Physic² 121:
Phundament°ls of Phy²ics I

December 1, 2006

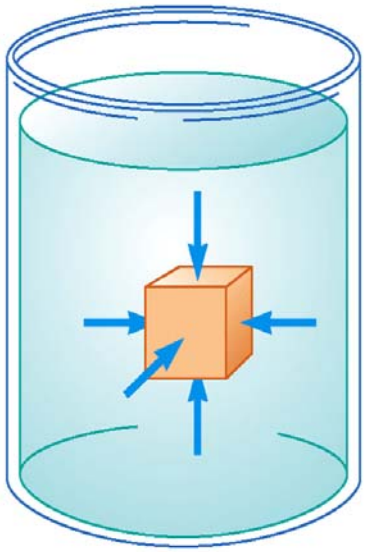
Chapter 9

Solids and Fluids

Pressure

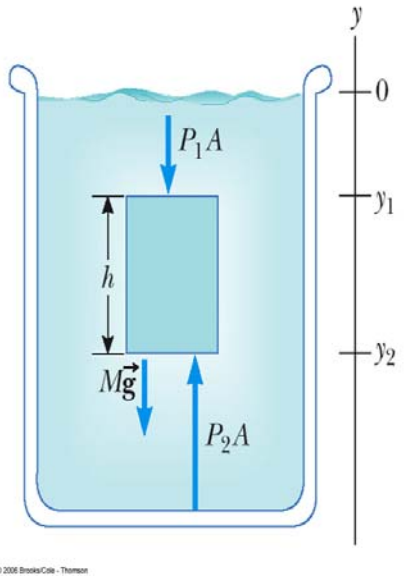
- The force exerted by a fluid on a submerged object at any point if perpendicular to the surface of the object

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



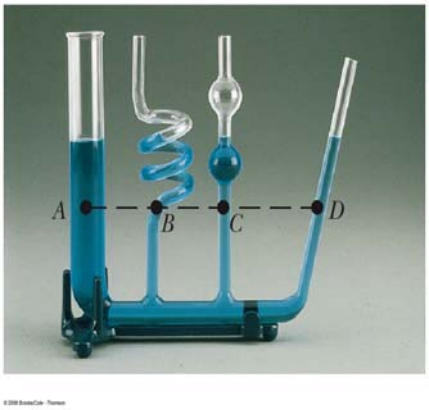
Pressure and Depth

- 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

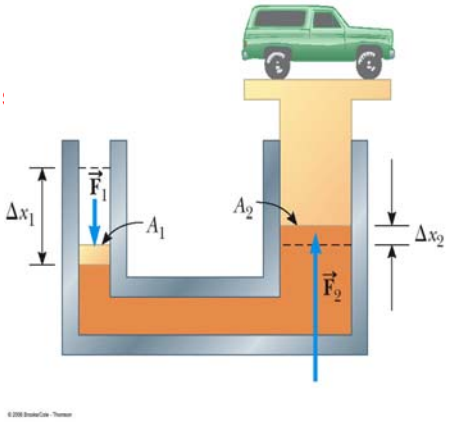
- A change in pressure applied to an enclosed fluid is transmitted undimished to every point of the fluid and to the walls of the container.
  - First recognized by Blaise Pascal, a French scientist (1623 – 1662)

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.



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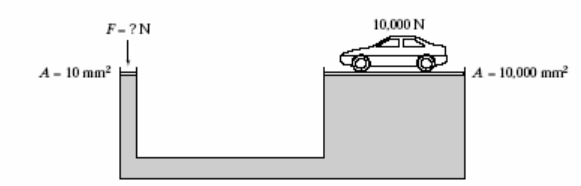
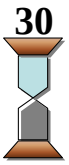
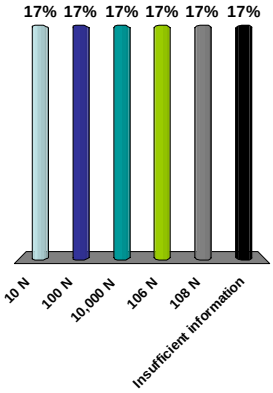
A container is filled with oil and fitted on both ends with pistons. The area of the left piston is 10mm^2; that of the right piston 10,000 mm^2. What force must be exerted on the left piston to keep the 10,000-N car on the right at the same height?



1. 10 N
2. 100 N
3. 10,000 N
4. 10^6 N
5. 10^8 N
6. Insufficient information





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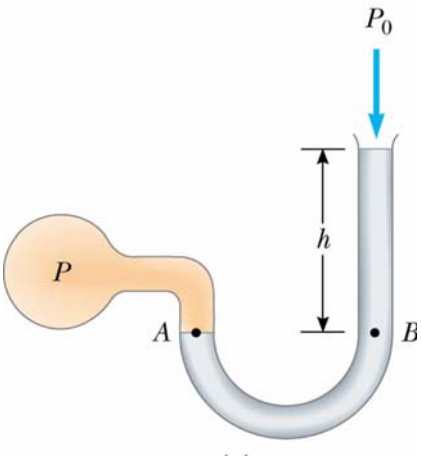
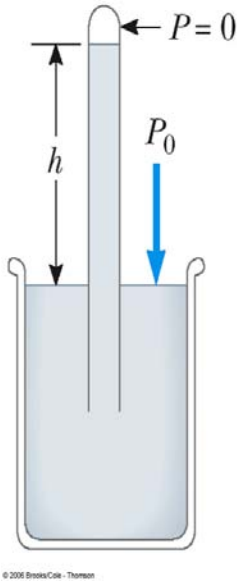
Pressure Measurements: Manometer

