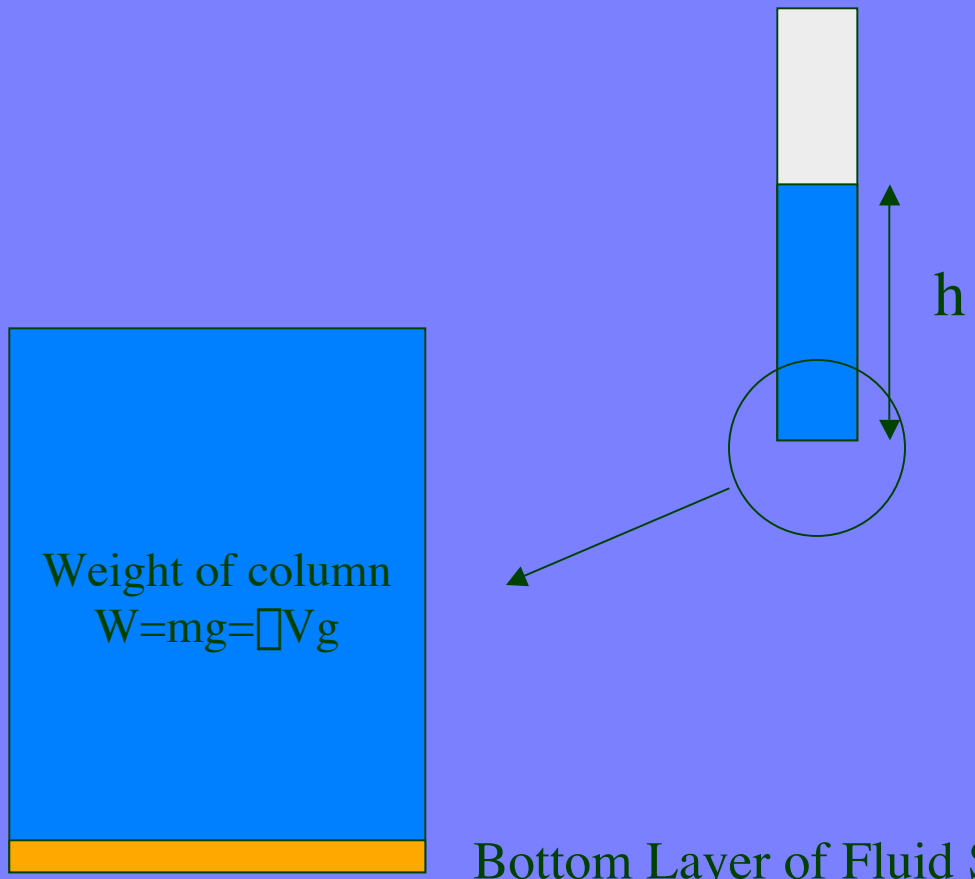
Lecture 9: Liquids and Gases in the Body

- Solids (bone)
  - Bulk modulus (Y) : $F/A = Y*\Delta L/L$
    - Compression and tension strength
    - Shear and torsional strength
- Liquids
  - Incompressible ($\beta^{-1} \sim 2x10^8$ N/m^2): $P=F/A=\rho gh$
  - Surface Tension, viscosity
  - Shear, torsion: NOT
- Gases
  - Compressible ($PV=nRT$)
  - Shear, torsion, Tension: NOT
  - Viscosity

