Physic² 121:
Phundament°ls of Phy²ics I

November 29, 2006

Chapter 8

Rotational Equilibrium
and
Rotational Dynamics

Angular Momentum

- Similarly to the relationship between force and momentum in a linear system, we can show the relationship between torque and angular momentum
- Angular momentum is defined as
  - L = I ω
    - Vector quantity – right-hand rule determines direction
    - Angular momentum is conserved in a system with no external torques
  - and

$$\sum \vec{\tau} = \frac{\Delta \vec{L}}{\Delta t}$$

  - Just like

$$\sum \vec{F} = \frac{\Delta \vec{p}}{\Delta t}$$

Angular Momentum, cont

- If the net torque is zero, the angular momentum remains constant
- *Conservation of Angular Momentum* states: The angular momentum of a system is conserved when the net external torque acting on the systems is zero.
  - That is, when

$$\Sigma\tau = 0$$

$$L_i = L_f$$

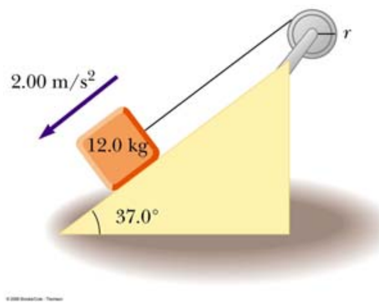
$$\text{or } \; I_i\omega_i = I_f\omega_f$$

Conservation Rules, Summary

- In an isolated system (no external forces or torques, no non-conservative forces), the following quantities are conserved:
  - Mechanical energy
  - Linear momentum
  - Angular momentum

Example Problem (8.60)

- A 12.0-kg object is attached to a cord that is wrapped around a wheel of radius r = 10.0 cm. The acceleration of the object down the frictionless incline is measured to be 2.00 m/s^2. Assuming the axle of the wheel to be frictionless, determine
  - (a) the tension in the rope
  - (b) the moment of inertia of the wheel
  - (c) the angular speed of the wheel 2.00 s after it begins rotating, starting from rest.



Chapter 9

Solids and Fluids

Density (Section 9.3)

- The density of a substance of uniform composition is defined as its mass per unit volume:

$$\rho \equiv \frac{m}{V}$$

- Units are kg/m^3 (SI) or g/cm^3 (cgs)
- $1\ g/cm^3 = 1000\ kg/m^3$

Density, cont.

- The densities of most liquids and solids vary slightly with changes in temperature and pressure
- Densities of gases vary greatly with changes in temperature and pressure

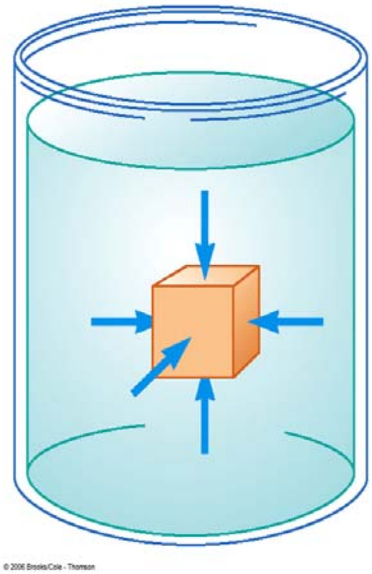
Specific Gravity

- The *specific gravity* of a substance is the ratio of its density to the density of water at 4° C
  - The density of water at 4° C is 1000 kg/m^3
- Specific gravity is a unitless ratio

Pressure

- The force exerted by a fluid on a submerged object at any point if perpendicular to the surface of the object

$$P \equiv \frac{F}{A} \text{ in } Pa = \frac{N}{m^2}$$

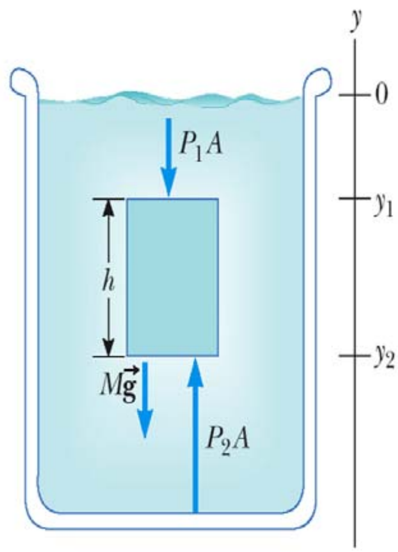


Variation of Pressure with Depth

- If a fluid is at rest in a container, all portions of the fluid must be in static equilibrium
- All points at the same depth must be at the same pressure
  - Otherwise, the fluid would not be in equilibrium
  - The fluid would flow from the higher pressure region to the lower pressure region

