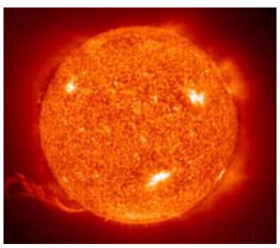
The Oscillation Period of Gaseous Spheres

Any collection of matter that is governed by the force of gravity has a natural period of oscillation. For example, a simple pendulum such as a playground swing, will move back and forth with a time period in seconds, T, given by the formula to the right, where L is the length of the swing in centimeters, and g is the acceleration of gravity at Earth's surface given by 980 cm/sec^2. The period of a swing that is 3 meters long is then T = 3.5 seconds.

$$T = 2\pi\sqrt{\frac{L}{g}}$$

This behavior also applies to any body held together by gravity whether it is a star or a planet. The natural oscillation period of such bodies is given by the formula to the right, where D is the density of the body in grams/cm^3 and G is the Newtonian constant of Gravity G = 6.6 x 10^{-8} dynes cm^2 gm^2 and T is in seconds. For example, the planet Jupiter has a density of about D = 1.3 gm/cm^3 so its period, T, will be about 10,500 seconds or T = 3 hours. From the information below, calculate the natural periods for the various astronomical bodies.

$$T^2 = \frac{3\pi}{G\ D}$$



Courtesy SOHO-EIT

The sun is about 1.5 million kilometers across, and has an average density of about 1.5 grams/cm^3

T = ______________ hours.

Courtesy NASA-Apollo

The Earth has a diameter of about 12,500 kilometers, and has an average density of about 5.5 grams/cm^3

T = ______________ minutes.

Courtesy NASA-Dana Berry

A neutron star is about 50 kilometers in diameter, and has an average density of about 2 x 10^{14} grams/cm^3

T = ______________ seconds.

Answer Key:

The sun is about 1.5 million kilometers across, and has an average density near its surface of about 1.5 grams/cm^3

$$T^2 = 3 \times (3.141)/(1.5 \times 6.6 \times 10^{-8})$$
$$= 9.5 \times 10^7$$

So T = 9,800 seconds
= 2.7 hours

The Earth has a diameter of about 12,500 kilometers, and has an average density of about 5.5 grams/cm^3

$$T^2 = 3 \times (3.141)/(5.5 \times 6.6 \times 10^{-8})$$
$$= 2.5 \times 10^7$$

So T = 5,100 seconds
= 85 minutes

A neutron star is about 50 kilometers in diameter, and has an average density of about 2 x 10^{14} grams/cm^3

$$T^2 = 3 \times (3.141)/(2.0 \times 10^{14} \times 6.6 \times 10^{-8})$$
$$= 7.1 \times 10^{-7}$$

So T = 0.00085 seconds