Pressure In a Fluid or Gas

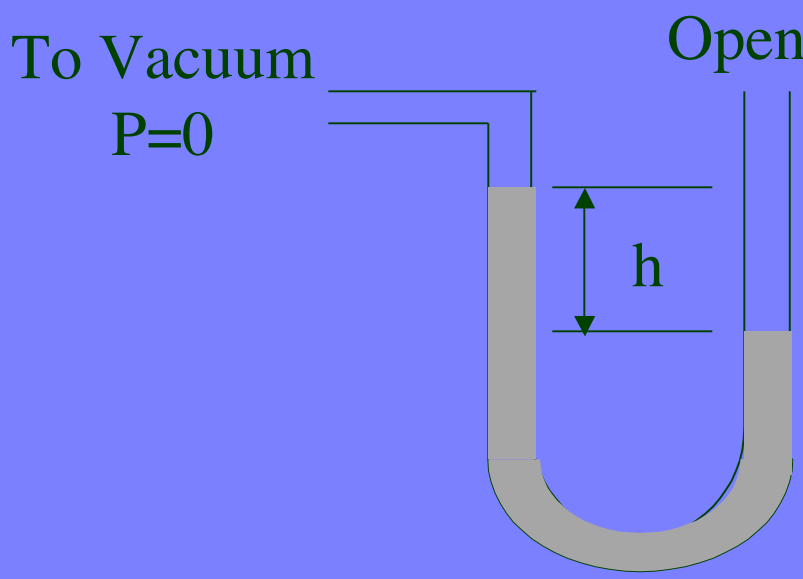
1 Pa = 1 N/m2



Bottom Layer of Fluid Supports W=ρgV=ρghA

P=F/A=ρghA /A = ρgh

Atmospheric Pressure



Air Pushes Down

$F = PA = \rho g (hA)$

1.01×10^5 Pa ~ 760 mm Hg ~ 29.9 in Hg

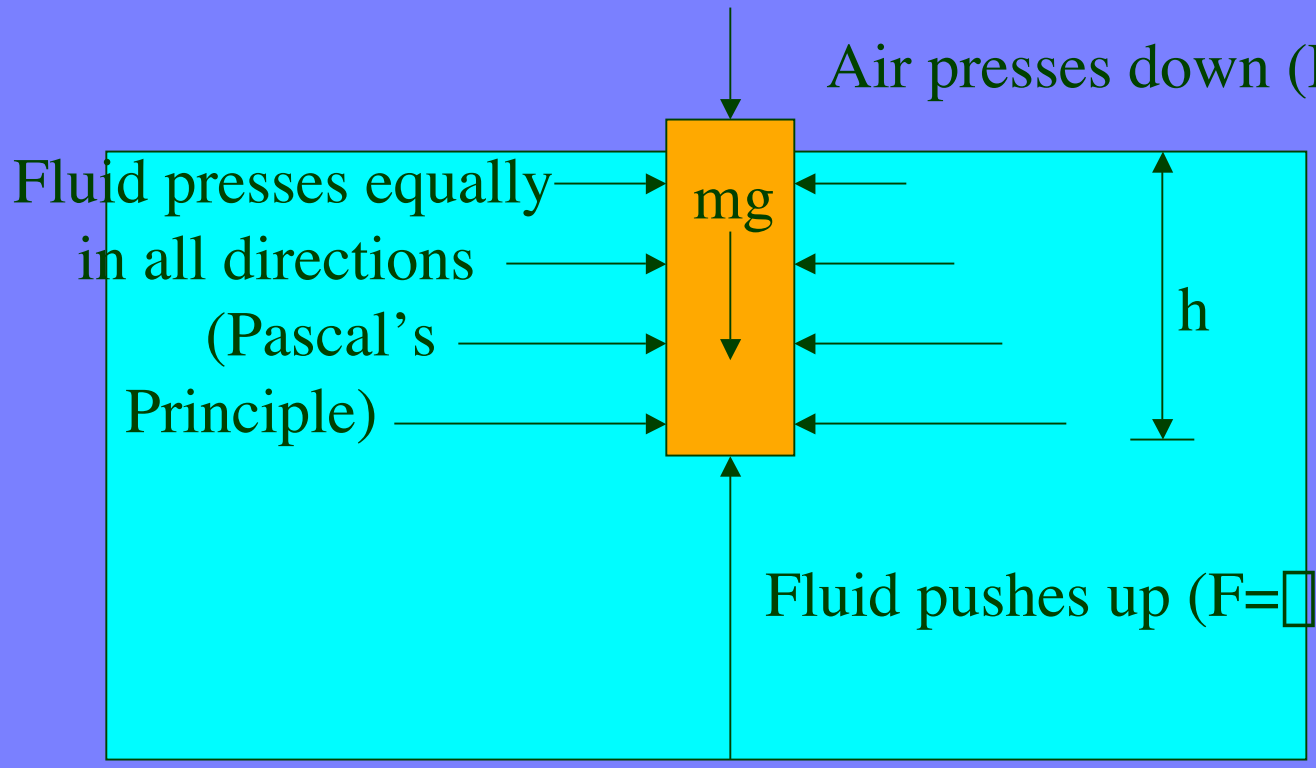
Absolute Pressure: Relative to Vacuum

Gauge Pressue: Relative to 101 kPa

Pressure in the Body

- Lung (inhaling) P_G = - 200 Pa (-1.5 mm)
- Blood Pressure P_S = 120 mm Hg/P_D = 80 mm Hg
  arterial 100-140 60-90
- Venous Blood: 5 mm Hg
  3-7
- Capillary Differential (A-V): 20 mm
- CSF: 5-10 mm

