Hand in your solutions by 5pm on Wednesday, September 13. You should put them in the lower box outside my office.

Here are a few guidelines for this – and every – homework assignment...same as last assignment (with two more added at the end), just stated here again because they're important:

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

(a) How far apart *in meters* are two points on the Earth that – if viewed from the center of the Earth – would appear to be separated by and angle of one arc second?

(b) How long does it take a point on the Earth's equator to move this distance simply due to the Earth's rotation?

(c) How many degrees per hour is the Earth's rotation rate?

(d) How far apart *in meters* are two points on the Earth that are at the same latitude but have longitudes that differ by of one arc second, if their latitude is 30 degrees north of the equator?

Problem 2

(a) The International Space Station (ISS) orbits about 250 km above the surface of the Earth. How does the force of gravity an astronaut feels on the space station compared to the force of gravity she feels on the surface of the Earth? (Hmmm, I thought astronauts in orbit were "weightless".)

(b) Given the semi-major axis of the orbit of the International Space Station and the mass of the Earth, use Kepler's third law to compute the orbital period of the ISS. Express your answer in minutes.

(c) If we could move the ISS to a higher orbit, with a bigger semi-major axis, it would have a longer period. What semi-major axis would be required to give the ISS (or any satellite) an orbital period equal to exactly one day? This is the "geosynchronous" orbit, such that a satellite (if its orbit were in the equatorial plane) would remain always over the same spot on the earth. Express your answer in meters *and* in Earth radii.

Problem 3

Consider two objects orbiting the Sun. One is on a circular orbit and one is on a highly eccentric orbit ($e = 0.9$). The two orbits have the same semi-major axis length. Sometimes the object on the eccentric orbit is closer to the Sun than the object on the circular orbit and sometimes it is farther away. Over the course of one orbital period, does it spend more time closer or farther from the Sun than the object on the circular orbit? Explain your answer and provide a sketch that's more or less to scale, showing the Sun and the two orbits.

Problem 4

Do Ryden and Peterson's problem 3.1 on p. 81. Fig. 3.6 and the definition of the eccentricity, e, may be helpful.

Problem 5

Do Ryden and Peterson's problem 3.5 (part (a) only) on p. 81. And then also answer the following questions:

(b) What is the maximum angular separation between Jupiter and Io as seen from the Earth? Give your answer in arc seconds, please. For full credit, make it clear how you determined the relevant distance to Jupiter used to calculate your answer.

(c) If you see Io pass behind Jupiter, how long would it take to reappear on the other side of the planet? You can assume Io's orbit is in the plane of Jupiter's equator and you can look up Jupiter's radius in the Appendix of the textbook. Other than that, the information provided in the problem is sufficient for you to answer this question.

(d) What is the maximum light travel time between Jupiter and the Earth? What is the minimum light travel time between Jupiter and the Earth? Let's say you measure the orbital period of Io around Jupiter very carefully and observe it orbit the planet once when the Earth-Jupiter distance is its maximum value. You note the time you see it pass a certain point in its orbit (say, coming out from behind Jupiter) during that observation. You can then predict the times in all subsequent orbits of Io when you should see it in the same place (again, coming out from behind Jupiter). Later, you observe Jupiter and Io again, but this time when the Earth-Jupiter distance is at its minimum. How will the time you see Io at that special point in its orbit (coming out from behind Jupiter) differ from your prediction? (This measurement was used to measure the speed of light with good accuracy in the late 1600s!)