ASTR430 Homework # 1 – Planetary Formation/Kepler's Laws
Due Thursday, September 14, 2023

Homeworks will be made available on the web at http://www.astro.umd.edu/~hamilton/ASTR430/ about 1.5 weeks before they are due. You are encouraged to work together on the problems, but put significant time in on them on your own first as practice for the midterms and the final. I will try to have homeworks graded and back to you within a week.

1. Read through the "Building Physical Intuition in Mechanics" handout. Then do the problems below making sure for each of the incorrect candidate answers to show why the expression is incorrect.
a) Do problem #17 by checking units.
b) Do problem #36 by checking limits.
c) Do problem #49.
d) Do problem #72.

2. a) Estimate the minimum rotation period of a star in hours by equating gravity with the centrifugal force at the star's equator. How does your answer differ for a planet?
b) Calculate the spin angular momentum of the Sun (look up the moment of inertia for a uniform sphere in a physics book), the spin angular momentum of Jupiter, and the orbital angular momentum of Jupiter.
c) If, somehow, Jupiter were absorbed by the Sun (assume that the angular momentum vectors are parallel, that the total angular momentum is conserved, and that the radius of the Sun is not changed), how fast would the Sun spin? What would its rotation period be? What would happen?
d) Now imagine a one-solar-mass spherical cloud of gas with uniform density and radius 1 light year. How fast does it spin if it has the same angular momentum as the Sun-Jupiter system? How long would it take to rotate once?

3. Structure of an exosphere. The derivation of an atmosphere's scale height discussed in class assumed that gravity and temperature are both constant with height. It is not difficult to relax these assumptions. Work out how the density ρ in the exosphere (distant part of the atmosphere) drops off with height z using $g = GM/r^2$ for gravity. You can assume T=const - is this a good approximation? Discuss. Start with the expression for pressure derived in class ($dP/dz = -\rho g$), derive an expression for $d\rho/dz$, and integrate. Put your final answer in terms of ρ_0, the density of the atmosphere at Earth's surface, and $H_0 = kT/mg_0$, the scale height at the Earth's surface. Check your answer carefully.