For a floating object, the buoyant force equals the object's weight

Imagine a cargo-filled raft floating on a lake. There are two forces acting on the raft and its cargo: the downward force of gravity and the upward buoyant force of the water. Because the raft is floating in the water, the raft is in equilibrium and the two forces are balanced, as shown in **Figure 3.** For floating objects, the buoyant force and the weight of the object are equal in magnitude.

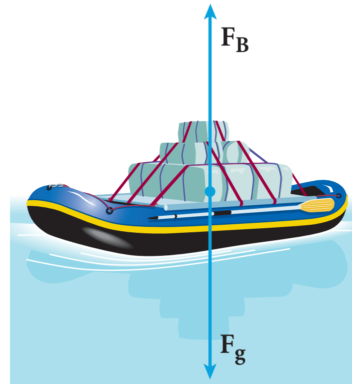

Figure 3
The raft and cargo are floating because their weight and the buoyant force are balanced.

BUOYANT FORCE ON FLOATING OBJECTS

$$F_B = F_g(object) = m_o g$$

buoyant force = weight of floating object

Notice that Archimedes' principle is not required to find the buoyant force on a floating object if the weight of the object is known.

The apparent weight of a submerged object depends on density

Imagine that a hole is accidentally punched in the raft shown in **Figure 3** and that the raft begins to sink. The cargo and raft eventually sink below the water's surface, as shown in **Figure 4.** The net force on the raft and cargo is the vector sum of the buoyant force and the weight of the raft and cargo. As the volume of the raft decreases, the volume of water displaced by the raft and cargo also decreases, as does the magnitude of the buoyant force. This can be written by using the expression for the net force:

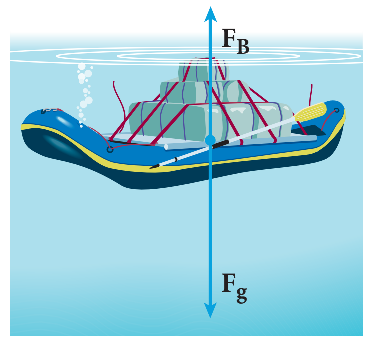

Figure 4
The raft and cargo sink because their density is greater than the density of water.

$$F_{net} = (\rho_f V_f - \rho_o V_o)g$$

Because the raft and cargo are completely submerged, V_f and V_o are equal:

$$F_{net} = (\rho_f - \rho_o)Vg$$

Notice that both the direction and the magnitude of the net force depend on the difference between the density of the object and the density of the fluid in which it is immersed. If the object's density is greater than the fluid density, the net force is negative (downward) and the object sinks. If the object's density is less than the fluid density, the net force is positive (upward) and the object rises to the surface and floats. If the densities are the same, the object hangs suspended underwater.

A simple relationship between the weight of a submerged object and the buoyant force on the object can be found by considering their ratio as follows:

$$\frac{F_g(object)}{F_B} = \frac{\rho_o \cancel{Vg}}{\rho_f \cancel{Vg}}$$

$$\frac{F_g(object)}{F_B} = \frac{\rho_o}{\rho_f}$$

This last expression is often useful in solving buoyancy problems.

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