Rules of Unit Analysis (aka Dimensional Analysis)

Why It's Good to Pay Attention to Units:

- It's universal to physics. All physics equations need to balance units
- You can use it to figure out problems.

Rules/Tools for using Units:

- We will use "SI units" (French for International System of Units)
- These are an extension of "mks" units, which are easier to remember:
 - Stands for "meters kilograms seconds"
 - Symbols: m = meters, kg = kilograms, s = seconds
- 1. Units in an equation must be the same to be compared:
 - E.g. A = B + C
 - The Units of A, B and C must all be the same

o Good example: 9 m = 6 m + 3 m

o Bad example: 9 m = 6 m + 3 kg (doesn't make sense)

2. Units can be factored, commuted and cancelled just like normal numbers and variables:

• Factor example: 9 m = 6 m + 3 m = (6 + 3) m = 9 m

• Commute and cancel example: 9 m = 3 m/s * 3s = (3*3) (m/s * s) = 9 m

3. Most units let you use a factor-label method to convert:

$$\frac{10 \text{ miles}}{\text{hour}} * \frac{1609 \text{ meters}}{1 \text{ mile}} * \frac{1 \text{ hour}}{3600 \text{ seconds}} = \left(\frac{10}{1} * \frac{1609}{3600}\right) \frac{\text{meters}}{\text{second}} = 4.47 \frac{\text{meters}}{\text{second}}$$

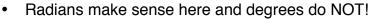
- Search for "dimensional analysis factor label method" for more examples
- 4. A few units cannot use this method (its any conversion where you add a term, not just multiply, e.g. converting temperature Celsius, Fahrenheit, Kelvin):

• 50 °C =
$$(50 * 9/5 + 32)$$
 °F = 122 °F, 100 °F = $(100 - 32) * (5/9)$ °C = 37.78 °C

- 5. Google's web search will convert units for you: "50 degrees celsius to fahrenheit"
- 6. One last oddity: angles in radians "dimensionless units"
 - Radians are defined by the notion of arclength:

 \circ I = rθ, Units: [meters] = [meters][radians]

• In order for this to make sense according to rule 1, radians are considered "dimensionless units".



- o If the $\theta = 2\pi$, and the radius is 1m, we get the full circumference of a 1m-radius circle is 2π meters ~ 6.28m. If you straightened this circle, and measured its length, that's what you get.
- If you assume degrees are the same and use them without converting, degrees are defined as 1/360 of the angle swept by a full circle, you get the arclength as (1m)*(360 degrees) = 360 meters?! Which is silly.