# ASTR 558

Exoplanets, Spring 2022 -Prof. Agol

## Problem Set 3

Due: May 19, 2022

1. Install the dynamical integrator REBOUND using Python: `https://rebound.readthedocs.io/en/latest/` Look through the example notebooks, and familiarize yourself with initializing and running a planetary system. [2 pt]

2. Look up the parameters of the multi-transiting planet system Kepler-289c/d (aka Planethunters 3; ignore planet b). Assume the planets' orbits lie in a plane, and vary the inclination of the system (so that it would not transit). Pretend that the masses were detected with RV (they were actually measured with TTVs!), so that as you incline the orbit, the planet masses increase as $(\sin i)^{-1}$. At what inclination does the system become unstable after $10^3$ orbits of the inner planet? What upper limit would this place on the planets' masses if they were measured with RV rather than TTV? [4 pt]

3. Simulate the edge-on radial velocity of the star, and then fit this RV with four Keplerian orbits. How big are the residuals? How does this compare to typical RV errors? [6 pt]

4. Look at the REBOUND TTV example. Make a plot of the TTVs of Kepler-289c/d over 4 years (assuming edge-on, so that planets do in fact transit). Measure amplitude and period of the sinusoidal variation component. How does it change if you vary the mass of Kepler-289d downward and upward by a factor of 2? [4 pt]