PhyzJob:
Journey to the Centre of the Earth

F E LI X

Prior to Cavendish, the best estimate of the earth's mass had to be obtained by the following method.

1. The density of an object in terms of its mass and volume is

   $D = \frac{m}{V}$

2. So the mass of an object in terms of its density and volume is

   $M = DV$

3. The volume of a sphere is

   $V = \frac{4}{3}R^3$

4. Therefore the mass of a sphere (in terms of density and radius) is

   $M = \frac{4DR^3}{3}$

5. The radius of the earth was known to be 6.37×10^6 m. The earth was assumed to be mostly rock, and rocks have an average density of 3000 kg/m^3. Using this information, the mass of the earth was calculated to be

   $M = \frac{4 \cdot 3.0\times10^3 \text{kg/m}^3 \cdot (6.37\times10^6 \text{m})^3}{3} = 3.3 \times 10^{24}$ kg

6. What is the *actual* mass of the earth?

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

7. How does your answer in question 5 compare to the actual mass of the earth (as it was determined by the law of universal gravitation)?

   Since the mass of the earth is 6.0×10^{24} kg, the answer in Q5 is too small.

8. What does this tell you about the density of the earth beneath the crust?

   The actual density must be greater than 3000 kg/m^3.

9. Calculate the average density of the earth by using the relations in questions 1 and 3.

   $D = m/V = 3m/4 R^3 = 3 \cdot 6.0\times10^{24} \text{kg}/4 (6.37\times10^6 \text{m})^3 = 5.5 \times 10^3 \text{kg/m}^3$.

This density (along with other information) indicates that the earth's core is composed mostly of nickel and iron. By measuring *G*, Henry Cavendish revealed not only the mass of the earth and sun, but also information about the earth's core that could not be discovered by even the deepest hole drilled into the earth!

9. 5500 kg/m^3