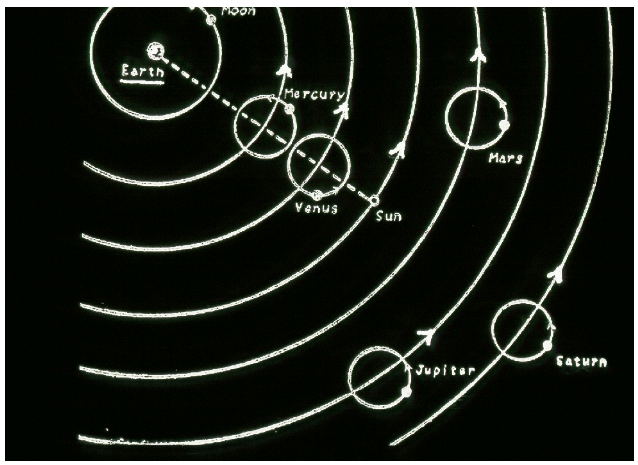
AST 101 ANSWERS TO ASSIGNMENT 2

<u>CHAPTER 4</u> "The Copernican Revolution" etc.

Questions

3. Because in reality Mercury and Venus have smaller orbits ("inferior planets") than we and are always viewed to be near the sun, the Greeks had to somehow constrain the movement in their epicycle model to be near the sun. Their additional constraint was to draw a line connecting earth and sun and require the centers of their epicycles to always be on that line. The other planets, which we now know to be the outer ("superior") planets need have no such constraints; they are sometimes viewed in the direction of the sun and at other times away from its direction. The drawing below shows the superior planets in the same general direction of the sun.



4. Epicycles served two purposes, but primarily they could show how planets, for a limited time, can reverse their direction in the sky–retrograde motion. I don't know whether Copernicus knew that epicycles were no longer needed in the new, heliocentric model, but it doesn't matter. This is because those little circles on the big circles (the deferents) were the way the geocentric model, with its "perfect circles" assumption could have planets get closer and farther from the sun, as they do in their elliptical orbits. A single circle, a deferent alone, could not do that–all points on a circle are equidistant from the center point. I may be reading too much into this, though. He may not have been aware of this point at all.

5. This, I won't belabor here. It is covered too well in both class and text. I have nothing to add here.

6. Politics and religion. Galileo was condemned by the largest, most widespread authority of the day–the Catholic Church. He was a Catholic living in Catholic-controlled territory. Kepler was a Protestant, living in Protestant-controlled territory. Protestantism was brand new, fragmented with no central authority, and did not have the political influence of the Catholic Church. Some individual Protestants may have disagreed with Kepler's work, but there was no Protestant Pope,

supported by a single church bureaucracy, to condemn Kepler. There was no point in the Catholic Church condemning Kepler. Being a Protestant, he was damned regardless of what he said.

9. I'm reasonably certain the author is wanting you to respond that it was circular motion that was swept aside by these laws. That's true, but they also clearly say that it is the sun, not the earth, that planets orbit.

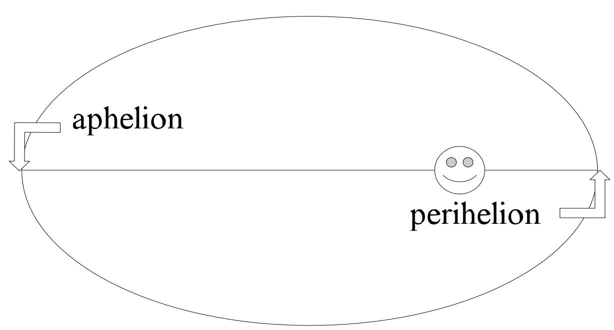
Discussion Questions

3. The two ways, discussed in any general philosophy textbook and brought up in this lecture/lab course is naturalistic (science) versus supernaturalistic (creationism).

Problems

5. $P^2 = a^3$ This is a comparative statement, a relation, that becomes expressible as an equality when it is the earth that orbital properties are compared to. This means that so long as you use earth units–year for the period and AU. for the semimajor axis, you can use this simple relation as an equation to get an answer for the period or size of the orbit of any other object orbiting the sun. It doesn't have to be a planet. Given that a = 4 AU, you solve for the orbital period by first taking the square-root (the inverse operational counterpart of squaring) of both sides of the equation to reduce P^2 to P. a^3 is reduced to $a^{3/2}$. Then, plug in 4 for *a*. For the answer, you don't even need a calculator. Before you read the next sentence, exercise your mind by solving the problem in your mind, now. Remember, getting in the habit of using your head is one of the points of learning science–going to college, generally. OK? As with multiplication and division, you have the choice of first taking the cube of 4 or the square root. Taking the latter first is easier, since it makes for a smaller number when you then take the cube. (Mental Math Trick!) The square root of 4 is 2 and 2^3 is 2 x 2 x 2 = 8. 8 years, that is.

6. This problem is solved in the same manner, except that here you need to first determine just what the semimajor axis value is. You are pushed here to look closer at the ellipse and Kepler's First Law, which concluded that the Sun is at one of the foci. One picture is worth a thousand words, so look again (next page):



You see that the major axis is the addition of the aphelion distance and the perihelion distance. These are given in this problem as being 5.5 AU and 0.5 AU, respectively. With the major axis 6 AU, the semimajor axis is 3 AU. Plug in for a to get 3^3 power. So, cube it (3 x 3 x 3) to get 27, then use a calculator to take the square root. The calculator will give you 5.1961524... You should round off the answer to the nearest tenth of a year, the accuracy of the input data. The answer, then, is 5.2 years. Notice, from this problem, that the eccentricity (how elliptical the ellipse is) is irrelevant to determining how long is the orbital period. Any orbit with a semimajor axis of 3 AU will have an orbital period of 5.2 years, regardless of whether the orbit is circular or really flattened.

7. Here the problem is the inverse of the first two; you are given the orbital period of Pluto and are

asked to calculate its size. So, first solve for *a* by applying the inverse operation (cube root) to *a* cubed. Of course, because it is an equation, meaning the quantities on both sides of the equal sign are quantitatively equal, you also take the cube root of *P* squared to get $P^{2/3}$. Substitute 247.7 for *P* and square it and take the cube root (or vice-versa; it doesn't matter, remember). Do it now with your calculator. You should get 39.4 AU, rounded off appropriately.