W4260: Problem Set #1

Due: Tuesday, Feb 3

Problem 1

The first problem is to install `python`, `numpy` (a numerical python library) and `matplotlib` (a plotting package) on your computer, or identify a computer with these packages that you can use (more details below). Additionally, you may wish to install `ipython` (an interactive notebook), `scipy` (scientific libraries) and `astropy` (an astronomical library) although these will not be required immediately. You can install these packages in many ways, of which three are listed here:

1. Probably the easiest way is to use a single distribution for all packages – this is done by a few different organizations: one is `Anaconda`, which is free for academic use and can be found at store.continuum.io/cshop/anaconda. Another possibility is www.enthought.com.
2. If you're feeling a bit more adventurous, a very nice way to install and control python packages is through `pip`. Most recent python installations (e.g. from www.python.org) come with `pip`, which can be used through the command line: for example: `pip install numpy` will find and install the numpy package. More documentation on `pip` can be found at pip.pypa.io.
3. Finally, you can also install each package directly from the package web pages (e.g., see www.python.org for instructions on how to install python, and see www.numpy.org for instructions on how to install numpy, etc.). This is possible, but not really recommended.

In each case, you will have the choice between python 2.7 and python 3.4. Either can be used – python 2.7 is the older version that can be used with basically all packages; python 3.4 is newer but cannot be used with some older packages. For this class, I suggest using 3.4.

You will also want to install some way to edit and run programs. Perhaps the easiest way to do that is with the `ipython` notebook. `ipython` is a package which can be installed in any of three ways described earlier and uses a web browser to create and evaluate notebooks, which can be shared. Alternately, you may wish to install an interactive development environment (IDE) to help write and debug programs. There are many IDE's available – see the python wiki for a list – but a relatively straightforward one is spyder, available at pythonhosted.org/spyder/

No submission is required for this problem.

If you do not have access to a computer that you can install these packages on, then you will have to use python either on the astronomy lab computers in Pupin 1402, the computers in the Engineering and Science Library, or connect remotely to `cunix`, Columbia University's UNIX system (see www.wikicu.com/CUNIX for instructions on how to access it). Let me know if this is the case for you.

Problem 2

Write a program to print out the value of x and $\ln(x)$ where x ranges from 1 to 10 in steps of 0.5. Note that you may need to `import math` to use the python math functions.

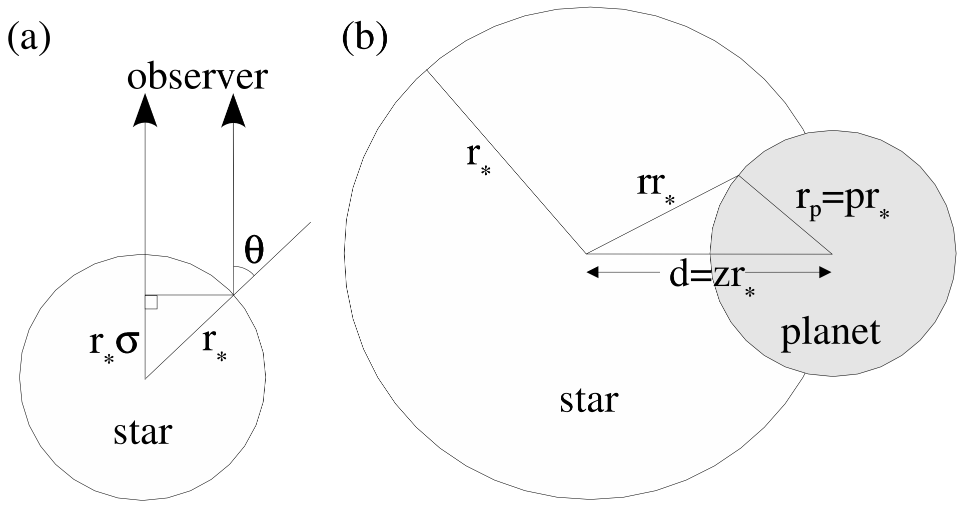

Figure 1: (a) Geometry of the eclipse. The star is seen edge on, with the observer off the top of the page. The star has a radius r_* and θ is defined as the angle between the observer and the normal to the stellar surface, while $\mu = \cos\theta$ (although we will not use definitions in this problem). (b) The transit geometry from the perspective of the observer.

Problem 3

Here is a more complicated function which can be used to determine how much of a star's light is blocked by a transiting planet. We can model the transit as an eclipse of a spherical star by an opaque, dark sphere (see Figure 1). In what follows, d is the center-to-center distance between the star and the planet (as seen by the observer), r_p is the radius of the planet, r_* is the stellar radius, $z = d/r_*$ is the normalized separation of the centers, and $p = r_p/r_*$ is the size ratio of the planet to the star. The flux relative to the unobscured flux is F.

For a uniform source, the ratio of obscured to unobscured flux is $F^e(p,z) = 1 - \lambda^e(p,|z|)$ where

$$\lambda^e(p,z) = \begin{cases} 0 & 1+p<z \\ \frac{1}{\pi}\left[p^2\kappa_0 + \kappa_1 - \sqrt{\frac{4z^2-(1+z^2-p^2)^2}{4}}\right] & |1-p| < z \leq 1+p \\ p^2 & z \leq 1-p \\ 1 & z \leq p-1, \end{cases} \tag{1}$$

and $\kappa_1 = \cos^{-1}[(1-p^2+z^2)/(2z)]$, $\kappa_0 = \cos^{-1}[(p^2+z^2-1)/(2pz)]$. Note that the inverse cosine $\cos^{-1}()$ is written in python as acos(), and similarly for $\sin^{-1}()$.

Write a program to compute $F^e(p,z)$ for $p = 0.1$ and z going from -1.21 to 1.21 by steps of 0.1.

Note: When submitting solutions, please include (1) the program listing, (2) any input to the program, and (3) all program output. The output alone is not a valid solution. You may consult other students, but please write and run your program yourself. Also, if you do work with others, please indicate who you worked with. Solutions may be submitted via the courseworks web page or emailed to greg.bryan@columbia.edu (preferably as one email with attachments clearly marked); please be sure to include the course number [W4260] and problem set number in the subject. Thanks.