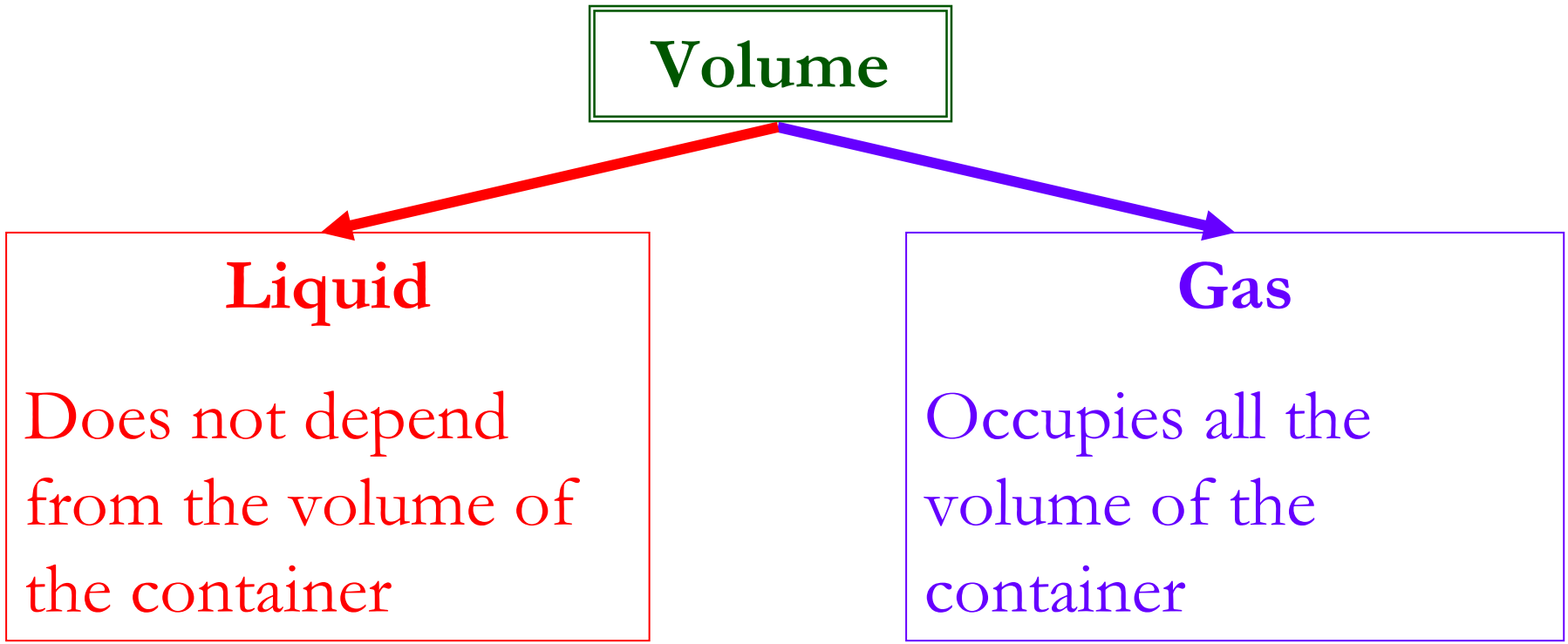
What is a Fluid?

A substance that has not its own shape but takes the shape of its container



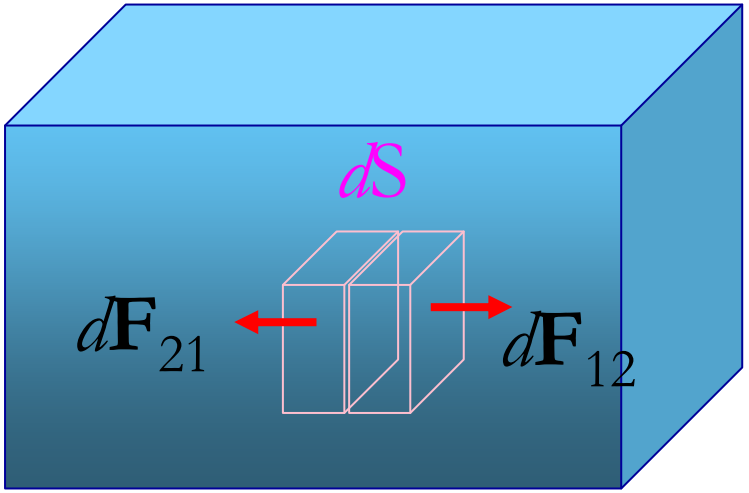
Fluids: surface forces and volume forces

