HOMEWORK #11 (due start of class Feb 12)

LEARNING GOALS for this assignment:

1. To understand the physical principles and implications of Kepler's Laws.
2. To understand some concepts relating to orbital energetics.
3. To apply this understanding in practical situations in modern astronomy.

TO RECEIVE FULL CREDIT:

1. Staple multiple pages and identify yourself by Star Name (worth 5 points!).
2. You must **show how** you derived your answer by writing all the logical steps that led you to it. Follow the format of the "Homework Example" on our Web site.
3. All sentence responses must be typewritten and in complete sentences. You may handwrite any arithmetic. Use good English grammar.
4. **If you work more than three hours on this assignment, you should stop, record your work here, and contact Dr. McCarthy or Mr. Hammer (our Teaching Assistant) for help.**

Kepler's Laws, Orbital Mechanics, and Implications

Part I. Review

In Ryden and Peterson's textbook, carefully study section 3.4 (*"The Virial Theorem"*).

Part II. Questions

1. Prove this statement:

"The energy needed to achieve low Earth orbit is roughly half of the total energy to reach anywhere in the Solar System." [NOTE: To "reach anywhere in the Solar System," you need to escape Earth's gravity.]

2. Apply concepts of orbital mechanics to the Parker Solar Probe

Experts in launching spacecraft from Earth to other locations in our Solar System have stated that: *"It's much more difficult to reach the Sun than it is to leave the Solar System altogether."*

a. From equations (3.56) or (3.67) in reading (Homework #9,10) derive an expression for the escape speed from the Solar System. Be sure to state any assumptions clearly.

b. Calculate the minimum velocity (km/sec) a spacecraft from Earth must achieve to escape the Solar System. What is the ratio of that speed to the Earth's present orbital speed?

c. The Parker Solar Probe will reach a perihelion distance of 0.04 AU. What is the speed for a circular orbit at that distance? If you could simply cancel the Earth's orbital speed and let a spacecraft fall towards the Sun, what speed would a spacecraft achieve when it arrived at a distance of 0.04 AU?

3. (Extra Credit – 25 points) More About the Parker Solar Probe

Experts in orbital mechanics have stated that, *"It takes 55 times more energy to go to the Sun than it does to go to Mars."*

Using the concept of a Hohmann transfer orbit (pp.76-78 in R&B's textbook), confirm this statement and show your detailed calculations.