ASTRO 301: Tips on how to study/apply formulae and laws

In this class, you will encounter several laws (e.g., Newton's law of gravity or Wien's law). A common mistake of students is **to memorize laws and concept as mathematical formulas without understanding the underlying concept or quantities represented by the symbols.** It is important that you are able to express the laws that we learned in class *in words*, apply them to various situations, and do simple calculations based on them. Use the learning tips below.

- When you are studying a new concept or a formula, **learn to express it IN WORDS**, explicitly state **what quantities the symbols refer to**, and focus on **the concept that relates all these quantities to each other**. It is not important to know all the constants in a law or formula: instead, focus on **how the quantities depend on each other** (e.g., directly proportional to some power, or inversely proportional to some power). The golden rule of thumb is that if you cannot explain a law or formula in *simple English* to a friend, and illustrate it with one clear example, then you have not mastered it yet!

  Example 1: Newton's law of gravity, $F = Gm_1m_2/4\pi d^2$, can be stated in words as follows. The force of gravity between two bodies is directly proportional to the product of their masses and inversely proportional to the square of their separation. This statement tell us that if one of the masses increases by a factor of 10, while the separation increases by a factor or 2,, then the force of gravity between the masses will change by $(10/2^2) = 10/4 = 2.5$.

  Example 2: The relationship $F{=}L/4\pi d^2$ can be expressed in words as follows. The flux F received at a distance d from an object of luminosity L is directly proportional to the luminosity L and is inversely proportional to the square of the distance. This statement tells us that if the luminosity increases by a factor of 10, while the separation increases by a factor or 50, then the flux will change by $(10/50^2) = 10/2500 = 0.004$.

  Example 3: Wien's law can be expressed as follows: a star emits the maximum flux in its thermal continuum spectrum at a wavelength that depends inversely on its surface temperature T. So, hotter stars will emit their maximum flux at shorter wavelengths. Similarly, this law means that a star whose flux peaks at ultraviolet wavelengths is hotter than the Sun whose flux peaks at visible wavelengths.

  Example 4: The energy E of a photon is inversely proportional to its wavelength λ and directly proportional to its frequency f. So, a red photon has less energy than a blue photon.

- Whenever possible, **draw a diagram** to illustrate a concept, law, or formula. This will help you visualize the situation and identify aspects of the concept that you have not yet mastered.

- **Use the correct units in formulas or laws and do simple consistency checks to verify that you have the right units.**

  Example 1: Suppose that you are using Wien's law, which states that a star will emit a maximum flux in its continuum spectrum at a wavelength $\lambda_{\rm peak}$ that depends inversely on the surface temperature T, such that $\lambda_{\rm peak} = W/T$. If you use a Wien's constant W in units of m K, then you must express $\lambda_{\rm peak}$ in m in order to derive T in units of K.