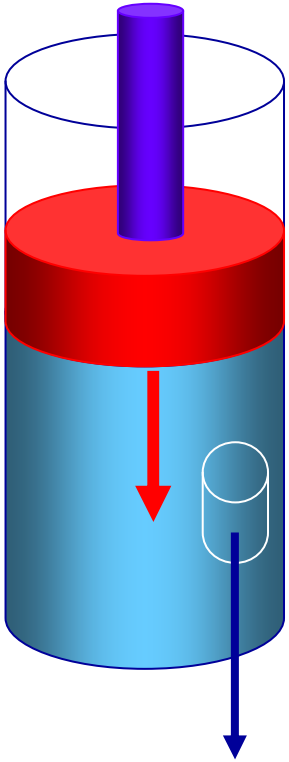
Surface Forces

Act only on the surface

Volume Forces

Act on any mass element dm





$$d\mathbf{F}_{21} = -\,d\mathbf{F}_{12} \qquad \mathbf{p}_{12} = d\mathbf{F}_{12}/dS$$

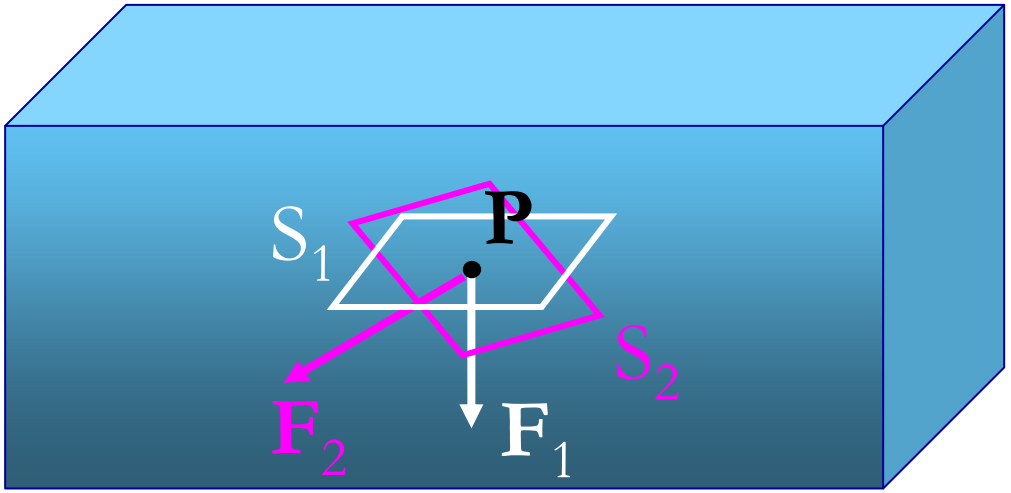
$$\mathbf{P} = d\,\mathbf{m}\,\mathbf{g} = \rho\, d\,\mathbf{V}\,\mathbf{g}$$

