Homework

1. The eccentricity of the Mars Elliptic Orbit is $e = 0.092$ and the distance from the sun to the aphelion is $R_a = 1.665\,\mathrm{AU}$. A figure (drawn to scale!) of this orbit is shown below. It is easy to see (from the figure) that Mars does not orbit in a circle around the sun. It is *much* more difficult to see that Mars does not move in a circle about the point "C" (as is clear from the figure). Indeed, Kepler played with this as a possibility but eventually ruled it out.

   To show that this figure is not a circle we need to show that R_{CM} = the distance to mars $\neq R_{CA}$.

   (a) What is an AU? What is the distance to the Mars aphelion in km?
   (b) What is $\bar{R} = (R_p + R_a)/2$ in AU.
   (c) Explain why for an ellipse $L = \bar{R}$. (Hint, what is an ellipse?)
   (d) Show that $\sin\theta \simeq 0.092$ (Hint, find the distance between the center and the Sun first, and then find the angle)
   (e) Determine R_{CM} in AU (use geometry and $\cos\theta$).
   (f) Show that $R_{CA}/R_{CM} = 1.0042$ as claimed in lecture.

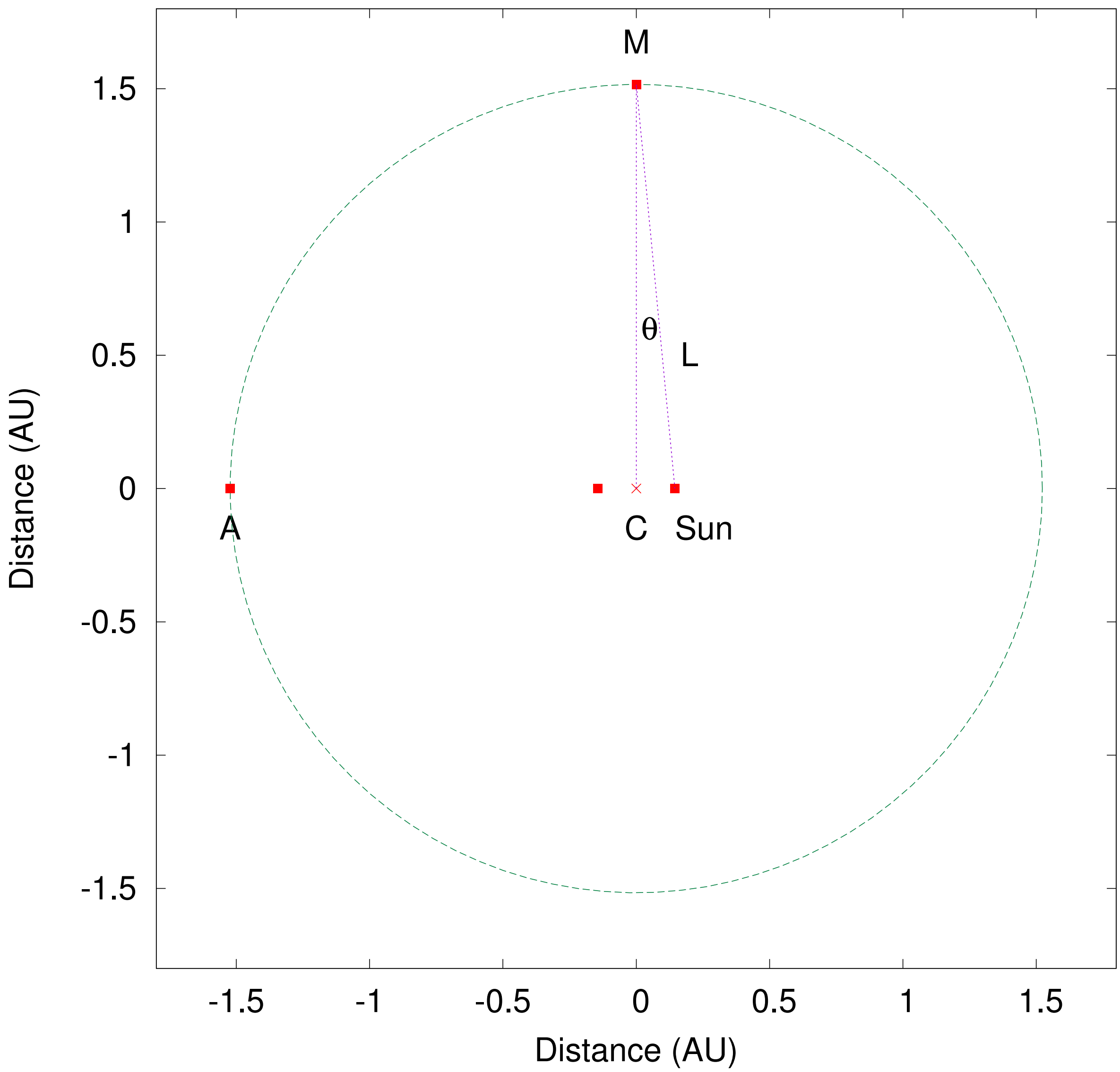
   An approximate formula (which goes beyond the math of this course) shows that the ratio $R_{CA}/R_{CM} \simeq 1 + e^2/2$. The fact that the orbit is almost circular (though not around the sun) is what made the Ptolemaic system quite successful.

