ASTRO 301 (48310): GUIDELINES AND TIPS

1. Exam policy regarding math and formulas

1. No calculators are allowed in the exam. Any questions with mathematical calculations will involve high school algebra and can be worked out without a calculator.

2. You do NOT have to memorize the mathematical formulas and constants for the laws (e.g.,the gravitational constant G in Newton's law of gravity, the Hubble's constant, the mass of electrons, protons and neutrons, etc). Formulas and constants, will be given to you during the exam.

3. You should be able to express the laws that we learned in class *in words*, apply them to various situations, and do simple calculations based on them, like we did in class. Use the learning tips in section 2.

2. Tips on how to study concepts, laws, and formulas

I strongly recommend that you adopt the following approach when studying for the class, homeworks, and exams. It has helped countless students master the concepts and move beyond 'the math'.

- 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: Stefan-Boltzmann law can be stated as follows: the total flux $F_{\rm surf}$ emitted at the surface of a star is proportional to the fourth power of its surface temperature T.

So, hotter stars will have higher flux at their surface; if the surface temperature of a star increases by a factor of 3, the flux at its surface increases by 3^4 or 81.

Example 5: 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.

- A common mistake of students is **to memorize laws and concept as mathematical formulas (rather than in words), without understanding the underlying concept or quantities represented by the symbols.** For example, we find that students are able to state that Newton's second law of motion is represented by F=ma, but cannot explain in words what the law is or what the force F is. Many answers will *incorrectly* state that F is the force *exerted by* a body of mass m moving with an acceleration a. Yet, a student who focused on the concept of Newton's second law of motion would know that this law defines the force F that must be *applied to* a body of mass m in order to make it move with an acceleration a. Often the problem is NOT the math, but a lack of understanding of the concept.

- 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.