Pressure and Depth

- Examine the darker region, assumed to be a fluid
  - It has a cross-sectional area A
  - Extends to a depth h below the surface
- Three external forces act on the region



Pressure and Depth equation

- $P = P_o + \rho g h$
- P_o is normal atmospheric pressure
  - 1.013×10^5 Pa = 14.7 lb/in^2
- The pressure does not depend upon the shape of the container

Pascal's Principle

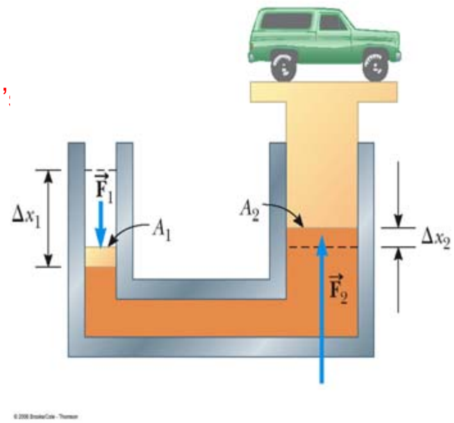
- A change in pressure applied to an enclosed fluid is transmitted undimished to every point of the fluid and to the walls of the container.
  - First recognized by Blaise Pascal, a French scientist (1623 – 1662)

Pascal's Principle, cont

- The hydraulic press is an important application of Pascal's Principle

$$P = \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

- Also used in hydraulic brakes, forklifts, car lifts, etc.

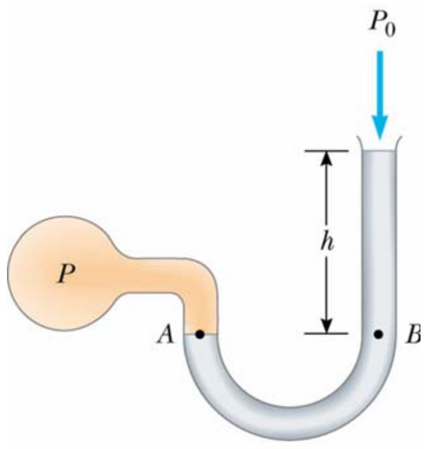


Absolute vs. Gauge Pressure

- The pressure P is called the ***absolute*** pressure
  - Remember, $P = P_o + \rho gh$
- $P - P_o = \rho gh$ is the ***gauge*** pressure

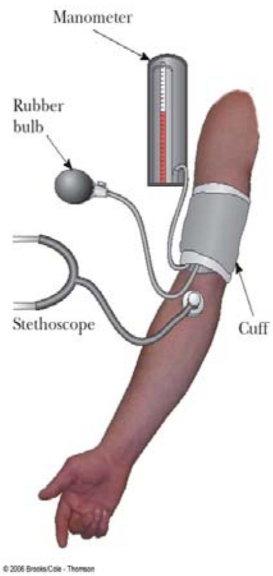
Pressure Measurements: Manometer

- One end of the U-shaped tube is open to the atmosphere
- The other end is connected to the pressure to be measured
- Pressure at B is $P_o + \rho g h$



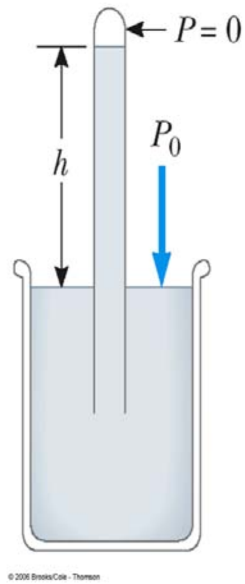
Blood Pressure

- Blood pressure is measured with a special type of manometer called a *sphygmomano-meter*
- Pressure is measured in mm of mercury



Pressure Measurements: Barometer

- Invented by Torricelli (1608 – 1647)
- A long closed tube is filled with mercury and inverted in a dish of mercury
- Measures atmospheric pressure as ρgh



Pressure Values in Various Units

- One atmosphere of pressure is defined as the pressure equivalent to a column of mercury exactly 0.76 m tall at 0^o C where g = 9.806 65 m/s^2
- One atmosphere (1 atm) =
  - 76.0 cm of mercury
  - 1.013×10^5 Pa
  - 14.7 lb/in^2