac{\Delta \vec{v}}{\Delta t}$
  - Typical units for acceleration are meters per second squared. That's it. Those are the only units that are typically used for linear acceleration.
  - If the time interval over which the average acceleration is taken is very small, then the acceleration is considered to be instantaneous acceleration. That is, the acceleration at a specific time, rather than the acceleration over a time period.
  - Acceleration is a vector.
- When the acceleration of an object does not change, we can use the uniformly accelerated motion or UAM equations. These are also often called the kinematics equations.
  - These three are on the equation sheet:
    - $v_x = v_{x0} + a_x t$
    - $v_x{}^2 = v_{x0}{}^2 + 2a_x (x - x_0)$
    - $x = x_0 + v_{x0} + \frac{1}{2} a_x t^2$
  - This UAM equation is not on the equation sheet:
    - $\Delta x = \frac{1}{2} (v_x + v_{x0})\, t$
  - All of these equations assume the initial time is zero.
- If an object is close to the surface of planet Earth and air resistance can be ignored, then the acceleration of the object in the y-direction under the influence of just the force of gravity is 9.81 m/s^2 down.
  - 9.8 m/s^2 is also acceptable, however, you really should just use 10 m/s^2.
  - This is often referred to as free fall motion with $g \approx 10\ m/s^2$.
  - Notice this is Uniformly Accelerated Motion!
  - Remember the velocity of the object at the top of the path in the y-direction is zero.

Motion Graphs:

- The slope of a position vs. time graph is velocity.
- The slope of a velocity vs. time graph is acceleration.
- The area between the curve and the time axis on a velocity vs. time graph is change in position.
- The area between the curve and the time axis on an acceleration vs. time graph is change in velocity.
- Area above the horizontal axis is positive and area below the horizontal axis is negative.
- The 3 graphs below all describe the same, uniformly accelerated motion.

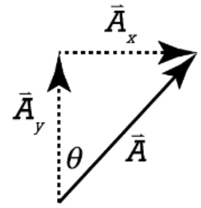






<u>Two-Dimensional Motion:</u>

- You will have to be able to break, or resolve, vectors into their component vectors. For example:



$$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}} = \frac{A_x}{A} \Rightarrow A_x = A\sin\theta$$
$$\cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}} = \frac{A_y}{A} \Rightarrow A_y = A\cos\theta$$

  - Be careful, theta will not always be with the horizontal, therefore, the x-component will not always use cosine.
- Projectile motion is where an object is moving in two-dimensions near the surface of a planet where the only force acting on it is the force of gravity.
  - In projectile motion typically we separate our known values into x and y-directions:

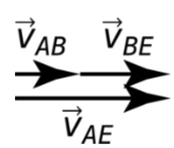
x-direction:	*y-direction:*
$a_x = 0$	free fall
Constant Velocity	$a_y = -g = -9.81\ m/s^2 \approx -10\ m/s^2$
$v_x = \frac{\Delta x}{\Delta t}$	Uniformly Accelerated Motion
Δt is the same in both directions because it is a scalar and has magnitude only (no direction).	

  - Break the initial velocity into components.
    - Unless the initial velocity is completely horizontal, then $v_{iy} = 0$.
  - The velocity at the top *in the y-direction* is zero.
  - When $\Delta y = 0$, $\Delta t_{up} = \Delta t_{down}$ and $v_{iy} = -v_{fy}$

<u>Relative Motion:</u>

- The description of the motion of an object changes depending on the frame of reference of the person observing the motion.
- Combining the motion of an object and the motion of an observer in a reference frame involves vector addition.
- The AP Physics 1 exam restricts relative motion problems to one dimensional motion.

Example: “A stationary observer measures car A to be moving at 60 km/hr East and car B to be moving at 35 km/hr East. What would a person in car B measure the velocity of car A to be?”



$$\vec{v}_{AE} = 60\frac{km}{hr}\text{East} \ \& \ \vec{v}_{BE} = 35\frac{km}{hr}\text{East} \ \& \ \vec{v}_{AB} = ? \quad \vec{v}_{AB} + \vec{v}_{BE} = \vec{v}_{AE}$$

$$\vec{v}_{AB} = \vec{v}_{AE} - \vec{v}_{BE} = 60\frac{km}{hr}\text{East} - 35\frac{km}{hr}\text{East} = 25\frac{km}{hr}\text{East}$$