HOMEWORK #14 (due start of class February 19)

LEARNING GOALS for this assignment:

1. To apply your understanding of blackbody emission to Jupiter's internal source.
2. 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.**

Jupiter's Internal Energy Source

Part I. Reading

In Ryden and Peterson's textbook, read sections 12.3 and 12.4.

Part II. Jupiter's Excess Energy

Several of our Solar System's "gas giant" planets emit more energy than they receive from the Sun: Jupiter, Saturn, Neptune. Because of their relatively large distances from the Sun, these planets have low temperatures. Therefore, according to Wien's Law, they will emit light primarily at long wavelengths in the infrared. The excess emission was discovered in the 1960's when a UA astronomer (Dr. Frank Low) pioneered airborne astronomy and measured Jupiter's "far-infrared" emission with telescopes in jet aircraft above Earth's absorbing atmosphere.

Measurements of Jupiter's emitted light indicate that it radiates in the infrared with a total flux of 14.1 W/m^2. In this problem, you will explore the origin of this emission. Some physical variables you will need: $R_{Jup} = 6.99 \times 10^7$ m, a = 5.2 AU, and $M_{Jup} = 1.9 \times 10^{27}$ kg ~ 318 M_{Earth}.

a. What is the total rate of energy emitted by Jupiter in the infrared? Give your answer in Watts.

b. What is the rate of energy absorbed by Jupiter from solar radiation? Assume Jupiter has an albedo of A = 0.343. Give your answer in Watts.

c. From (a) and (b), calculate the excess energy $(dE/dt)_{internal}$ emitted by Jupiter.

d. Could gravitational contraction account for Jupiter's excess energy emission? Use the Virial Theorem, as discussed in Homework #12, to calculate dU/dt. Assume Jupiter is a uniform density sphere contracting at a rate dR/dt. What contraction rate (dR/dt, give as km/Gyrs) could account for the excess energy? [HINT: Differentiate U and set dU/dt = excess energy emitted.]

e. Assuming dR/dt has been the same over 4.6 Gyrs, what fraction of Jupiter's present radius has it contracted?