Chapter 1 Problem 63 †

Given

$\rho_{sun} = 1000\ kg/m^3$

Solution

a) Estimate the diameter of the sun.

From the textbook, the approximate mass of the sun is $10^{30}\ kg$.
The volume of a sphere is

$$V = \frac{4}{3}\pi\ r^3 = \frac{4}{3}\pi\ (D/2)^3 = \frac{1}{6}\pi\ D^3$$

Density equals mass divided by volume; therefore, the mass equals

$$m = \rho\ V = \rho \frac{\pi\ D^3}{6}$$

Solving for diameter gives

$$D^3 = \frac{6m}{\rho\pi}$$

$$D = \left(\frac{6m}{\rho\pi}\right)^{1/3}$$

$$D = \left(\frac{6(10^{30}\ kg)}{(1000\ kg/m^3)\pi}\right)^{1/3}$$

$$D = (1.9 \times 10^{27}\ m)^{1/3} = 1.2 \times 10^9\ m$$

b) Find the distance from the earth to the sun.

The sun subtends 1/2 degree in the sky. Convert this into radians gives

$$\theta = 0.5^\circ \left(\frac{\pi\ rad}{180^\circ}\right) = 8.7 \times 10^{-3}\ rad$$

Assume the earth has a circular orbit around the earth. When the angle is in radians, the relationship between arc length and radius of the circle is

$$s = r\ \theta$$

The diameter of the sun is the arc length. Solving for radius gives

$$r = \frac{s}{\theta} = \frac{1.2 \times 10^9\ m}{8.7 \times 10^{-3}\ rad} = 1.4 \times 10^{11}\ m$$

†Problem from University Physics by Ling, Sanny and Moebs (OpenStax)