- 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 $P_o+\rho gh$



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



Archimedes

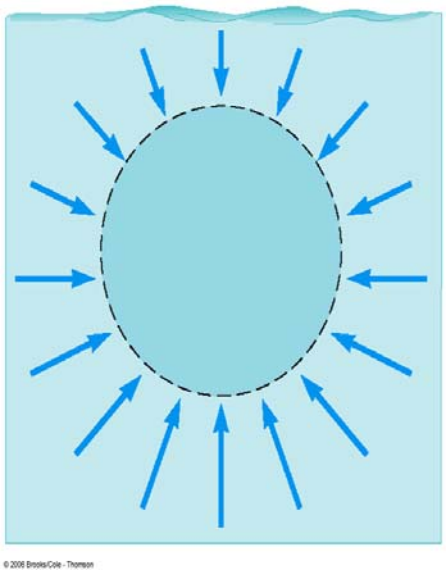
- 287 – 212 BC
- Greek mathematician, physicist, and engineer
- Buoyant force
- Inventor

Archimedes' 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.

Buoyant Force

- The upward force is called the *buoyant force*
- The physical cause of the buoyant force is the pressure difference between the top and the bottom of the object



Buoyant Force, cont.

- The magnitude of the buoyant force always equals the weight of the displaced fluid

- The buoyant force is the same for a totally submerged object of any size, shape, or density

$$B = \rho_{fluid} V_{fluid} g = w_{fluid}$$

Buoyant Force, final

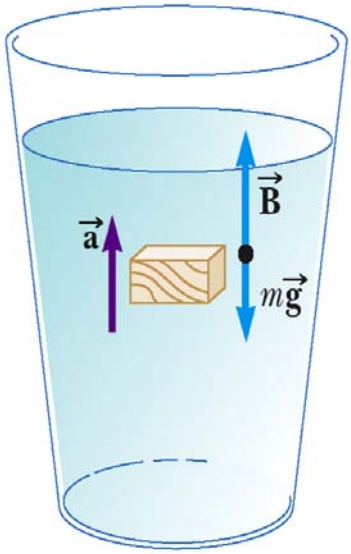
- The buoyant force is exerted by the fluid
- Whether an object sinks or floats depends on the relationship between the buoyant force and the weight

Archimedes' Principle: Totally Submerged Object

- The upward buoyant force is $B=\rho_{fluid}gV_{obj}$
- The downward gravitational force is $w=mg=\rho_{obj}gV_{obj}$
- The net force is $B-w=(\rho_{fluid}-\rho_{obj})gV_{obj}$

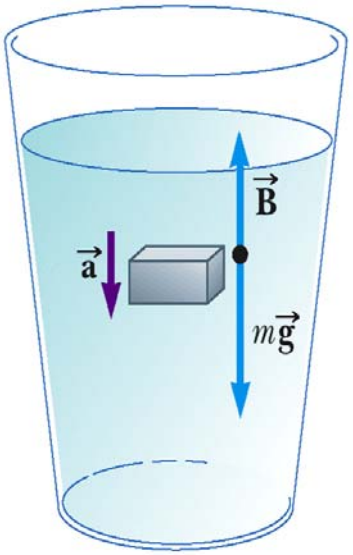
Totally Submerged Object

- The object is less dense than the fluid
- The object experiences a net upward force



Totally Submerged Object, 2

- The object is more dense than the fluid
- The net force is downward
- The object accelerates downward



Archimedes' Principle: Floating Object

- The object is in static equilibrium
- The upward buoyant force is balanced by the downward force of gravity
- Volume of the fluid displaced corresponds to the volume of the object beneath the fluid level

Archimedes' Principle: Floating Object, cont

- The forces balance
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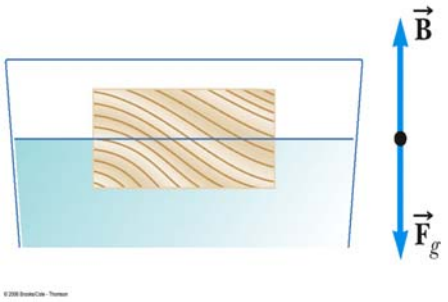
$$\frac{\rho_{obj}}{\rho_{fluid}} = \frac{V_{fluid}}{V_{obj}}$$



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A ball floats on water, as seen in the photograph below, but will sink when put into mineral spirits. The water is dyed green with food coloring to distinguish it from the clear mineral spirits. Note how far the floating ball sinks into the water.

When the mineral spirits is poured slowly onto the top of the water, it will remain on top because the two fluids are immiscible.

If the mineral spirits is poured slowly on top of the water while the ball is floating on the water, what will happen to the level at which the ball floats?

1. The ball will float lower in the water
2. The ball will float higher out of the water
3. The ball will float at the same level with respect to the surface of the water after the mineral spirits are poured on top of the water

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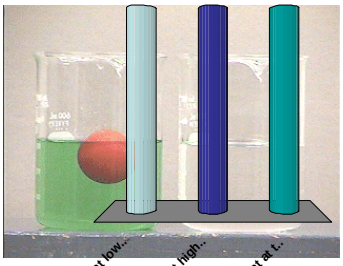

33% 33% 33%

The ball will float low... The ball will float high.. The ball will float at t...

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