ASTR 589 – Physics of Astrophysics
Assignment VI, on Stellar Dynamics
Due Date: Thursday November 30 at 11am.

1. Complete the following table for the dynamical timescales for open clusters, globular clusters, and elliptical galaxies. The times are expressed in years.

   Please consult the literature to find the most recent values of the masses and radii in each of the systems. Choose typical values for M and R in each case.

System	τ_{mix}	τ_{rec}	τ_{evap}
Open clusters			
Globular clusters			
Elliptical galaxies			

2. Infrared observations of the stellar orbits in the vicinity of the radio source Sgr A* in the center of the Milky Way show that a non-luminous object with mass $4.15\times10^6 M_\odot$ is confined to a volume of at most 10^{-6} pc^3 (GRAVITY collaboration, https://arxiv.org/abs/1904.05721). Argue that the possibility of a cluster of compact objects with this total mass, confined to the same volume, is not a plausible alternative to the black hole hypothesis. Assume that each compact object has a mass larger than 0.1 $M_\odot$.

Conceptual Questions and Review. Do not turn in these answers.
Dynamics

1. In a gravitationally interacting N-body system, define relaxation, evaporation, and mixing.

2. Why can't we treat a gravitationally interacting N-body system, such as a star cluster, as a fluid?

3. What are the assumptions one makes in applying the virial theorem to an observed system?

4. Which effects determine the distribution of masses retained in a star cluster?

5. What is the restricted 3-body problem?

6. What are the different methods for inferring the presence and measuring the profile of dark matter in galaxy clusters?

7. What are the different methods for measuring the masses of black holes in the centers of galaxies?