Experimentally: in a fluid in equilibrium, forces are orthogonal to dS

Isotropy of Pressure

$p_1(P) = F_1/S_1$ $\quad$ $p_2(P) = F_2/S_2$

$p_1(P) = p_2(P) =$ pressure in P

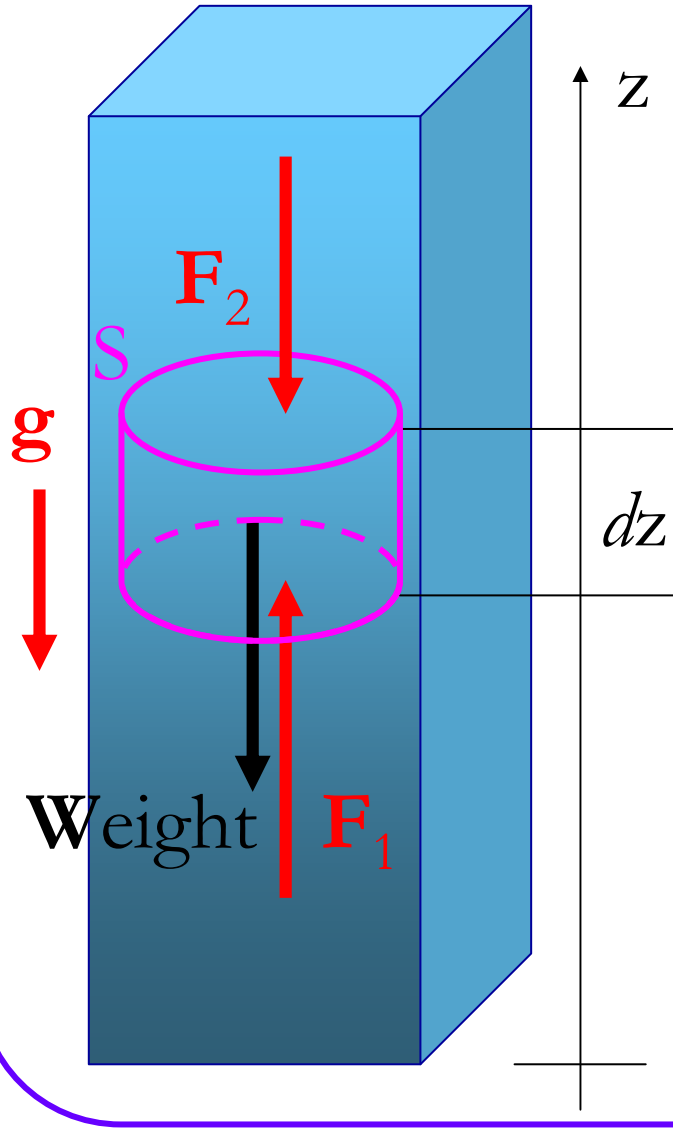


pressure: $[p] = ml^{-1}t^{-2}$

$N/m^2 \equiv$ Pascal (Pa)

$1\ atm = 1.013 \times 10^5\ Pa$

Law of Stevino



Still Fluid: **At equilibrium for any volume element** $\mathbf{F = 0}$

Weight $= -\varrho S\, dz\, g$

force on upper surface $= -p_2 S$

Force on lower surface $= p_1 S$

$$-\varrho S g dz - p_2 S + p_1 S = 0$$

$$-\varrho g dz = p_2 - p_1 = dp$$

Incompressible Fluids (cannot be compressed) (Liquids)

$$p(z_2) = p(z_1) + \varrho g (z_1 - z_2)$$

Density

	Temp. (°C)	Density (10^3 kg/m^3)
Water	4	1.000
	30	0.996
	100	0.958
Sea water	15	1.025
Ice	0	0.917
Mercury	0	13.600
Blood	37	1.05
Blood plasma	37	1.03
EthilicAlcool	20	0.79
Glicerine	0	1.26

Paraffine	15	0.90
Olive Olio	15	0.92
Palm Olio	15	0.97
Milk	20	1.03
Air	20	0.0012
CO_2	0	0.002
Pb	20	11.3
Au	20	19.3
Ag	20	10.5
Pt	20	21.4
Bone	20	1.6
Mango wood	20	0.7

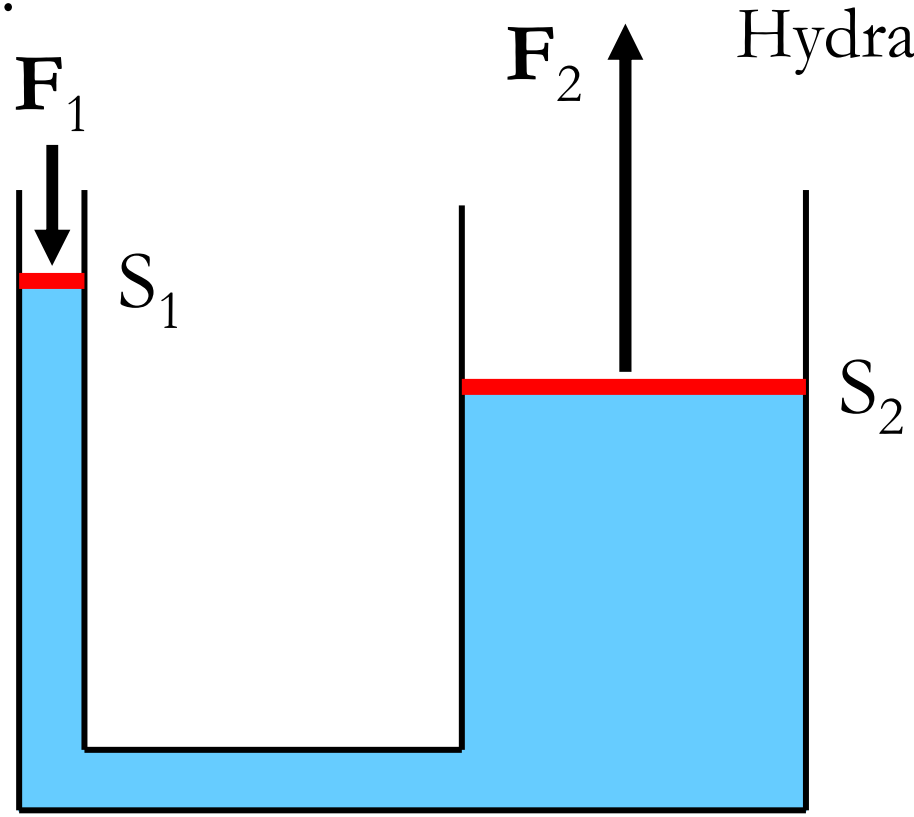
Law of Pascal

$$p(z_2) = p(z_1) + \varrho g(z_1 - z_2)$$

Small difference in level, low ϱ:

