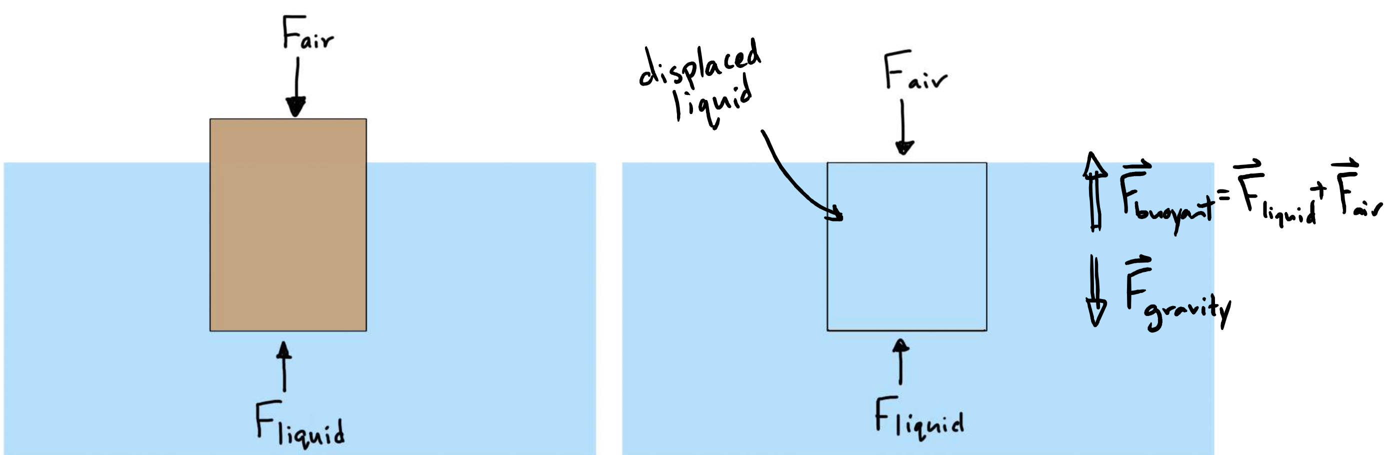
The Buoyant Force:

Objects bobbing up and down in a liquid provide a familiar example of simple harmonic motion. To analyze this motion, we need to understand a little about the forces on these objects from the liquid and air surrounding them. The net force from the liquid and the air is known as the **buoyant force.** This is always an upward force. A key result is that **the magnitude of the buoyant force is equal to the weight of the "missing" or "displaced" liquid.** To calculate this, we first find the volume V_D below the surface of the water that does not contain any liquid because of the presence of the object. The weight of this volume of liquid is equal to m_{liquid} g, where the mass is determined in terms of the volume and density by $m_{liquid} = V_D\ \rho_{liquid}$. So overall, we have:

$$\mathbf{F_{buoyant} = V_D\ \rho_{liquid}\ g.}$$



Now let's understand why this is true. The first picture shows an object in some liquid. The second picture shows the situation with the object removed and the part of the object under the liquid replaced by more liquid. The box in the second picture isn't real; it just shows the new liquid we have added. The force from the liquid on the object in the first picture is the same as the force from the surrounding liquid on the new liquid in the second picture, since this force is from the pressure of the water, which is the same in both cases (it is determined by the depth). Also, the air pressure is the same in both cases, so the force from the air is the same. Thus, the upward buoyant force (the net force from the air and water) is the same in both situations. But in the second situation, the water is in mechanical equilibrium, so this upward buoyant force must exactly balance the downward force of gravity. Thus, $|\mathbf{F_{buoyant}}|$ equals the weight of the water in the box, which is the amount of water displaced by the object in the first picture.