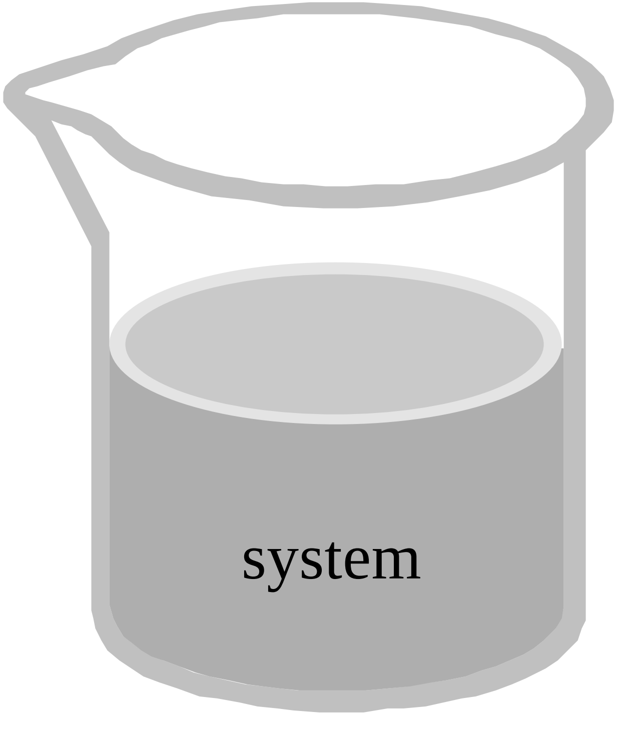
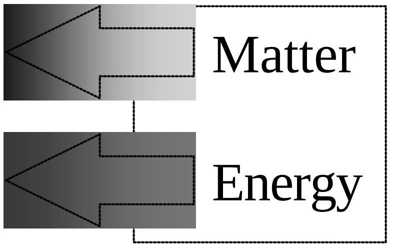
# System and Surroundings

- System - the part of the world in which we have a special interest.
- Surroundings - where we make our observations.

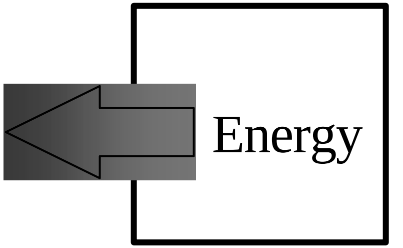


# Types of Systems

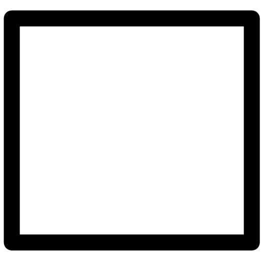
- ***Open*** - exchanges matter and energy with surroundings.




- ***Closed*** - exchanges only energy with surroundings.




- ***Isolated*** - no interchange with surroundings.



# Walls

- Rigid vs. moveable.  Rigid walls allow the system to do no work.
- Adiabatic vs. diabatic.  Adiabatic walls allow no heat transfer.
- Non-permeable vs. permeable.  A non-permeable wall allows no influx of matter.

# Equilibrium

- Thermal Equilibrium – system and surroundings at the same temperature.
- Mechanical Equilibrium – system and surroundings at the same pressure.
- Chemical Equilibrium – system and surroundings at the same chemical concentrations.

# GLOSSARY

Variables are classified as either ***extensive*** or ***intensive***.

**Extensive variables vary linearly with the size** of the system.

Internal energy, *E,* is an example of an extensive variable.

**Extensive variables** exhibit the property of being **additive** over a set of subsystems. As example: if a system is composed two subsystems, one with energy *E1*, the second with energy *E2*, then the total system energy is *E = E1 + E2*.

Other examples of **extensive variables** in thermodynamics are: volume, ***V***, mole number, ***N***, entropy, ***S***.

***Intensive*** variables are **independent of the size** of the system.

The intensive variables commonly encountered in thermodynamics are temperature, ***T*** and pressure, ***P***

