Astronomy C10 / L&S C70U, Fall 2006
Math Review: Summary of Required Skills

The math skills that will be required for this course don't go beyond basic algebra. You should be comfortable with scientific notation, squares and square roots, ratios, unit conversions, and solving equations for unknowns (basic solve-for-x type problems). While we don't emphasize math as much as other courses (like Astro 7—a good choice if you loved calculus), the science of astronomy is based on describing the heavens in as much detail as possible, which math can help us do. As an astronomer, you will use math as a tool for gaining a deeper understanding of the questions we ask about the world around us. The following summarizes a few key points and gives a few sample problems for you to test your skills.

1. **Scientific Notation**

   Scientific notation is useful for writing very large and very small numbers concisely. The general format is: a number with a single digit and then a few digits after a decimal point, multiplied by a power of ten. For example:

Standard	Scientific
2000	2.000×10^3
0.045	4.5×10^{-2}
153.6	1.536×10^2
0.490	4.90×10^{-1}
1.02	1.02×10^0

2. **Unit Conversions**

   In general, this course will use metric units. You are expected to know the important metric prefixes below, and be able to convert between them. The top row gives the prefix abbreviation (k for $k$ilo-, for example), the bottom row gives the power of ten it represents. For example, a kilometer is 1000 meters because the k in "km" represents 10^3. Thus, 1 km is 10^3 m = 1000 m.

Prefix:	n	μ	m	c	-	k	M	G
Power of 10:	10^{-9}	10^{-6}	10^{-3}	10^{-2}	10^0	10^3	10^6	10^9

   In general, these units will be easier to remember and manipulate for numbers in scientific notation.

   Besides the ordinary metric conversions, you will need to know that an angstrom (Å) is 10^{-10} meters. Astronomers use it. For real. Also, you should know how to convert units of time (in other words, know that there are 24 hours in a day, 365 days in a year, that kind of thing).

   Steps for converting between two numbers of different units:

   - Write what you have.

   - Decide what units you want.

- Multiply your starting number by the fraction (or fractions) that cancels unwanted units and leaves the desired units. Make sure this fraction equals ONE (e.g., 100cm/1m).

- Cancel units and multiply the numbers.

3. **Solving Basic Equations**
   In this class, you'll frequently be asked to solve an equation for an unknown. You should be able to take a formula, plug in the numbers you know, and then manipulate the equation to solve for the variable that's left. Astronomical equations will often involve squares and square roots, and there's one notorious equation that involves a number raised to the fourth power. You should also know that there are **no calculators allowed during exams**, so keep this in mind when doing the homework: if you find yourself relying heavily on your calculator, you may want to take some time to remind yourself how to do algebra by hand.

4. **Ratios**
   The general idea behind ratios is comparison. By knowing how one quantity relates to another (say, how force changes with distance), you can solve problems by comparing two systems. Consider the following problem:

   If a rabbit can hop 40 m in 1 minute, how long will it take the rabbit to travel 1 km?

   Solution: First, recognize that 1 km is 1000 m. We want all our distances to be in the same units. Then, set up two fractions equal to each other—

$$\frac{1000 \text{ m}}{40 \text{ m}} = \frac{t}{1 \text{ min}}$$

   —where I've set t equal to the unknown time. Notice that meters will cancel and I'll be left units of time. Solve for t to get

$$t = \frac{1000 \text{ m}}{40 \text{ m}} \cdot 1 \text{ min} = 25 \text{ min}.$$

   Notice that in this problem, we're using the equation $distance = velocity \times time$, but the ratios allow us to skip the step of actually solving for the velocity.

   Things can get trickier when things are no longer directly proportional, as time and distance travelled were in the above example. For example, suppose we want to calculate the volume of the Sun, knowing that the volume of Earth has a volume of about 10^{12} km^3 and that the radius of the Sun is about 100 times that of the Earth. It is not 100 times the volume (10^{14}). To solve this problem, turn the equation for volume ($V = \frac{4}{3}\pi R^3$) into a ratio equation:

$$\frac{V_1}{V_2} = \frac{R_1^3}{R_2^3}$$

   (To do this, we take the equation for the volume of object 1 and divide by the equation for the volume of object 2. All constants cancel out, leaving only the variables.) This can then be easily solved for the Sun's volume, remembering that $R_1/R_2 = 100$:

$$V_1 = V_2 \times \frac{R_1^3}{R_2^3} = (10^{12} \text{ km}^3) \times (100)^3 = 10^{18} \text{ km}^3$$