**Static Fluids**

**Learning Objectives**

After you complete the homework associated with this lecture, you should be able to:

- Determine the pressure at a particular point in a fluid below its surface;
- Analyze basic problems involving hydraulic forces;
- Use Archimedes Principle to argue that a fluid produces a buoyancy force upward on the portion of any object submerged in it;
- Predict the apparent weight and the submerged portion of an object in a fluid.

**Pressure in a Fluid**

A fluid is a state of matter that is not rigid, i.e.,

- liquid
- gas

The surface of an object submerged in a fluid will experience a force acting on the surface. Because of the nature of fluid, this force is distributed over the surface. We describe the effect as a PRESSURE:

\[ \text{Pressure} = P = \text{Force magnitude per Area} \]

The pressure acts at a point.

**Pressure and Force**

\[ dF = \rho \cdot g \cdot h \cdot dA \]

The force is directed inward, perpendicular to surface.

Over a flat surface, total force magnitude is

\[ F = \int dF = \int \rho \cdot g \cdot h \cdot dA \]

**Fluids in a Gravitational Field**

If you lie down and pile bricks on top of your chest, you feel the pressure.

Same occurs if you “pile” a fluid on top.

- In a fluid of density \( \rho \), the change in pressure \( P \) as you descend a vertical distance \( h \) is

\[ P_{\text{below}} - P_{\text{above}} = \rho \cdot g \cdot h \]

**Demo**: Magdeburg spheres
Pressure At Same Level Is The Same

All points that are at the same level in a contiguous fluid have the same pressure.

**Example:** Given $h$ and fluid densities, what is $D$?

\[
D = \frac{P_{\text{Atmos}} - \rho_a gh}{\rho_b g}
\]

Example of Buoyancy Force

You place a wooden object of volume $V_o$ and density $\rho_o$ into a fluid with twice its density. You push down on the object with a force that equals half its weight and find that some portion of it is still above the fluid. What fraction of the object’s volume is below the fluid line?

Buoyancy & Archimedes’ Principle

An object in a fluid will experience an upward buoyancy force equal to the weight magnitude of the fluid it displaces.

\[
F_B = \rho_{\text{fluid}} V g = \rho_{\text{fluid}} V_{\text{disp}} g
\]

\[
F_g = m_{\text{fluid}} g = \rho_{\text{fluid}} V g
\]

\[
F_g = m_{\text{obj}} g = \rho_{\text{obj}} V_{\text{obj}} g
\]

**DEMO:** Buoyancy force on a can lowered into fluid

DEMO: Fluid pressure in column attached to bladder, which also shows the power of hydraulics

Video: [http://campus.mst.edu/physics/courses/23/handouts/Agincourt.pdf](http://campus.mst.edu/physics/courses/23/handouts/Agincourt.pdf)
Volume under fluid line = $V_{\text{disp}}$

$\sum F_y = B_y + F_{g_\rho} + P_y = m a_y$

$(+B) + (-F_g) + (-\frac{1}{2}F_g) = m (0)$

$B = \frac{3}{2} F_g = \frac{3}{2} M_o g$

$\rho_f V_{\text{disp}} g = \frac{3}{2} (\rho_o V_o) g$

$$\frac{V_{\text{disp}}}{V_o} = \frac{3}{2} \rho_o = \frac{3}{2} \frac{\rho_o}{2 (2 \rho_o)} = \frac{3}{2} \cdot \frac{1}{2} = \boxed{\frac{3}{4}}$$