PhyzJob:
The Galactic Weigh Station

NEELIX

1. "Weighing" the Earth

A 1.0kg mass is found to have a weight of 9.8N, and the radius of the earth is 6.37×10^6m; use the law of universal gravitation ($F=GMm/R^2$) to calculate the mass M of the earth (since G is now known, this calculation is possible).

$F = GMm/R^2$

$M = FR^2/Gm$

$M = 9.8N(6.37 \times 10^6 m)^2/(6.67 \times 10^{-11} N \cdot m^2/kg^2)1.0kg$

$M = 6.0 \times 10^{24} kg$

2. "Weighing" the Sun

Knowing G, it was now possible to measure the mass of the sun as well. Follow these steps.

a. Write "Kepler's Rule" (Kepler's law of harmony). $R^3/T^2=K$

b. Complete Newton's substitution $4\pi^2 K =$ GM

c. Write an expression for K in terms of G, M, 4, and π^2. $K = GM/4\pi^2$

d. Notice that you have an expression for K in part a and in part c. Equate them and solve for M.

$M = 4\pi^2 R^3/GT^2$

e. If $R = 1.5 \times 10^{11}$m and $T = 365$d (how many seconds is that?), what is the mass of the sun?

$M = 2.0 \times 10^{30} kg$

3. How 'bout "weighing" Jupiter and Saturn while we're at it?

a. Jupiter has a moon named Europa. Europa has an orbital radius 6.88×10^8m and a period 3.55d. What is the mass of Jupiter?

$2.1 \times 10^{27} kg$

b. Saturn has a moon named Tethys. Tethys has an orbital radius 2.95×10^8m and a period 1.89d. What is the mass of Saturn?

$5.7 \times 10^{26} kg$

Is physics cool, or what? Measuring the force of attraction between a couple of hunks of lead made it possible to "weigh" whole planets and stars!

Check your answers with the Solar System Information Reference.