Astron 211 Problem Set 1

Given: Sep 6. Due: Sep 13 at the beginning of class

Homework Policy: You can consult class notes and books. Always try to solve the problems yourself; if you cannot make progress after some effort, you can discuss with your classmates or ask the instructor. However, you cannot copy other's work: what you turn in must be your own. Make sure you are clear about the process you use to solve the problems: partial credit will be awarded.

Reading: Kutner Chapter 1 (Introduction)

Problem 1 Forces and Accelerations

Consider a planet with a mass $5M_\oplus$ a distance of 3 AU away from a star with a mass of $1.5M_\odot$.

a. What is the magnitude of the force due to gravity from the star on the planet? Remember that $F = GM_1M_2/r^2$. The answer should be in Newtons (or $\mathrm{kg\,m\,s^{-2}}$).

b. What is the magnitude of the force due to gravity from the planet on the star? Remember that $F = GM_1M_2/r^2$. The answer should be in Newtons (or $\mathrm{kg\,m\,s^{-2}}$).

c. What is the acceleration of the planet due to gravity from the star? Remember that acceleration of a body with mass M_2 toward a body with mass M_1 is $a = GM_1/r^2$. The answer should be in $\mathrm{m\,s^{-2}}$.

d. What is the acceleration of the star due to gravity from the planet? Remember that acceleration of a body with mass M_1 toward a body with mass M_2 is $a = GM_2/r^2$. The answer should be in $\mathrm{m\,s^{-2}}$.

e. How does the answer from part (c) compare with the acceleration we feel on the surface of the Earth $g = 9.8\,\mathrm{m\,s^{-2}}$? How many times larger or smaller is it?

Problem 2 More Accelerations

Consider a planet with a mass $5M_\oplus$ a distance of 3 AU away from a star with a mass of $1.5M_\odot$. The planet has a radius of $2R_\oplus$.

a. What is the acceleration of somebody at the center of the planet due to gravity from the star? The answer should be in $\mathrm{m\,s^{-2}}$.

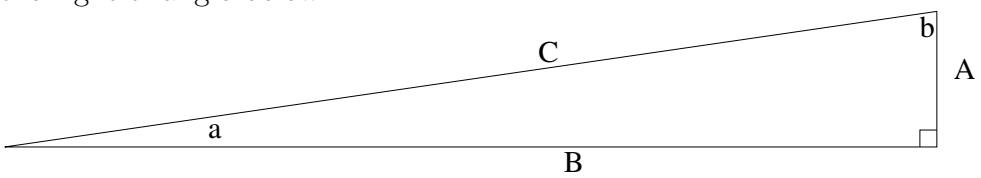
b. If that person is instead on the side of the planet closest to the star, what is the accleration? What is the *difference* in acceleration between somebody on the close side and somebody at the center?

c. If that person is instead on the side of the planet farthest from the star, what is the accleration? What is the *difference* in acceleration between somebody on the far side and somebody at the center?

Be careful: while your answer for part (a) shouldn't have too many significant digits, you might need to cary more significant digits in your calculation to get part (b) right.

Problem 3 Small Angles

Consider the right triangle below:



Remember that in the small-angle approximation, $\sin a \approx a$ and $\tan a \approx a$ *only if* a *is in radians.*

a. If side $B = 1\,pc$ and angle $a = 5''$:

   (a) What is angle a in radians?

   (b) Using the small-angle approximation, what is $\sin a$?

   (c) Using your calculator, what is $\sin a$?

   (d) Using your calculator, what is $\tan a$?

   (e) What is side A? Make sure you specify units for A.

b. If angle $a = 1'$:

   (a) What is angle a in radians?

   (b) Using the small-angle approximation, what is $\sin a$?

   (c) Using your calculator, what is $\sin a$?

   (d) Using your calculator, what is $\tan a$?

c. If angle $a = 1^\circ$:

   (a) What is angle a in radians?

   (b) Using the small-angle approximation, what is $\sin a$?

   (c) Using your calculator, what is $\sin a$?

(d) Using your calculator, what is $\tan a$?

d. Clearly at some point if we keep increasing a, the difference between $\sin a$ using the small angle approximation and the correct value using your calculator will be significant. We can define the fractional error as:

$$\frac{\text{small angle value} - \sin a}{\sin a}$$

Find the value of a in degrees such that the fractional error is 10%.

Problem 4 Order of Magnitude Problem

Submit your own order of magnitude problem. You do not need to know the solution, but you should have an idea of where to start. This could be something that you wondered about, or that puzzled you. It need not be related to astronomy or physics. Be creative, but not *too* creative (we want this to be solvable).

You might also look at:
http://www.nytimes.com/interactive/2009/03/31/science/20090331-angier-quiz.html
or:
https://what-if.xkcd.com

which have nice problems with solutions. Do not use these for your submission, but you can look at them for inspiration (some of the XKCD ones are rather complicated). Or, if you want to test yourself, you can see how you do.