

PhyzJob: The Galactic Weigh Station

NEELIX

1. "Weighing" the Earth

A 1.0 kg mass is found to have a weight of 9.8 N, and the radius of the earth is 6.37×10^6 m; 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).

$$F = GMm/R^2$$

$$M = FR^2/Gm$$

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

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

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 , a , and π^2 . $K = GM/a^3$

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?

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

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

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

$$2.1 \times 10^{27}\text{kg}$$

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

$$5.7 \times 10^{26}\text{kg}$$

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.