Stability of a Submerged Body

Having derived **Archimedes Principle** we now address the issue of the equilibrium of a submerged body such as the submarine depicted in Figure 1 or the balloon depicted in Figure 2. When both the body

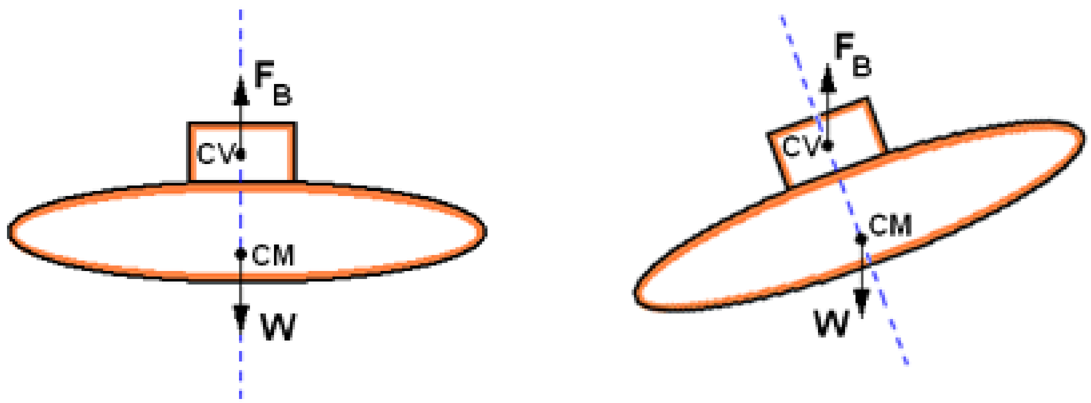

Figure 1: The hydrostatic forces on a submerged body (CM = center of mass, CV = center of volume or buoyancy).

and the fluid are at rest it follows that the forces acting on the submarine are the weight, W, and the buoyancy force, F_B, both of which act in a vertical direction as shown. If the submarine is in equilibrium then these forces must be equal. Moreover the equilibrium will only be stable if the orientation of the submarine is such that the center of mass, CM, through which the weight acts is vertically below the center of volume (or center of buoyancy), CV, through which the buoyancy force acts. If this is not the case then the submerged body will rotate until this orientation is achieved. Only if these two centers coincide (as they would for a body made of homegeneous material) will there be no particular orientation of stable equilibrium.

As can be seen by considering the tilted orientations on the right hand side of each of the figures, when CM is below CV the tilt leads to a moment which corrects the tilt. Moreover the magnitude of this correcting moment will be greater the larger the distance seperating the centers of mass and buoyancy. Consequently the submarine stability is enhanced by loading the ballast as low as possible in the vessel and having the air volumes as high as possible. The balloon of Figure 2 is very stable since most of the volume is overhead in the balloon itself while most of the mass is in the basket.

The **stability of a floating body** is more complex and is addressed elsewhere.

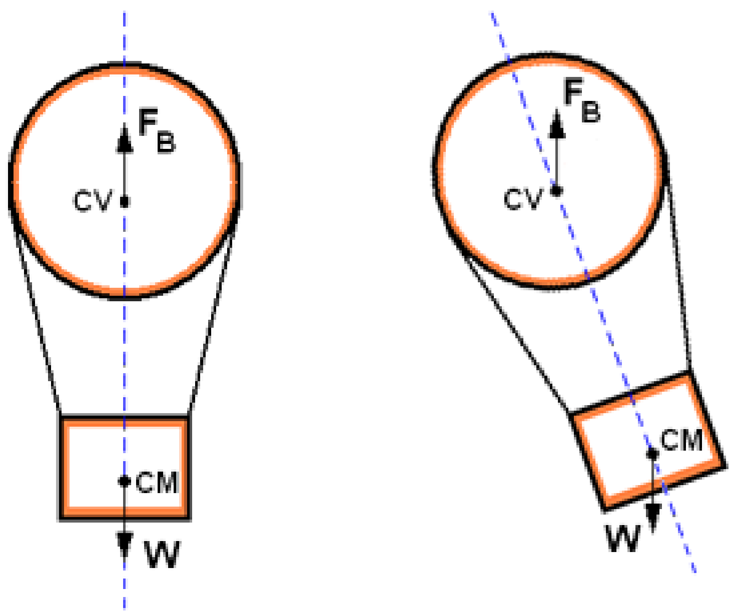

Figure 2: The hydrostatic forces on a balloon (CM = center of mass, CV = center of volume or buoyancy).