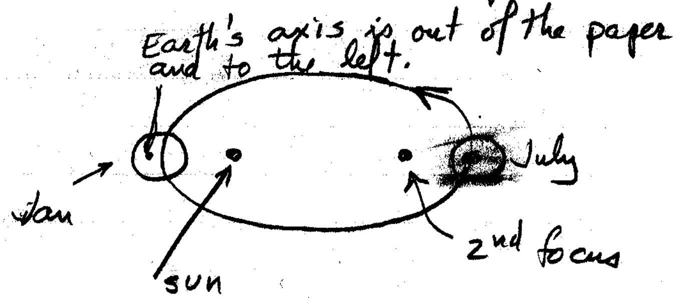
AST 207 Homework 3 Due 19 September 2008

1. **Summer is long and winter is short**. More precisely, the length of time from the spring equinox in March to the fall equinox in September (186.4 days) is longer than the time from the fall equinox to the spring equinox (179.1 days). This fact is a consequence of the earth's elliptical orbit, the tilt of its axis, and the relationship between the tilt and the orbit. (Recall that the sun is north of the equator in summer and it is on the equator on the equinoxes.)
   a. (6 pts.) Draw the earth's orbit and tilt that accounts for the longer summer.
   b. (4 pts.) Explain why summer is longer than winter using the key features in your picture.
2. In another solar system, a planet orbits the star at a distance 1 AU with a period of 0.5 earth-years.
   a. (2 pts.) Without doing any calculations, explain why the mass is greater or less than the sun's mass.
   b. (5 pts.) Find the mass of the star. Express your answer in terms of the sun's mass.
   c. (0 pts.) Could Kepler answer this question? (2 pts.) Explain your reasoning.
   d. (0 pts.) Could Newton answer this question? (2 pts.) Explain your reasoning.
3. **Halley's Comet** has an orbital period of 76 years, and its eccentricity is 0.967. Recall that the eccentricity is (distance between foci)/(major axis).
   a. (6 pts.) How far from the sun does it get? Give your answer in AU. (You must explain how you found this from the information given.)
   b. (2 pt.) How close to the sun does it get?

Ast 207 Hwk 3 19 Sept 08

1. The earth's orbit is slightly elliptical. The earth is closest to the sun in Jan. According to Kepler's 2nd law, the earth moves fastest in Jan and slowest in July.



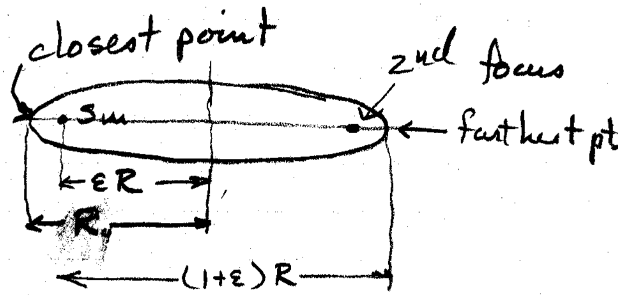
Therefore the earth spends less time in the part of its orbit where the northern hemisphere is tilted away from the sun.

2. a) The acceleration is proportional to distance / time^2. ~~Since~~ The distance the hypothetical planet moves is the same as the earth's. The time is half the earth's. Therefore the acceleration is greater. Because the force exerted by the star is proportional to the acceleration, the force exerted by the hypothetical star is greater. Its mass is greater.

b) Newton's generalization of Kepler's 3rd law: $P^2 = \frac{M_\odot}{M} R^3$.
$\frac{1}{2}^2 = \frac{M_\odot}{M}$. $M = 4 M_\odot$.

c) ~~~~ This required Newton's realization that K's 3rd law involved the mass of the star.

K's 3rd law: $P^2 = R^3$ $76^2 = R^3$
$R = (5776)^{1/3} = 17.9$ AU.



a) Farthest point is at
$(1+\varepsilon) R = 1.967 R = 35.3$ AU

b) Closest point is at
$(1-\varepsilon) R = 0.033 R = 0.59$ AU