# GLOSSARY

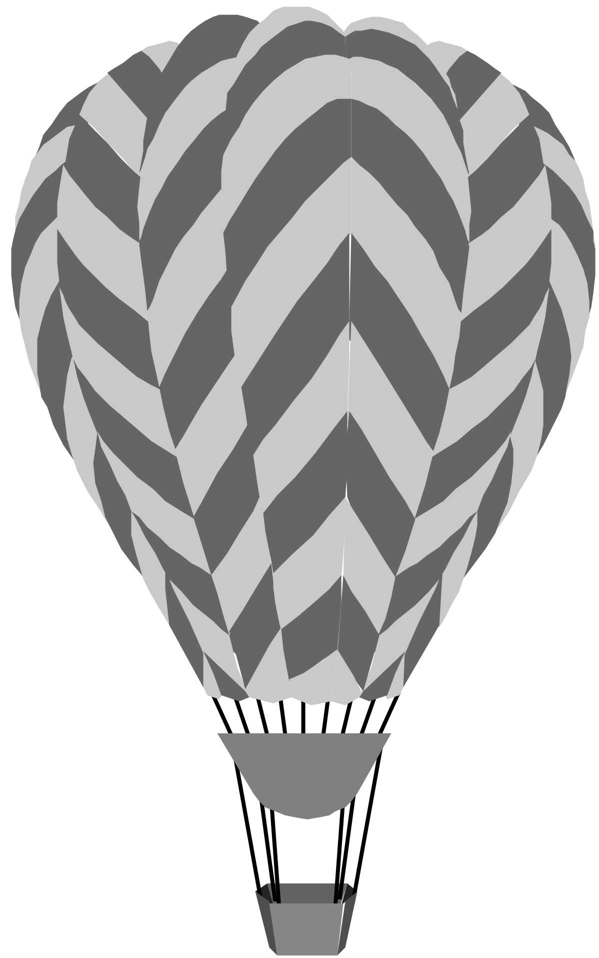
**Equation of State** A relationship between the state variables of the system.

Simple systems in equilibrium are fully specified by two properties such as **temperature** and **volume**; all the other functions of state are functions of these.

For an ideal gas, the equation of state is $PV = nRT$.

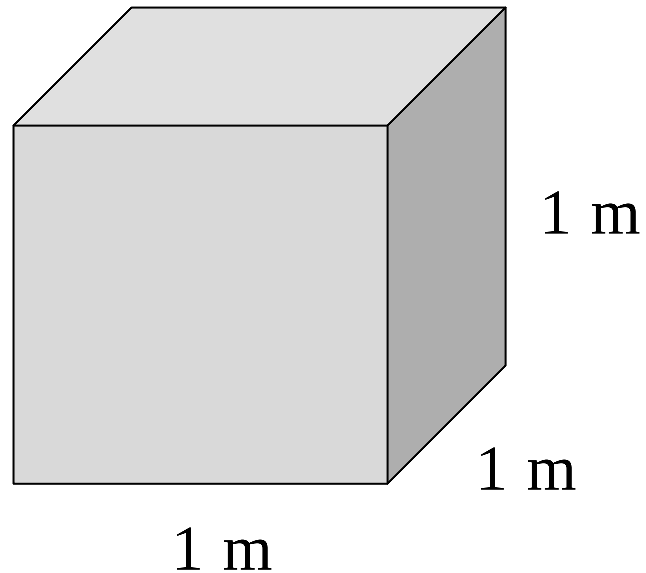
# Bulk Variables

- Volume - $m^3$
- Pressure - Pa
- Temperature - K
- Composition - moles



# Volume

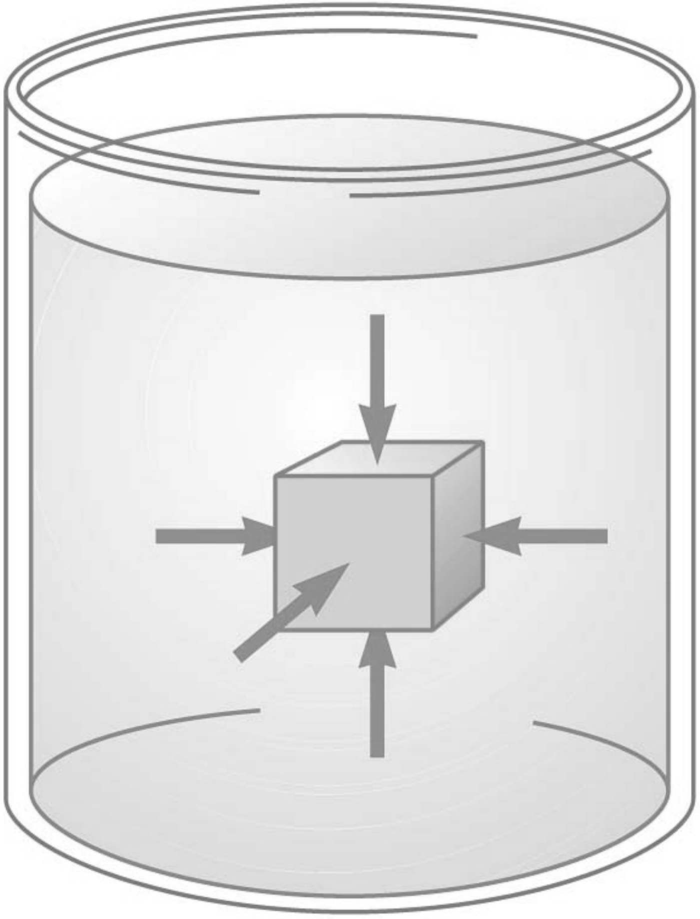
- length$^3$
- units
  - – $m^3$ or $cm^3$
  - – liter = 1000 $cm^3$



