Fluids

Fluids Mechanics

Static Fluids - in equilibrium

Density

- Compare two objects of the same size; one floats and the other does not
- One object is more dense than the other
- ρ - density (rho - "row")
- ρ = m/V
- m - mass (in kg)
- V - volume (in m^3)

Specific Gravity

- Ratio of the density of a substance to the density of water @ 4°C
- Density of water: $1.0\ x\ 10^3\ kg/m^3$
- No units (density / density)
- To find density multiply specific gravity by $1.0\ x\ 10^3\ kg/m^3$

Pressure in Fluids

- Pressure = Force/Area
- $[Pa]\ =\ [N]/[m^2]$
- Pa - Pascal
- Force is a vector, pressure is scalar
- Force is perpendicular to the area

Examples

- Animal paws walking over you
- Gold shows/baseball cleats vs. Smooth soles
- High-heeled shoes
- Snowshoes
- Bed of nails

- Fluids attempt to compress objects that are submerged
- The forces exerted by a fluid on an object are always perpendicular to the object
- The fluid exerts the same pressure in all directions
- If this were not true, there would be a net force and fluid would cause itself to move

Pressure increases with depth

- $P\ =\ P_o\ +\rho a_g h$
- Pressure "P" at depth "h" is greater than atmospheric pressure "P_o" by the amount "$\rho a_g h$"
- All points at the same depth must be at the same pressure

Buoyancy

- Compare lifting someone under water to lifting them in air
- Holding a kickboard underwater
- In water, there is a buoyant force
- The buoyant force occurs because the pressure in a fluid increases with depth

Buoyancy

- The buoyant force occurs because the pressure in a fluid increases with depth
- The pressure at the top of an object will be different than the pressure at the bottom of an object

Archimedes's Principle

- Any object completely or partially submerged in a fluid is buoyed up by a force whose magnitude is equal to the weight of the fluid displaced by the object
- Magnitude of buoyant force = weight of fluid displaced by object

- Mass of volume of the fluid = Density * volume
- F_B (buoyant force) is exerted by the fluid. The magnitude is determined by the fluid density
- All objects of same volume will have same buoyant force
- $F_b = \rho_{fluid} * V * a_g$

Case I: Totally submerged object

F_g downward
F_B upward
If $F_B > F_g$ (density of object is lower than the density of the fluid) accl up
If $F_g > F_B$ (accl down)
$F_B = F_g$ (no accl b/c no net force)

Case II: Partially Submerged

$F_B = F_g$
The volume of the fluid displaced is not equal to the volume of the object

9.7 Fluids in Motion

- Streamline/laminar – every particle moves exactly along a smooth line
  - Streamlines cannot cross ("Don't cross the beams" Ghostbusters)
  - At any point the streamline coincides w/ direction of fluid velocity @ same point
- Turbulent – unstable flows (eddy currents)
- Viscosity – degree of internal friction
- Ideal fluid:
  - Fluid is non-viscous
  - Fluid is incompressible (constant density)
  - Fluid motion is steady
  - Fluid moves w/o turbulence
- Equation of continuity – particles move along streamlines in steady-state flow
  - $\rho_1 A_1 v_1 = \rho_2 A_2 v_2$