Student name: AST221H
Student #: **Assignment 1** Due: Sept. 24, 2020

You may work together with other students to solve these problem sets, but all solutions must be written and submitted independently. Submit your assignment as a single .pdf file following the instructions on Quercus. ***Part marks only will be given for solutions with no explanation. Show your work, including intermediate steps and diagrams if necessary!*** *Check the syllabus for reading recommendations. Careful with units!*

Problem 1: The mass of Jupiter

When the planet Jupiter is observed at opposition, its moon Io orbits the planet every 1.77 days and attains a maximum angular separation from Jupiter of 2.3 arc minutes. Jupiter's **synodic orbital period** is 399 days. Use only these facts and Kepler's third law to calculate the mass of Jupiter. Assume that all orbits in the problem are circular and are in the same plane. Be clear about the steps you followed to solve for Jupiter's mass, and include all intermediate calculations. Express your answer in cgs units and check for accuracy.

You may also use the known values for:

- the astronomical unit (au): 1 au $= 1.5 \times 10^{13}$ cm
- the year: 1 year = 365.26 days
- the gravitational constant (G): $G = 6.67 \times 10^{-8}$ dyne cm^2 g^{-2}

Hint: Revisit C&O Chapters 1.2 and 3.1. Draw a diagram to help work out the problem!

Problem 2: Seasons in our Solar System

In principle, two effects could cause seasons: a changing distance from the Sun in an eccentric orbit, and a changing amount of daytime and height of the Sun in the sky if a planet's rotation axis is inclined relative to its orbit. For Earth, the latter effect dominates. Here, we prove this, and examine the relative impact of these two effects for other planets in the solar system. For this problem, you can use planetary data from C&O Appendix C. You might also revisit your python assignment 1.

1. Write down a general expression of the flux f received from the Sun as a function of luminosity of the Sun, $L_\odot$, distance from the Sun r, and the zenith distance z (the angle between the zenith and the line of sight to the Sun; see C&O Chapter 1.3). Include a diagram to show your work.

2. Calculate the fractional change in f due to the variations in r for the Earth (i.e., the ratio between f at perihelion and f at apohelion, for the same z). Also calculate the fractional change in f due to variation in z at noon (i.e., for the days when the Sun is highest and lowest in the sky when it crosses the meridian; keep r fixed and assume a Northern latitude of 45 degrees). Are your results consistent with the statement above that the inclination of the Earth's axis to the orbit is more important for causing seasons?

3. Now repeat the above calculation for Mercury, Mars, Jupiter, and Uranus. Which effect dominates for each of these planets?

4. Another common misconception is that seasons are due to one hemisphere of the Earth being closer to the Sun than the other. Show that this has negligible effect.