# Pressure

- The **pressure** *P* of the fluid at the level to which the device has been submerged is the ratio of the force to the area

$$P \equiv \frac{F}{A}$$

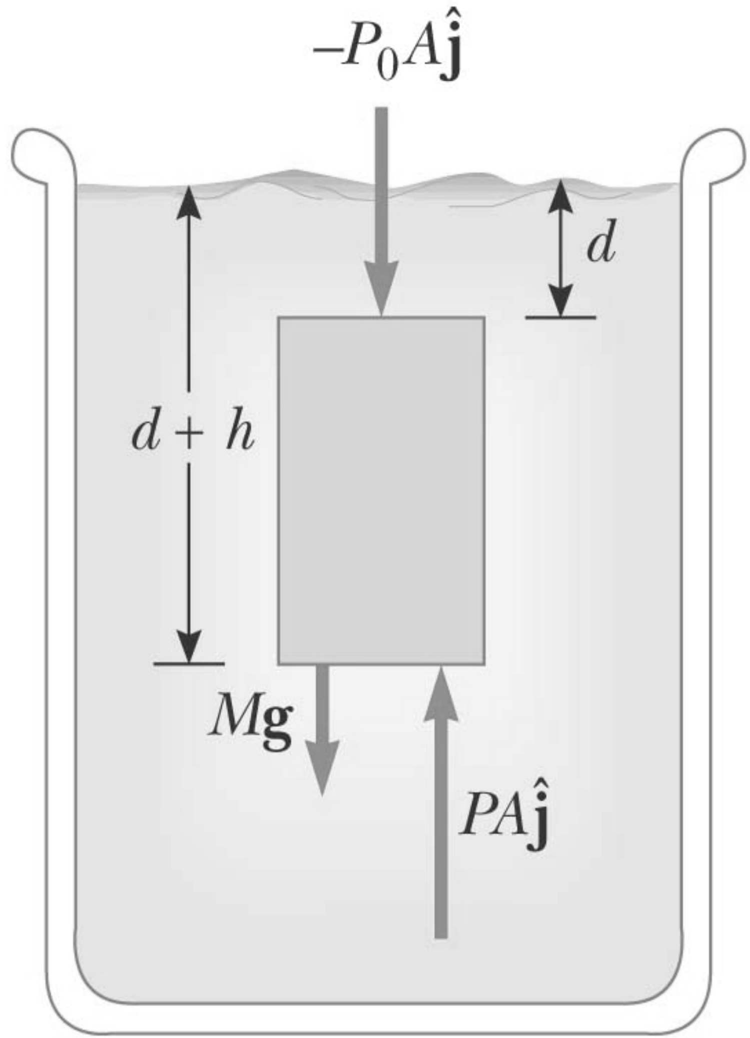


# Variation of Pressure with Depth

- Fluids have pressure that varies with depth
- If a fluid is at rest in a container, all portions of the fluid must be in static equilibrium
- All points at the same depth must be at the same pressure
  - Otherwise, the fluid would not be in equilibrium - **flow**

# Pressure and Depth

- Examine the darker region, a sample of liquid within a cylinder
  - It has a cross-sectional area *A*
  - Extends from depth *d* to *d* + *h* below the surface
- Three external forces act on the region



# Pressure and Depth

- The liquid has a density of $r$
  - Assume the density is the same throughout the fluid
  - This means it is an **uncompressible** liquid
- The three forces are:
  - Downward force on the top, $P_0A$
  - Upward on the bottom, $PA$
  - Gravity acting downward, $M\mathbf{g}$
    - The mass can be found from the density:

$$M = \rho V = \rho A h$$

$$\mathbf{P = P_0 + ?gh}$$

# Pascal's Law

- The pressure in a fluid depends on depth and on the value of $P_0$
- An increase in pressure at the surface must be transmitted to every other point in the fluid
- This is the basis of ***Pascal's law***

