Density and Specific Gravity

The density (ρ) of an object or material sample is equal to its mass (m) divided by its volume (V).

$$\rho = \frac{m}{V}$$

The specific gravity (SG) of a material is equal to its density divided by the density of pure water.

$$SG_{material} = \frac{\rho_{material}}{\rho_{water}}$$

The specific gravity is greater than one for materials that are denser than water and less than one for materials that are less dense than water.

Hydrostatic Fluid Pressure

The following very general formula can be used to calculate the change in pressure (Δp) associated with a specific change in depth (Δh) in any *incompressible* fluid having density (ρ_{fluid}) subjected to any *constant* acceleration (a). For example, this formula can be used to calculate pressure changes under an ocean of liquid water on Europa (one of Jupiter's moons) or even under the sea of liquid methane thought to exist on Titan (one of Saturn's moons).

$$\Delta p = \rho_{fluid} a \Delta h$$

In the specific case of water on or near earth's surface, where the freefall acceleration due to gravity is g = 9.8 m/s^2, this becomes:

$$\Delta p = \rho_{H_2O} g \Delta h$$

For additional information about calculating hydrostatic pressure on earth, including tables of pressure as a function of depth in both freshwater and seawater, please refer to *Appendix III: Hydrostatic Pressure.*

Absolute and Gauge Pressure

Under water, the total pressure (called the absolute pressure) is the sum of two pressures: the pressure of the air pressing down on the surface of the water, which is one atmosphere (1 atm) of pressure, and the additional pressure (P_{gauge}) caused by the weight of the water pressing down from above.

$$P_{absolute} = P_{gauge} + 1\ atm$$

Note that tire pressure gauges and most other pressure gauges display *gauge* pressure, so they read 0 in air at sea level, even though they are really exposed to 1 atmosphere of pressure there. However, for calculating changes in gas volume associated with changes in depth, you should always use the *absolute* pressure.

Hydrostatic Force

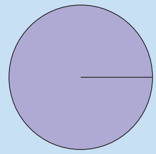
When hydrostatic pressure acts on a surface, it applies a force perpendicular to the surface. Hydrostatic forces can be huge and are one of greatest threats to underwater vehicles. The magnitude of the net hydrostatic force pushing inward (F_{in}) on a section of pressure hull is equal to the pressure difference between inside and outside ($p_{out} - p_{in}$) multiplied by the surface area (A) exposed to the pressure difference.

$$F_{in} = (p_{out} - p_{in})A$$

Some Useful Geometry Formulas

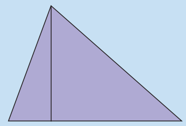
Rectangle or Square
(Length = L, Height = H)

Area = LH
Perimeter = 2(L+H)



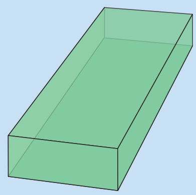
Circle
(Radius = R)

Area = πR^2
Circumference = $2\pi R$



Triangle
(Base = B, Height = H)

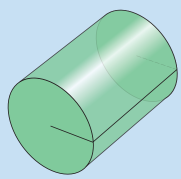
Area = $\frac{1}{2}BH$



Rectangular Block or Cube
(Length=L, Width=W, Height=H)

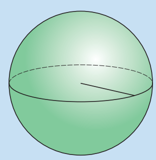
Area = 2(LW + LH + WH)
Volume = LWH

Note that for a cube L=W=H, so...
Area = $6L^2$
Volume = L^3



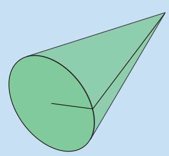
Cylinder
(Length = L, Radius = R)

Area of circle at each end = πR^2
Area without ends = $2\pi RL$
Total Area = $2\pi R^2 + 2\pi RL$
Volume = $\pi R^2 L$



Sphere
(Radius = R)

Area = $4\pi R^2$
Volume = $\frac{4}{3}\pi R^3$



Cone
(Height = H, Radius of base = R)

Area of circular base = πR^2
Area without base = πRH
Total area = $\pi R^2 + \pi RH$
Volume = $\frac{1}{3}\pi R^2 H$