Key Concepts

Chapter 5

Buoyant force

Archimedes' principle

Newton's laws

Specific gravity

Density

Takeaways

Unit conversion is common in problems dealing with buoyancy, specific gravity, or density. Use dimensional analysis to assist you. Specific gravity is an often-forgotten quantity but one that is easily calculated.

$\rho_{water} = 1 \text{ g/cm}^3 = 1{,}000 \text{ kg/m}^3$.

Things to Watch Out For

The buoyant force depends on the density of the fluid, *not* the density of the object. This is a common misconception.

Specific Gravity

A cube, composed of substance X and having a side length of 5 cm, hangs from a string while fully submerged in saltwater ($\rho = 1.1 \text{ g/cm}^3$). The tension in the string is 11 N. What is the specific gravity of substance X?

1) Find the volume of the cube.

The volume of a cube is the side length cubed.

$$V = (\text{side})^3 = (5 \text{ cm})^3 = 125 \text{ cm}^3$$

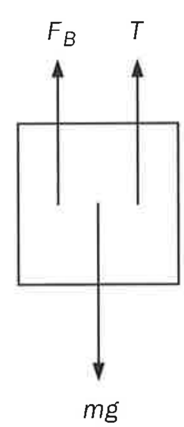
2) Find the buoyant force on the cube.

generic: $F_B = \rho_{fluid} g V_{submerged}$

The buoyant force depends on the density of the fluid, acceleration due to gravity, and volume of the object submerged. Convert the density of saltwater to kg/cm^3 so that the buoyant force will be in newtons.

$$(\rho_{fluid} = \rho_{saltwater} = 1.1 \text{ g/cm}^3 = 1.1 \times 10^{-3} \text{ kg/cm}^3)$$
$$F_B = (1.1 \times 10^{-3} \text{ kg/cm}^3)(9.8 \text{ m/s}^2)(125 \text{ cm}^3) = 1.35 \text{ N}$$

3) Draw a free-body diagram of the cube.



There are three forces acting on the block: the weight of the block (which equals *mg*), the tension in the string (labeled *T*), and the buoyant force (labeled F_B).

Remember: *The buoyant force always acts upward.*

4) Add the forces in the *y*-direction and solve for the mass.

$\Sigma F_y = ma_y = T + F_B - mg$

Every time you draw a free-body diagram, the next step is to add the forces in a direction and set them equal to mass times acceleration in that direction. Because the cube is not moving, the acceleration is zero. Solve for mass.

$$a_y = 0 \rightarrow T + F_B - mg = 0$$

$$m = \frac{(T + F_B)}{g} = \frac{(11 + 1.35)}{9.8} = 1.26 \text{ kg}$$

5) Find the density of the cube.

1.26 kg = 1,260 g

The density of the cube is needed to find the specific gravity. Find the density in g/cm^3 because we know that the density of water is 1 g/cm^3. Density is mass divided by volume.

$$\rho = \frac{m}{V} = \frac{(1{,}260 \text{ g})}{(125 \text{ cm}^3)} = 10.08 \text{ g/cm}^3$$

6) Find the specific gravity of the cube.

$$\text{specific gravity} = \frac{\rho_{\text{material}}}{\rho_{\text{water}}} = \frac{(10.08 \text{ g/cm}^3)}{(1 \text{ g/cm}^3)} = 10.08$$

The specific gravity of a substance is the density of that substance divided by the density of water. When working in g/cm^3, this is a simple calculation because the density of water is 1.

Similar Questions

1) What is the specific gravity of a substance that weighs 40 N and has a volume of 4 cm^3?
2) Three liters of a certain fluid weigh twice as much as 2 liters of water. What is the specific gravity of the fluid?
3) The specific gravity of a block is 5.6. When fully submerged, what is the buoyant force, in water, on this 2 kg block?