# Pascal's Law

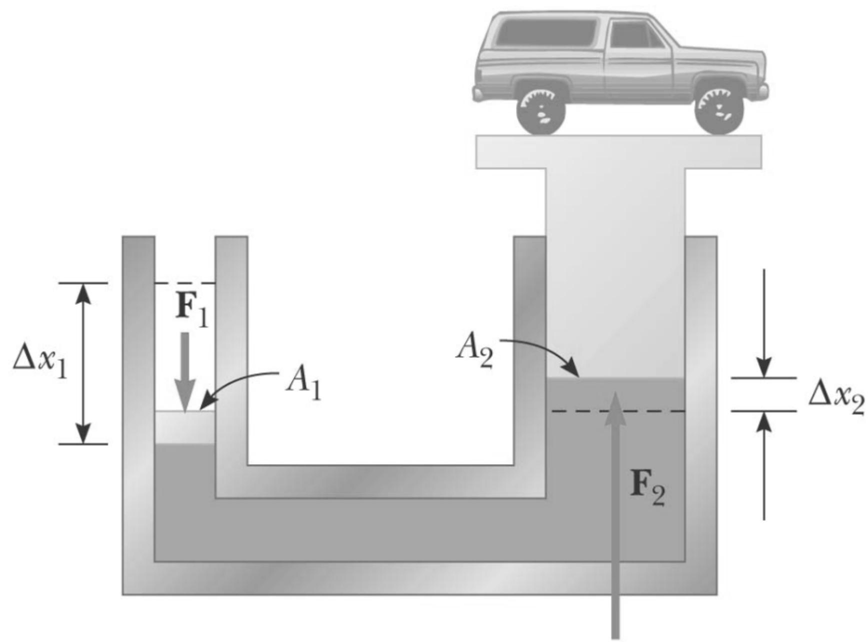
- Named for French scientist Blaise Pascal
- ***A change in the pressure applied to a fluid is transmitted undiminished to every point of the fluid and to the walls of the container***

$$P_1 = P_2$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

# Pascal's Law, Example

- Diagram of a hydraulic press (right)
- A large output force can be applied by means of a small input force
- The volume of liquid pushed down on the left must equal the volume pushed up on the right



(a)

# Atmospheric Pressure

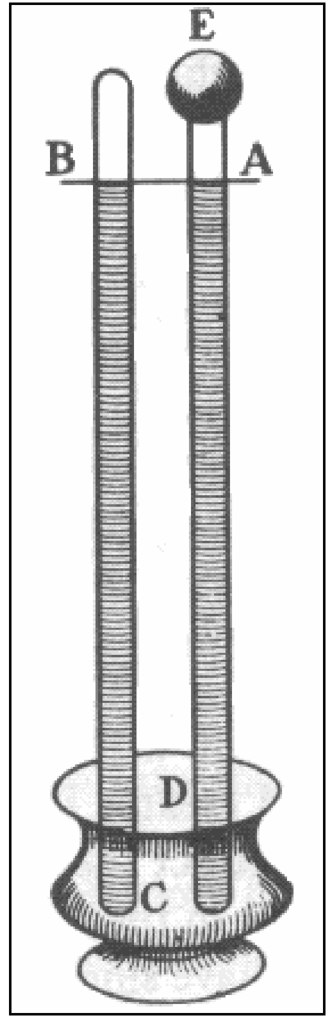
- If the liquid is open to the atmosphere, and $P_0$ is the pressure at the surface of the liquid, then $P_0$ is *atmospheric pressure*
- $P_0$ = 1.00 atm = 1.013 x $10^5$ Pa

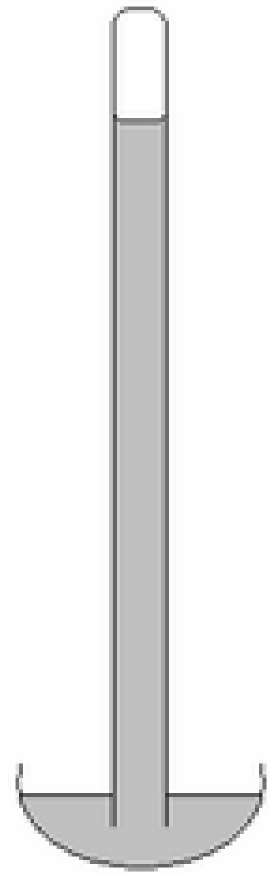
**1 Pa = 1 N/$m^2$ = $10^{-5}$ bar = 9.8692×$10^{-6}$ atm**

**1 Torr = 1 <u>mmHg</u>**

**1 Bar = 750.06** Torr

Evangelista Torricelli
lived from 1608 to 1647



## First barometer