ASTR 300 — Stars and Stellar Systems — Fall 2009

Homework Set No. 1 — Due Sep 15, 2009

Please type up or print out your homework and staple the pages together. Leave a blank space to write in mathematical equations or diagrams. Make sure you **show your work** for any calculations – "magical" answers will receive no credit. Problems are **due at the beginning of the lecture**.

Review questions, Problems, etc. which have a chapter and number noted are from your text *Stars and Galaxies*.

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1. Give two reasons why winter days are colder than summer days.
   (Chapt. 2, Review Question 9)

2. After Sirius, the second brightest star in the sky is Canopus (α Carinae). We don't see this star because it is located in the southern sky, 57^o below the celestial equator.

   Mexico City is located at a latitude of about 19^o N. Can Canopus be seen from there? If so, how high in the sky can it be? If not, how close can it come to the horizon?

3. Answer Question 3 of Chapter 2, Learning to Look.

4. The eccentricity of the orbit of Mars is $e = 0.0934$ (Appendix A-10). What is the ratio of the aphelion distance to the perihelion distance for this planet? Use the inverse square law to compute the ratio of the intensity of solar radiation on Mars at aphelion to the intensity at perihelion.

5. The **absolute magnitude** of the Sun is 4.83. This means that if the Sun were at a distance of 10 parsecs, it would have an apparent magnitude of 4.83. Assuming that the limit of naked-eye visibility under perfect conditions is 6.5 magnitudes, what is the increase in magnitude Δm needed to make a 4.83 magnitude star invisible? To what ratio of intensities does this Δm correspond? (See the first equation on p 17 of the text.) Finally, from the inverse square law, calculate the factor by which we would we have to increase the star's distance to get this reduction in intensity.

   Now you can answer the question: "At what distance would the Sun cease to be visible to the naked eye?" Give your answer in both parsecs and light years.

6. Both the Earth and the Moon orbit their common center of mass, but since the Earth is much more massive, its orbit is much smaller that that of the Moon. Look up the mass of the Earth and of the Moon in Table A-5 (p 437). How much more massive is the Earth than the Moon? (I.e., what is the ratio of their masses?)

   Look up the distance from the Earth to the Moon in Table A-11. Calculate the distance of the Earth's center from the center of mass of the Earth-Moon system. Express this distance in units of the Earth's radius.

7. We saw that the true form of Kepler's third law can be written

$$P^2 = \frac{a^3}{m_1 + m_2}$$

if we express the period P in years, the semi-major axis a in astronomical units (AU), and the masses of the two bodies, m_1 and m_2, in solar masses. (If the orbit is circular, then $a = r$, the distance between the two bodies.)

Consider a satellite orbiting Mars. What is the mass of Mars in solar masses? You can neglect the mass (m_2) of the satellite. (Look up the needed data in appendices A5 and A10 of your text.)

Suppose you want your satellite to orbit Mars in the same length of time that Mars takes to turn once on its axis, so that your satellite will be fixed in the Martian sky. Mars turns on it's axis in 24.623 hours. What is this period in years? From Kepler's law (above), find the radius of the orbit a in AU. What is this expressed in kilometers? What is the radius of the orbit expressed in terms of the radius of Mars? (1 AU = 1.496×10^8 km)?

Compare this result to the case of a geosynchronous satellite in orbit about the Earth; such satellites orbit at 6.61 Earth radii.