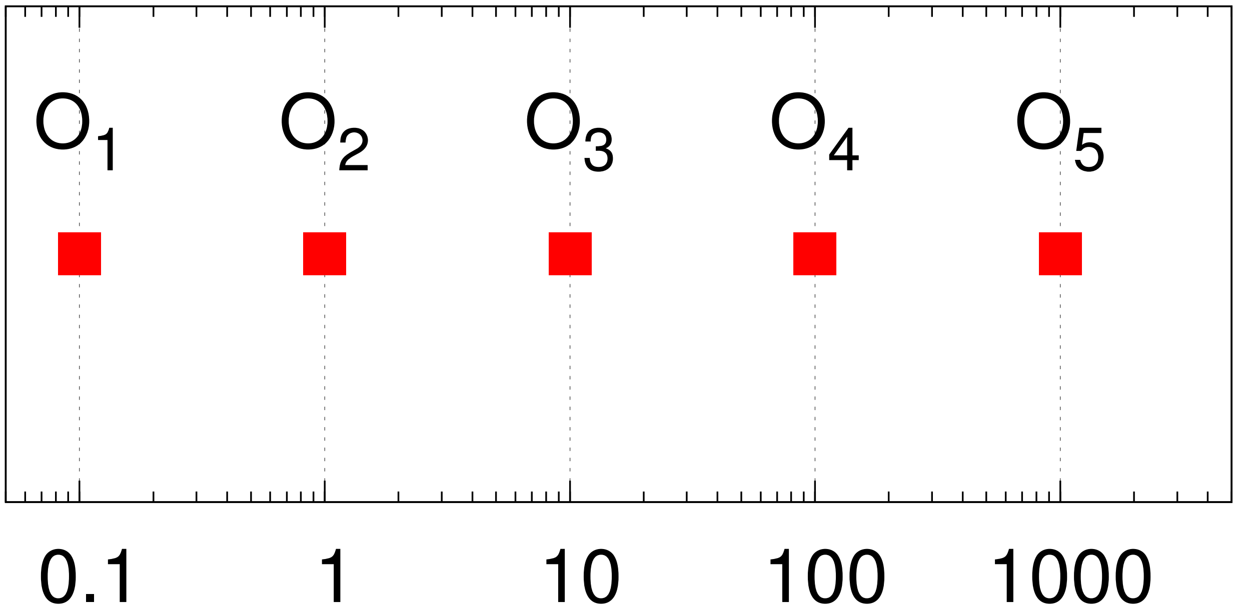
2. Describe qualitatively the funny way that the planets move in the sky. Give a qualitative explanation as to why they move this way.

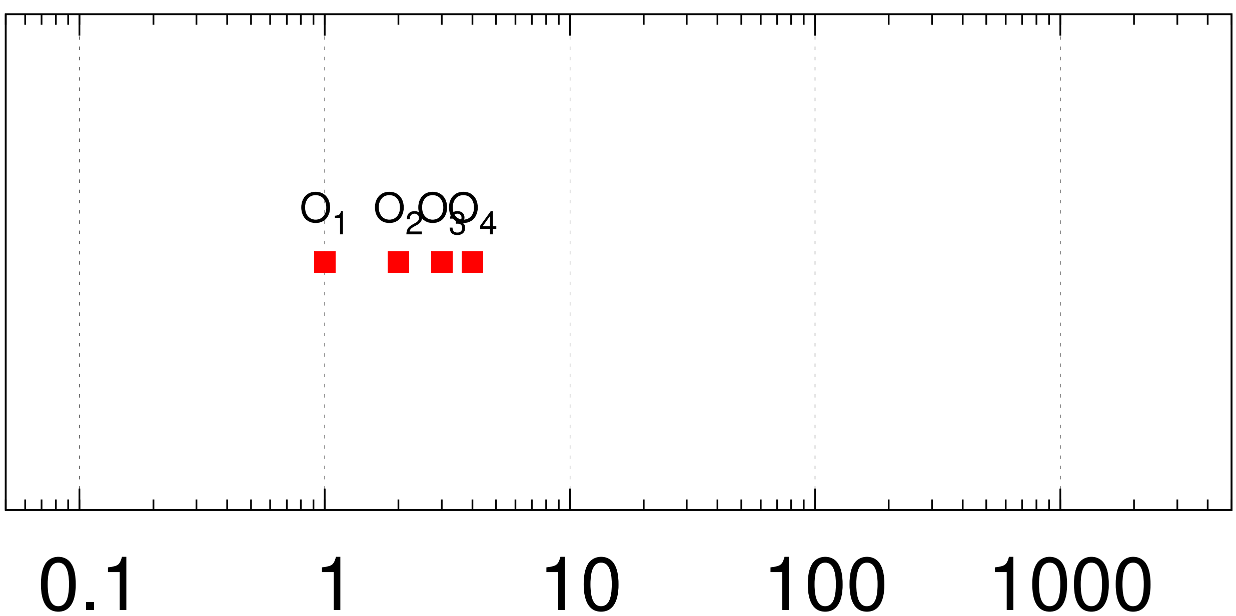
3. Why do all the heavenly bodies (the earth, the sun, the moon, and the planets, as well as the zodiac signs) move on the ecliptic.

