Homework #7

Name____________________________

DUE: April 29 (by 11 PM)

Your homework grade depends not only upon your getting the correct answer but also grammar, spelling and punctuation, particularly in questions that require explanations. Numerical answers to questions do not need to be written in complete sentences and you should show your work where ever it is appropriate. Partial credit may be given for showing your work even if your result is incorrect. You will also be graded on the use of significant figures, proper units of measure and proper scientific notation. You may work with others in determining the answers to the questions, but what you write should be in your own words – any homework assignments that look too similar to that of other students will receive no credit. Unless otherwise noted, all questions are worth 1 point. Homework can be turned in at the office Latham 121 during business hours, during class, or on-line at e-Learning.

1. (16 points total). There are thousands of asteroids known to exist and you’ll be investigating one based upon what we can observe of it. Follow the asteroid link at the course website. You will see a view of the night sky filled mainly with stars, but one of the objects is an asteroid. Once you press the right or left arrow keys on your keyboard, you should see the asteroid move. Click on the asteroid to get data on the asteroid’s apparent magnitude and angular position.

a. What is your asteroid’s apparent magnitude?

b. (2 points) What factors would influence how bright an asteroid appears in the sky? List 2 distinct factors (there are actually quite a few).

If you press an arrow key again, and then click on the asteroid, you’ll get a different value for the angular position. The amount that the asteroid moves depends upon its distance. Determine how far the asteroid moves from one day to the next and provide that value below.

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c. What is the angular position change of the asteroid from one day to the next?

Use the following relation to determine the average orbital distance, \(a\), based upon the angular position change, \(\Delta\).

\[
a = \left( \frac{0.981677}{\Delta} \right)^{\frac{1}{2}} \text{ AU}
\]

d. What is the average orbital distance, \(a\), for the asteroid?
Asteroids, like stars, also have an absolute magnitude, though it is defined different from how it is defined for stars. Once you have a value for an asteroid’s absolute magnitude, you’ve removed the influence that distance has on the asteroid’s appearance. To determine the absolute magnitude for your asteroid use the following relationship and the values from parts “a” and “d”.

Absolute magnitude = apparent magnitude – 5 log \((a^2 - a)\)

e. What is the value for your asteroid’s absolute magnitude?

The absolute magnitude (which is represented by \(H\) to keep it distinct from stars) of an asteroid is influenced by the size and albedo of an asteroid. Albedo is a measure of how reflective or “shiny” an object is, with a value of 0 = black and 1=white. Most asteroids are fairly dark so they have low values of albedo. But we don’t know the albedo value of your asteroid, so we’ll have to assume a range of likely values.

First we’ll assume the lower range for albedo, that of 0.055, which would be the case for a carbon rich asteroid.

The diameter of an asteroid can be found using the following relationship

\[
D = \frac{1329}{\sqrt{albedo}} \times 10^{(-0.2H)}
\]

Where the diameter \((D)\) is in km and \(H\) is the value of the absolute magnitude.

f. What is the diameter of your carbon rich asteroid?

\[
D = \frac{1329}{\sqrt{0.055}} \times 10^{(-0.2 \times 2.0)}
\]

\(D \approx 1105.8\) km

g. Divide the diameter in half to get the radius, and then multiply by 1000 to convert the radius to meters. What is the radius of your asteroid?

\[
r = \frac{D}{2} \times 1000
\]

\(r \approx 552.9\) m

h. Use the volume of a sphere to determine the volume of your asteroid, \(volume = \frac{4\pi r^3}{3}\), where \(r\) is the radius in meters. What is the volume of your asteroid?

\[
volume = \frac{4\pi (552.9)^3}{3}
\]

\(volume \approx 6.4 \times 10^{10}\) m³
i. An asteroid with a low albedo is likely made up mainly of carbon, which indicates that its density is probably around 1400 kg/m$^3$. If you multiply this value by your volume, you’ll determine the mass of your asteroid. What is the carbon rich asteroid’s mass?

The answer you got for the mass was based upon the assumption that the asteroid had a low albedo. Let’s do the same calculation for a higher albedo value, one composed of metal. In this case the albedo is 0.330 and the density is 5320 kg/m$^3$.

j. Using the formula and the processes you used previously in parts “f” and “g”, but the albedo value of 0.330, what is the radius of your metallic asteroid?

k. What is the volume of the metallic asteroid (just like you did in part “h”)?

l. What is the mass of the metallic asteroid (be sure to use the higher density given above)?

m. (2 points) How does the mass of the metallic asteroid (from part “l”) compare to that of a carbon rich asteroid (from part “i”)? Give both a quantitative and qualitative answer.

n. If you were on the surface of a carbon rich asteroid (low albedo), or a metallic asteroid (high albedo), you’d be on objects that would have two different surface temperatures. Which object would have a higher surface temperature?
2. (4 points total). Two newly discovered objects are orbiting about the Sun. One is asteroid McGann and the other is comet Hurt. Their orbits are shown below.

Each object is at the same average distance from the Sun, 27.3 AU. While asteroid McGann always remains the same distance from the Sun, comet Hurt goes from 10.1 AU to 44.5 AU.

a. Which object has the greatest variation in its orbital velocity about the Sun?

b. Which object has the lowest velocity at some time during its orbit about the Sun?

c. (2 points) Which object has the longest orbital period and what is the value of that orbital period? You can use the special form of Kepler’s third law, \( P^2 = a^3 \).