1) Calculate the Einstein Ring radius θ_E of the Earth, Jupiter and the Sun as viewed by an observer at a distance of 10,000 light years. Then calculate the values if they were instead at a distance of only 10 light years. In both cases, assume that the source is much more distant than the lensing object, for example a quasar several billion light years away. This is sometimes called the "contact lens" approximation and mathematically means that you should assume $D_{OS} = D_{LS}$. The expression given in lecture, $\theta_E=[4GMD_{LS}/(D_{OS}D_{OL}c^2)]^{1/2}$, will yields a result in radians, but your answers should be converted to arc seconds.

2) The angular radius of a distant object is $\theta_R=R/D_{OL}$ in the usual small angle limit. A spherical object, such as those considered in problem 1 above, acts like a point mass lens for light beams that pass outside the surface of the object but blocks the observer's view of any images that occur at $\theta_I < \theta_R$. Thus, if $\theta_R > \theta_E$ the object cannot produce any observable strongly lensed (displaced, distorted or magnified) images. Based on this condition, derive *an expression for the minimum distance* from the observer at which an object of mass M and radius R can act as a strong gravitational lens. As in problem 1, assume that the source is very distant, the "contact lens" approximation. Evaluate your expression for the Earth, Jupiter and the Sun to derive the minimum distance at which each could be a strong gravitational lens using the values of their masses and radii given in the lecture notes. Express your answers in units of AU.