Hand in your solutions by 3pm on Saturday, September 15. You should put them in the lower box outside my office.

Here are a few guidelines for this – and every – homework assignment:

Use a symbolic approach (often aided by sketches and careful definition of variables) – using variables to denote relevant quantities and then, only at the end, when you’ve derived an expression that solves the problem at hand, plug in numbers.

Use units; don’t go crazy with significant figures. Remember – you can never justify more significant figures in your answer than the least significant of the inputs to the problem.

Please show your work, write neatly – be organized. Explain what you are doing. Use sketches when you think they’d be helpful.

For full credit, you must show a reasonable amount of work and explain what you’re doing.

Comparisons between two related quantities most often should be ratios (e.g. “how many times larger, smaller, more massive, whatever...?”).

There are appendices at the back of your textbook with useful constants, conversion factors, and astronomical quantities.

Problem 1

How far would a 100 Watt light bulb have to be from you (in meters) so that it appeared to your eyes to be as bright as the star Arcturus (which is one of the brightest stars in the sky)? For this problem, assume Arcturus has a parallax angle in arc seconds ($\pi'' = 0.1$) and is 170 times as luminous as the Sun. You may assume that the full 100 W of power output by the bulb is in the visible part of the spectrum.

Would the bulb have to be closer or farther if not all of its light emission were in the optical part of the spectrum (e.g. the bulb’s power output in the visible part of the spectrum is only 50 W)? Make your reasoning clear for full credit. And see prob. 2, below.

Problem 2

(a) Ryden & Peterson problem 5.8 (p. 145).

After you answer that, answer this follow-up question:

(b) Given the temperature of the filament, would you expect a majority of the light it emits to be in the optical part of the spectrum? (For full credit, explain how you know.) If not, what part of the spectrum would the majority of the light be emitted in?

Problem 3

(a) How far from the Earth’s surface is the Earth-Moon system’s center of mass? (Use values taken
from the appendix of the textbook, and note that we discussed the center-of-mass equation in class 2, though it wasn’t in the reading. For this problem, you can assume that the Moon’s orbit is circular.)

(b) If the Moon’s orbital period is 27.3 days, then what is the speed of the Earth in its orbit around the Earth-Moon system’s center of mass?

Problem 4

The three images below are observations of a binary star system taken over the course of two years (the third observation was taken two years after the first). Orbital motion of the binary stars is evident in the images. Given the angular size of the star’s orbits – and assuming their distance from the Earth is 33 light years –

(a) what is the combined mass of the two stars? You may assume the orbits are circular. Express your answer in terms of the Sun’s mass.

(b) From the appearance of the orbits are the masses of the stars similar or quite different (and if different, which one is more massive)? You might want to annotate the data, above. If you do, hand in your work along with your solution, please.

Problem 5

(a) Compute the orbital speed (in m/s) of an object in low-Earth orbit, using Kepler’s third law. Assume the object is orbiting 250 km above the Earth’s surface.

(b) Given the Earth’s radius and the length of the day, compute the speed – due to the Earth’s rotation – of an object on the Earth’s equator (in m/s).

(c) If takes a lot of energy to put a satellite into orbit, even into low-Earth orbit. What fraction, or percent, of the total energy “cost” can be saved if a rocket is launched from the Earth’s equator, toward the East (in the direction of the Earth’s motion) rather than, say, launched from the North Pole where the Earth’s rotation would give the rocket no kinetic energy at all?

Problem 5 continued on next page...
It might be useful to recall that the kinetic energy of an object of mass, $m$, traveling at speed, $v$, is given by $\frac{1}{2}mv^2$.

(d) If you instead launched the rocket from Philadelphia (40 degrees north latitude), what would the energy savings be?

**Problem 6**

An apple weighing 100 g falls from a tree and hits the ground at a speed of 10 m/s.

(a) If all the kinetic energy of that apple turned into optical light, *how many* photons would be produced, given the conservation of energy? You may assume all the photons are yellow, with a wavelength in the middle of the visible part of the spectrum.

(b) If you observed those photons while moving away from the apple at a speed of 15,000 km/s (note km not m), what wavelength would you observe the apple-generated photons to have? And would these photons be redder or bluer than they’d look to an observer who’s stationary with respect to the apple?