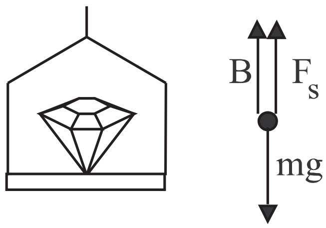
Chapter 15 Problem 30 [†]



Given
$m = 5.4\ g = 5.4 \times 10^{-3}\ kg$
$F_s = 32\ mN = 3.2 \times 10^{-2}\ N$

Solution
Find the density of the jewel.
Since the jewel is in equilibrium, the sum of forces must equal zero. The forces acting on the jewel are the force of gravity, force of the scales, and the buoyant force.
From Newton's 2^{nd} law we have

$$\sum F = B + F_s - mg = 0$$

Solving for buoyancy we have

$$B = mg - F_s = (5.4 \times 10^{-3}\ kg)(9.8\ m/s^2) - 3.2 \times 10^{-2}\ N$$

$$B = 2.09 \times 10^{-2}\ N$$

Since the buoyant force is result of displacing water, we have

$$B = \rho_{water} V g$$

Solving for the volume gives us

$$V = \frac{B}{\rho_{water} g} = \frac{(2.09 \times 10^{-2}\ N)}{(1.0 \times 10^3\ kg/m^3)(9.8\ m/s^2)}$$

$$V = 2.13 \times 10^{-6}\ m^3$$

Now that we know both the volume of the jewel and its mass we can calculate its density.

$$\rho = \frac{m}{V} = \frac{5.4 \times 10^{-3}\ kg}{2.13 \times 10^{-6}\ m^3} = 2.53 \times 10^3\ kg/m^3$$

Using conversions, this density becomes $2.53\ g/cm^3$. This is considerably less than $3.51\ g/cm^3$ and, therefore, the jewel is not a diamond.

[†]Problem from Essential University Physics, Wolfson