Introduction to Astrophysics 0321.3108
Exercise 2

1. The maximal radial velocities measured for the two components of a spectroscopic binary are 100 km s^{-1} and 200 km s^{-1}, with an orbital period of 2 days. The orbits are circular.

   a. Find the mass ratio of the two stars.

   b. Use Keplers Law to calculate the value of $M \sin^3 i$ for each star, where M is the mass and i is the inclination to the observers line of sight of the perpendicular to the orbital plane.

   c. Calculate the mean expectation value of the factor $\sin^3 i$, i.e., the mean value it would have among an ensemble of binaries with random inclinations. Find the masses of the two stars, if $\sin^3 i$ has its mean value. *Hint: In spherical coordinates, (θ, ϕ), integrate over the solid angle of a sphere where the observer is in the direction of the z axis, with each solid angle element weighted by* $\sin^3 \theta$.

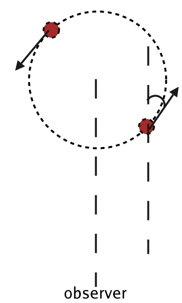
2. In an eclipsing spectroscopic binary, the maximal radial velocities measured for the two components are 20 km s^{-1} and 5 km s^{-1}. The orbit is circular, and the orbital period is $P = 5$ yr. It takes 0.3 day from the start of the eclipse to the main minimum, which then lasts 1 day.

   a. Find the mass of each star. Since the binary is of the eclipsing type, one can safely approximate $i \sim 90$. Check to what degree the results are affected by small deviations from this angle, to convince yourself that this is a good approximation.

   b. Assume again $i \sim 90$ and find the radius of each star. Is the result still insensitive to the exact value of i?

3. What is the velocity of the Sun as a result from the gravitational interaction with Jupiter?

4. Two luminous objects rotate (in circular orbit) around a central of mass point. Both have the same velocity $v = 0.5c$, and each emit spectral line, λ_0. From Earth we are viewing the Doppler shifted line λ for each object. Fine λ for which both objects exhibit the same wavelength as seen on Earth (as a function of λ_0).



5. A small mass m rotates around a massive object with mass M. An observer measured the following values: The velocity of the small mass m is 1000 km sec^{-1}, its acceleration is 2.2×10^{-7} km sec^{-2} and the angular separation between the two masses is: 0.004 arcsecond. Find the distance to the system (in Mpc), and the mass of the massive object M (in solar mass). The system is observed edge on.

6. In calss we saw that:

$$B_\nu = \frac{2h\nu^3}{c^2}\frac{1}{e^{h\nu/k_BT} - 1}. \tag{1}$$

   a. Find the frequency of the peak of the black body spectrum as a function of the temperature.

   b. Find the black body spectrum as a function of the wavelength $\lambda = c/\nu$, i.e., B_λ.

   c. Find the wavelength of the peak of the black body spectrum as a function of the temperature.

7. The effective surface temperature of the Sun is: 5800 K. What is the wavelength of the peak of the Suns black body spectrum?

8. The flux on Earth form the star Betelguese is approximately 10^{-5} erg sec^{-1} cm^{-2}, at distance of 172 pc, and it's effective surface temperature is 3400K. Assume that the star radiate as a black body.

   a. Find the luminosity of the star (in $L_\odot$).

   b. Find the radius of the star (in Au).