Name: _____

Astronomy 141
Winter Quarter 2012

Homework #4

Due Tuesday, February 28 in class

Instructions

This handout is your worksheet. Please write your answers in the spaces provided. In cases where a calculation is called for, please show your work including any sketches, so we can evaluate your answer and assign partial credit as appropriate. Answers given without showing at least some of the calculation will receive no credit. We will only accept homework turned in on this worksheet.

This homework assignment consists of the problems below.

1. The M2 supergiant star Betelgeuse has a radius of 936 R_{sun}. The radius of the Sun is 695,500 km, and 1 AU is 149.6 Million km. What is the radius of Betelgeuse in AU? If Betelgeuse were in our Solar System, which planets would be swallowed up by Betelgeuse (see the table of the solar system objects on the back of this problem set).

2. The equilibrium temperature of an Earth-like planet located at a distance D in AU away from a star with luminosity L in L_{sun} is given by:

$$T_{eq} \approx 287\text{K} \frac{L^{1/4}}{\sqrt{D}}$$

Answer the following

a. When the Sun is 12.2Gyr old it will become a red giant with a luminosity of L=2350 in units of L_{sun}. What will be the approximate equilibrium temperature at the Earth? Compare this temperature with the melting point of sand (2100 K).

b. During the Sun's red giant phase when L=2350, at what distance, D, in AU away from the Sun must you move the Earth so that the Earth's equilibrium temperature is back to 287K? Where is this distance relative to the current-day planets (what Solar System objects are out at this distance)?

3. The inner and outer edges of the Habitable Zone around a star with luminosity L in units of L_{sun} are approximately given by:

$$D_{inner} \approx 0.95\text{AU}\sqrt{L}$$

$$D_{outer} \approx 1.4\text{AU}\sqrt{L}$$

Answer the following questions:

a. At the start of the Archaean Eon the Sun's luminosity was L=0.7 (70% the present-day luminosity). Where was the Sun's Habitable Zone during the Archaean? Was Earth in the habitable zone during the Archaean?

b. An A-type main sequence star has L=20 (20 times more luminous than the Sun). Where are the inner and outer edges of the Habitable Zone around this star in AU, and how wide is it in AU?

c. An M-type main sequence star has a luminosity of L=0.003 (0.3% that of the Sun). Where are the inner and outer edges of the Habitable Zone around this star in AU, and how wide is it?

4. This problem is designed to get you thinking about the great vastness of interstellar and intergalactic distances in advance of future lectures. For each of the following places in the nearby Universe, compute how long it would take you to travel to them at the speed given. Use the conversion factor **1 light year (ly) = 9.46×10^{12} km**.

a. Epsilon Eridani B, a planet 10.53 ly away, your speed is 100,000 km/h?

b. The Galactic Center 26,000 ly away, your speed is 50% the speed of light?

c. The Andromeda Galaxy 2,500,000 ly, your speed is 90% the speed of light?

Properties of Selected Solar System Objects

Object	Orbital Semimajor Axis (AU)	Orbital Period (years)	Mass (M_{Earth})	Radius (R_{Earth})
Mercury	0.39	0.24	0.055	0.38
Venus	0.72	0.62	0.82	0.95
Earth	1.0	1.0	1.0	1.0
Mars	1.52	1.9	0.11	0.53
Ceres	2.8	4.7	0.00015	0.073
Jupiter	5.2	11.9	318	11.2
Saturn	9.5	29.4	95	9.5
Uranus	19.2	84	15	4.0
Neptune	30.1	164	17	3.9
Pluto	39.5	248	0.0022	0.18
Eris	67.7	557	0.0028	0.18

Math Reminders

Reminder 1: $x^{1/4}$

To compute $x^{1/4}$, you take the square-root twice.

For example:

$$28^{1/4} = \sqrt{\sqrt{28}} = \sqrt{5.29150} = 2.30033$$

So rounding to a reasonable number of digits

$$28^{1/4} = 2.30$$

Reminder 2: Distance/Speed/Time problems

The basic distance/speed/time formula is

$$dist = speed \times time$$

Example 1:

If you travel for 5 hours at a speed of 100 km/h, you travel

$$\begin{aligned} dist &= speed \times time \\ &= (5 \cancel{\text{h}}) \times (100 \text{ km}/\cancel{\text{h}}) \\ &= 5000 \text{ km} \end{aligned}$$

Example 2:

You need to get to a town 152km away in less than 2h, what is the slowest you can travel?

$dist = speed \times time$ ... solve for speed ...

$$speed = \frac{dist}{time}$$

$$speed = \frac{152 \text{ km}}{2 \text{ h}} = 76 \text{ km/h}$$