Buoyancy



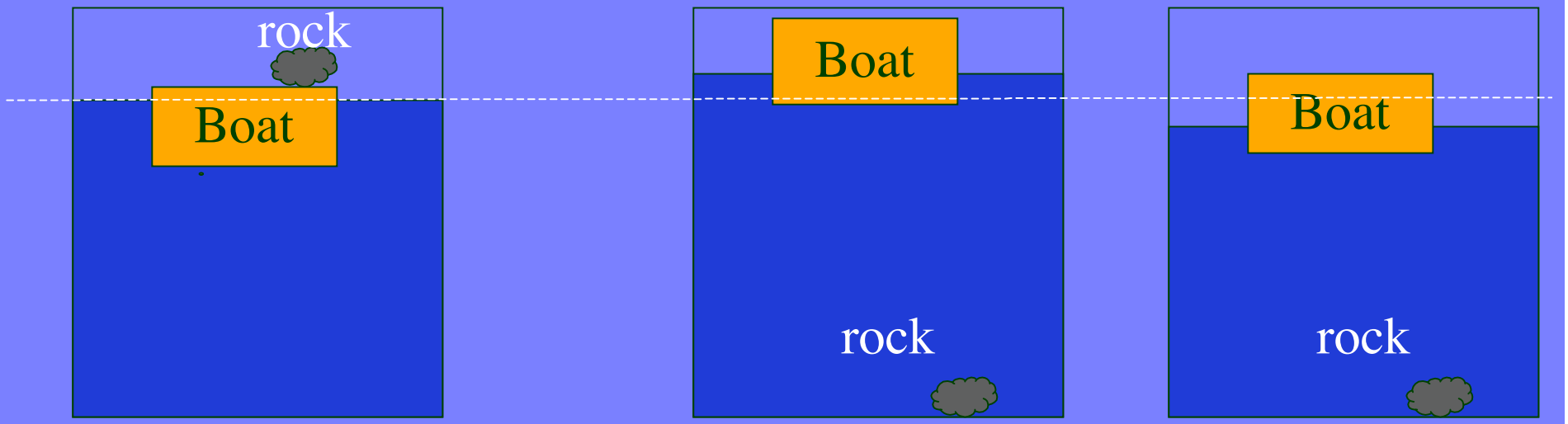
$mg=\rho_{H2O}ghA=\rho_{H2O}gV_{H2O}$

For a fully submerged object:

$(\rho_{object}V_{object}-\rho_{H2O}V_{object})g=F_{down}$

F_{down} is the downward force

Puzzle



Does the water level go UP or DOWN

$\rho_{H2O} V_{H2O} = m_{rock} = \rho_{rock} V_{rock}$

$V_{H2O} = V_{rock} * (\rho_{rock} / \rho_{H2O})$

$V_{H2O} = V_{rock}$

Diving

- PV=nRT (Density of Air is GREATER under water)
- Partial Pressure of O_2 and N_2 are GREATER
- Blood O_2 and N_2 concentrations are GREATER
  - Oxygen Poisoning
  - Nitrogen Narcossis
- RESURFACING:
  - Please exhale
  - Bends (extra N_2 dissolved in tissues and joints)
  - Collapsed Lung
  - Air Bubbles

High Altitude

- PV=nRT (Density of Air is LESS at Altitude)
- Partial Pressure of O_2 and N_2 are LESS
- Blood O_2 and N_2 concentrations are LESS
  - Slowed metabolism
  - Exhaustion
  - Asphyxiation

PRESSURE VS ALTITUDE

Altitude	Pressure	PO_2
Sea Level	760 mm	150 mm
h	$760 * e^{-h/5\ mi}$	