4. Draw a set of pictures approximately to scale showing the sun, the earth, the moon, α-centauri, and the milky way.

5. We plot objects of very different size on a log scale. In a log scale, one plots the log (base 10) of the distance on the x axis. (However, the labels indicate the number itself. Making it easy to plot.) If we have 5 objects of size 0.1 AU, 1 AU, 10 AU, 100 AU, 1000 AU, these size are equally placed on a log scale, since they differ by a common multiplicative factor. Formally, the log (base 10) of these numbers is -1, 0, 1, 2, 3, which are equally spaced. This is shown in fig (a) However 4 objects of size $1, 2, 3, 4$ AU, do not appear equally spaced on a loga scale, see fig (b). This is because the log of these numbers is, 0, 0.301, 0.477, 0.60, which are not equally spaced. The (uneven) small-tick marks show the locations of 1,2,3,4 on the log scale. Plot the size of the following objects on the log scale below, fig (c): (i) the radius of the earth, (ii) the radius of the sun, (iii) the earth-moon distance, (iv) the earth-sun distance, (v) the sun-Saturn distance, the distance to the nearest star in our galaxy, α-centauri.


M
θ
L
A
C
Sun
1.5
1
0.5
0
-0.5
-1
-1.5
Distance (AU)
-1.5
-1
-0.5
0
0.5
1
1.5
Distance (AU)


O_1
O_2
O_3
O_4
O_5
0.1
1
10
100
1000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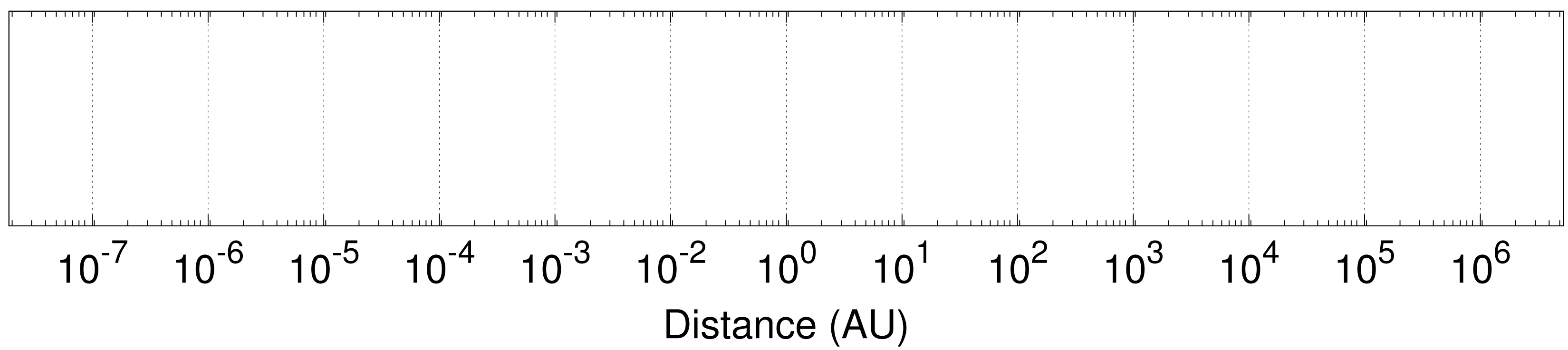

Figure 1: (c) Do your homework on this graph!