PHYSICS 151 – Notes for Online Lecture #28

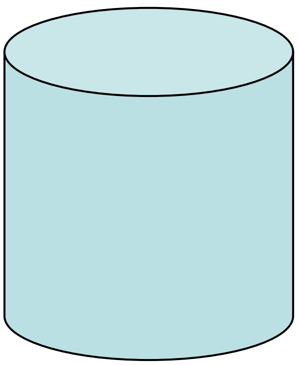
FLUIDS

- **A** fluid is a substance that cannot maintain is shape.
- It alters its shape to conform to the shape of its container
- This definition includes both liquids and gases -- however we are much more interested in fluids since they are incompressible.

Density: We are very interested in the density of fluids. Density is defined as the ratio of the mass to the volume.

$$\rho = \frac{M}{V}$$

and has units of kg/m^3 or g/cm^3.



A cylinder has a radius of 12 cm and a height of 24 cm? If its mass is 85.34 kg, what is the composition of the cylinder?

Pressure: We are also interested in describing the pressure in a fluid. Pressure is the force/area and has units of N/m^2 or pascals. Most devices that measure pressure (like a tire gauge) measure gauge pressure. This is the amount of pressure in excess of atmospheric pressure (1.013 x 10^5 N/m^2 at sea level).

$$P_{absolute} = P_{gauge} + P_{atm}$$

You Try It! A cube of aluminum 25.0 cm on a side sits on the floor. What is the pressure it exerts on the floor?

The pressure in water increases with depth since each layer must support the weight of the water above and is described by the formula

$$P = P_{atm} + \rho g h$$

Ex. 28-1 What is the pressure 30 m under the ocean?

$$P = P_{atm} + \rho g h = \left(1.013 \times 10^5\, Pa\right) + \left(1000 \frac{kg}{m^3}\right)\left(9.81 \frac{m}{s^2}\right)(30m)$$
$$= 3.96 \times 10^5\, Pa$$

Note that P_a is derived from the same principle it is the pressure due to the weight of the atmosphere above you. The scale height (the height it would have if of uniform density) of the atmosphere is about 8 km.

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You Try It! What would be the pressure at a depth of 11 m in a giant vat of olive oil?

Pascal's Principle - The pressure applied at one point in an enclosed fluid is transmitted undiminished to every part of the fluid and to the walls of the container. Fluids are often enclosed to take advantage of Pascal's Principle.

Examples:

- Hydraulic Lifts
- Air Compressors

Ex. 28-2 A hydraulic lift is used to raise a car weighing 15,000 N. The piston that supports the car has a diameter of 36 cm. What pressure of air within the system is required to just hold the car in place?

$$P_a = P_b$$

$$P_a = \frac{F_b}{A_b} = \frac{F_b}{\pi r^2} = \frac{(15000N)}{\pi(0.18m)^2} = 1.47 \times 10^5\ Pa$$

Ex. 28-3 A U-shaped tube is partially filled with equal columns of water and mercury. If each liquid fills a 20-cm-long section of the tube, what will be the difference in the levels of the upper surfaces?

The mercury being denser than water will certainly settle to the bottom of the U. A column of mercury of height y will stick up on one side to balance the pressure of the water column.

$$P_{Hg} = P_{water}$$

$$(\rho g h)_{Hg} = (\rho g h)_{water}$$

$$\left(1.36\times10^4 \frac{kg}{m^3}\right) g\,(y) = \left(1000 \frac{kg}{m^3}\right) g\,(0.2m)$$

$$y = 0.015m$$

So the difference in the heights of the two surfaces is 18.5 cm.