$$p(z_2) \approx p(z_1)$$

Hydraulic Press

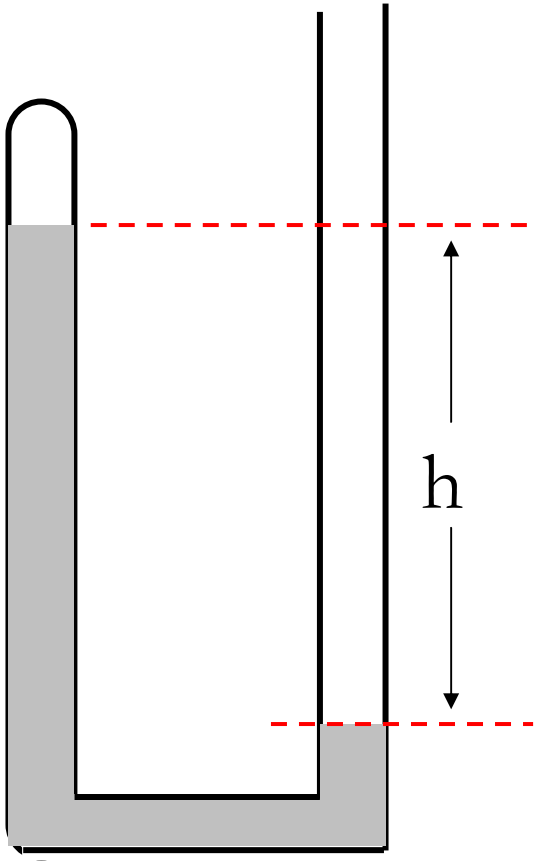


$$p_2 = p_1 \Rightarrow F_2/S_2 = F_1/S_1$$

$$F_2 = F_1(S_2/S_1)$$

Atmosferic Pressure

Experiment by Torricelli



$p_a = \varrho_m g h$

$1\,atm = 101335\,N/m^2$

Pratical Units of pressure:

$1\,bar = 10^5\,Pa = 0.987\,atm$

$1\ mbar = 10^{-3}\ bar$

tor or *mm of mercury*

$1\ tor = 1.333\,mbar$

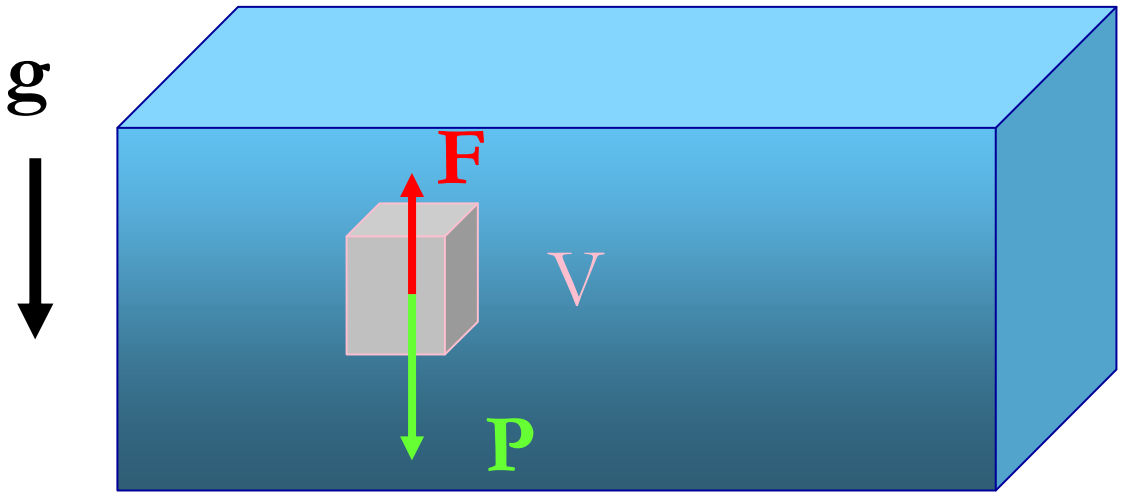
Law of Archimede (Bouyant or upthrust force)

Peso=**P**=ϱV**g**

Force balance = F = -P = - ρ V g

If ϱ_1 is the density, the total **force is**:

$$\mathbf{F_T} = \mathbf{F} + \mathbf{P} = -\varrho V\mathbf{g} + \varrho_1 V\mathbf{g} = (\varrho_1 - \varrho)V\mathbf{g}$$



Body floats if : $\varrho_1 < \varrho$

Volume displaced = V1

Upthrust force = weight of displaced fluid = V_1 g ρ_1