Lesson 6: Manipulating Equations

Manipulating equations is probably one of the most important skills to master in a high school physics course.

- Although it is based on familiar (and fairly simple) math concepts, it is still a stumbling block for most new physics students.
- Manipulating an equation means that you rearrange the equation so that the unknown you are trying to calculate is on its own on one side of the equation.
- Later in the course it will also give you the power to combine formulas (which is necessary) to solve more complicated problems.
- Learning how to manipulate formulas now (while the formulas are still easy ones!) will pay off later.

Warning!
Do not use any methods like "the triangle" that you learned in Junior High for the formula v = d/t. This works great for an easy formula, but try using it for $v_f^2 = v_i^2 + 2ad$... it does not work!

At all times remember two basic rules from math...

1. To move something to the other side, just do the opposite math operation to it.
2. If you do it to one side, do it to the other.

Example 1: The basic formula for calculating the velocity of an object is **v = d / t** , where "v" is the velocity, "d" is the displacement, and "t" is the time. This formula is great "as-is" if we are going to calculate velocity, but what if I need to calculate the displacement and I've been given the velocity and time? **Solve** the formula to solve for "**d**".

In the formula v = d / t, "d" is being divided by "t". **To get "t" to the other side, we need to do the opposite... multiply by "t"!**

$$v = \frac{d}{t}$$

$$v = \frac{d}{t}(t)$$

but what we do to one side, we do to the other...

$$(t)\,v = \frac{d}{t}(t)$$

the "t" on the right side cancel each other out leaving...

(t) v = d

the last step (and it's basically just a tradition) is to put our unknown on the left side of the equation. So let's flip flop the whole thing to get our final equation!

d = t v

And that's it! This is not a new formula you need to memorize; it is a formula already on your data sheet that you have manipulated to use more easily for a particular question.

Now try to solve the same formula for "t". You should get...

$$t = \frac{d}{v}$$

Be careful with formulas with addition, subtraction, square roots and squares.

- You basically need to follow the **BEDMAS** (Brackets, Exponents, Division, Multiplication, Addition, Subtraction) rule from math, but backwards.
- Usually take care of any addition and subtraction first, then multiplication and division, and finally exponents (remember, square root is just an exponent).

Example 2: **Solve** the formula "$v_f^2 = v_i^2 + 2ad$" for v_i

Before doing anything else, take care of anything being added or subtracted to v_i by doing the opposite...

$v_f^2 - (2ad) = v_i^2 + 2ad - (2ad)$

which leaves us with...

$v_f^2 - 2ad = v_i^2$

flip the whole formula (so v_i is on the left) and take the square root of both sides...

$$v_i = \sqrt{v_f^2 - 2ad}$$

and you're done!