Astronomy 111 — Problem Set #1

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Due September 2, 2025 at the beginning of lecture

1. Suppose the Sun can be considered a uniformly bright circular disk as seen from Earth's neighborhood.
   (a) Earth, much smaller than the Sun, casts a conical dark shadow, called the **umbra**, in the anti-Sun direction. Sketch this situation, to demonstrate that the umbra is indeed conical, and calculate the distance from Earth's center at which the apex of the cone lies. You will find the lengths you need on our website's Physical Constants worksheet.
   (b) During lunar eclipses, the Moon crosses the umbra. What is the diameter of the umbra cast on the Moon at its average distance from Earth? Compare your result to that shown in lecture.

2. An incandescent light bulb has an effective area of about 10 cm^2.
   (a) Suppose the surface of an object the size of the Sun were completely covered with 100 W light bulbs. What would the luminosity of this object be if all the light bulbs were turned on? How does this compare to the Sun's luminosity?
   (b) What is the effective temperature of a 100 W light bulb? Does this result seem reasonable, considering what you know about the physical temperature of light bulb surfaces?

3. *Angles on the sky.* An asteroid is observed at two different times. At UT = 02h00m00s (universal time), the asteroid is located at α = 02h23m35.65s, $\delta = +25°18'42.3"$. At UT = 03h00m00s, the asteroid is located at α = 02h23m36.95s, $\delta = +25°19'10.6"$.
   (a) How many radians are equivalent to an arcsecond in declination?
   (b) How many radians are equivalent to a second of time in RA for the above asteroid?
   (c) What is the angular distance in arcseconds between the two observations?
   (d) If the object is 1.5 AU away, how fast is it moving, in km/s, in the plane perpendicular to our line of sight?

4. Suppose the orbits of the planets are circles with radii equal to the semimajor axis lengths listed in the Physical Constants sheet on our website, and that the planets are spheres with radii also as given on this page.
   (a) Make a table of the minimum and maximum distance of each planet from Earth and the corresponding maximum and minimum angular diameter of each planet as seen from Earth, reporting your answer in arcseconds. (Recall: π radians = 180°, 60 arcminutes = 1°, and 60 arcseconds = 1 arcminute.)

(b) Atmospheric turbulence usually blurs the images seen through telescopes such that the smallest details that can be discerned are 1–2 arcseconds in diameter. For each of the planets, approximately when in the planet's orbit is it possible to obtain good, detailed pictures of the planet with a ground-based telescope (when is the size of the planet significantly larger than the blurring)?