



## Physics Lecture 5 – Fluids and Solids

Examcrackers MCAT Comprehensive Course, Charles Feng  
<http://fenguin.net/mcat> — fenguin@gmail.com — (224) 532-0039

### Fluids

- Molecules have high kinetic energy
- Intermolecular bonds break & reform rapidly
- Exerts pressure/force on wall of container

### Density

- $\rho = m/V$ , density of water is  $\rho_{water} = 1000 \text{ kg/m}^3 = 1 \text{ g/cm}^3$
- Intensive property (doesn't depend on amount)
- Compression can change density but we can assume liquids/solids are incompressible
- Specific gravity:  $SG = \rho_{substance}/\rho_{water}$  ( $SG > 1$  means heavier than water,  $< 1$  means lighter)

### Pressure

- Caused by molecular collisions
- $P = F/A$
- Fluid at rest (nonmoving):  $P = \rho gy$  where  $y$  is depth
  - For multiple layers of fluid, you can add pressures
  - If container is open, must also add atmospheric pressure =  $101 \text{ kPa}$
- Pascal's principle: if you add pressure anywhere, it'll be spread out everywhere – assumes incompressible
  - Hydraulic lift:  $F_1 d_1 = F_2 d_2$ ,  $\frac{F_1}{A_1} = \frac{F_2}{A_2}$ ,  $A_1 d_1 = A_2 d_2$

### Force

- Archimedes' principle: object inside water has buoyant force due to difference in pressures
- Buoyant force equal to weight of displaced fluid,  $F = \rho_{fluid} V_{submerged} g$ 
  - $V$  is volume of object that's submerged in water =  $m_{object}/\rho_{object}$
  - If object isn't completely in the water, only consider  $V$  that's in the water
  - Floating object: fraction submerged =  $\rho_{object}/\rho_{water}$  = specific gravity of object
- Center of buoyancy is always physical center of object, if center of mass isn't physical center then a torque is created

### Motion

- Random translational motion: contributes to fluid pressure
- Uniform translational motion: motion of fluid as a whole, doesn't contribute to pressure

### Ideal fluid

- No viscosity (resistance to flow, how "syrupy" fluid is)
- Incompressible (uniform density)
- Flows without turbulence (all points flow at same speed)
  - Volume flow rate  $Q = Av$ ,  $A$  is cross sectional area,  $v$  is velocity of all fluid particles
  - Pipe that changes cross sectional area:  $A_1 v_1 = A_2 v_2$

### Nonideal fluid

- Drag/viscosity will decrease flow velocity



## Physics Lecture 5 – Fluids and Solids

Examcrackers MCAT Comprehensive Course, Charles Feng  
<http://fenguin.net/mcat> — fenguin@gmail.com — (224) 532-0039

### Bernoulli's equation:

$$P + \rho gh + \frac{1}{2} \rho v^2 = \text{constant}$$

- $h$  is height of fluid above ground
- Random motion KE + gravitational PE + uniform motion KE = constant

### Applications:

- (1) Hole in bottle of fluid, distance  $h$  below surface of water:  $v = \sqrt{2gh}$
- (2) Velocity increases when pressure decreases, so in a pipe, wider = more pressure

**Intermolecular forces** create surface tension, cohesion/adhesion

### Solids

- *Stress* = force applied / area where it's applied
- *Strain* = change in shape / original shape
- Young's modulus: tensile (squishing/pulling),  $E = \frac{F/A}{\Delta h/h_0}$
- Shear modulus: shear (tearing),  $G = \frac{F/A}{\Delta x/h_0}$
- Bulk modulus: compression/expansion,  $B = \frac{\Delta P}{\Delta V/V_0}$