PROBLEM SET #1
ASTR340 – FALL 2019

Due Date: 19th September 2019
Book Chapters: 1 - 3

1. She blinded me with science… [20 pts.]

A. Please name and briefly explain the main properties of a scientific hypothesis according to the scientific method.

B. What do you think are the main differences between this approach to understand the physical world, and an alternative one like astrology (or magic)?

2. Location, location, location [20 pts.]

A. Outline three good arguments for the Geocentric view. Why should the Earth be at rest at the center of the Universe?

B. Who proposed the Heliocentric model first and when? What was the motivation?

C. What was the crucial observation that finally proved geocentrism could not be correct? What was the prediction from the Geocentric model and what was actually observed?

3. Erathostenes the astronaut [20 pts.]

A. On a given day the Apollo 11 flagpole on Mare Tranquillitatis casts no shadow (the Sun is directly overhead, that is, at 0 degrees from the zenith).
At precisely the same time, the flagpole on the Apollo 17 landing site, situated 590 km almost directly north of Mare Tranquillitatis in the Taurus-Littrow region, casts a pretty noticeable shadow because the Sun is about 20 degrees away from the zenith. What is the circumference of the Moon according to these numbers?

B. Research the size of Titan. How far away its equators (in km) will a flagpole have to be to cast a shadow similar to the example above?

4. The distance to the stars [20 pts.]

A. Parallax is the change in apparent position of an object against the background, as the observer moves. In annual parallax, the observer is carried ±150,000,000 km by the Earth in its orbit around the Sun. Think about a right triangle with the 90 degree vertex on the Sun, another vertex at the Earth, and a third at a very distant star. If the angle subtended by the Earth-Sun distance as seen from the star is 1 arcsecond (1" is 1/3,600 of a degree, or π/(180*3,600) radians), what would be the distance from the Sun to the star? That distance (D) is called a "parsec", and it is a common distance unit in astronomy, useful because the parallax measured in arcseconds is the inverse of the distance in parsecs (P[arcsecon]=1/D[parsec]). Hint: sketch a drawing and recall the definition of tangent of an angle.

B. Procyon is the brightest star in the constellation of Canis Minoris and it happens to be one of the closest stars to the Sun. Its annual parallax is 285 milli-arcseconds. How far away is it in light-years? (Hint: one parsec is approximately 3.27 light-years. Recall the definition of parsec and why it is a useful distance unit for computing parallaxes)

C. Did Tycho Brahe stand any chance of measuring the parallax to Procyon? What do you think this means about a crucial objection leveled against the Heliocentric model?

5. Kepler's third law [20 pts.]

A. Ultima Thule was recently imaged by the New Horizons mission. It orbits the Sun with a period of 297 years. Use Kepler's third law to find out the semimajor axis of the orbit of Ultima Thule, expressed in Astronomical Units (AU).

B. The first extrasolar planet (i.e., a planet orbiting another star) was found around the solar-type star 51 Pegasus in 1995. Its period is about 4.5 days (a very short year!). What would be its distance to 51 Pegasus? (Hint: solar-type means its mass is very similar to the mass of the Sun)

C. Geostationary satellites complete a revolution around the Earth in 24 hours, so that for an observer on the Earth's surface they appear fixed in the sky (they don't partake of the daily motion). Use the full version of Kepler's third law found by Newton to figure out the radius of their orbit in km. (The mass of the Earth is approximately 6×10^{27} g, and the gravitational constant is $G=6.7\times10^{-8}$ cm^3 g^{-1} s^{-2}. Note that it is important to make sure that the units are consistent throughout: convert the period to seconds, and the result will be the orbital radius in cm, which you can then easily convert to km.)